Appendix A

CHAPTER 171

AN ACT concerning **Greenhouse Gas Emissions Reduction Act of 2009**

FOR the purpose of setting forth certain findings of the General Assembly; requiring the Department of the Environment to publish and update certain inventories based on certain measures on or before certain dates; requiring the State to reduce greenhouse gas emissions by a certain amount by a certain date and to develop a certain plan, adopt certain regulations, and implement certain programs that reduce greenhouse gas emissions; requiring the Department to submit a proposed plan to the Governor and the General Assembly on or before a certain date; requiring the Department to make the plan available to the public; requiring the Department to convene a series of public workshops for comment on the plan; requiring the Department to adopt a final plan in accordance with certain requirements on or before a certain date; requiring the Department to consult with State and local agencies under certain circumstances; prohibiting State agencies from adopting certain regulations; requiring the Department to take certain actions as it develops and implements the plan in a certain manner; requiring an institution of higher education in the State to conduct a certain study and submit it to the Governor and the General Assembly on or before a certain date; requiring the Governor to appoint a certain task force consisting of certain representatives to oversee the study; requiring that, to the extent practicable, the members appointed to the task force reflect the geographic, racial, and gender diversity of the State; authorizing certain greenhouse gas emissions sources to receive certain credits under certain circumstances; requiring the Department to submit a certain report to the Governor and the General Assembly in accordance with certain requirements on or before a certain date; authorizing the General Assembly to maintain, revise, or eliminate certain greenhouse gas emissions reduction requirements under certain circumstances; requiring the Department to monitor the implementation of a certain plan and to submit certain reports to the Governor and the General Assembly on or before certain dates; requiring the Department to include certain agencies and entities in certain discussions regarding certain matters; defining certain terms; making the provisions of this Act severable; providing for the correction of certain errors and obsolete provisions by the publishers of the Annotated Code; providing for the termination of a certain provision of this Act; and generally relating to the reduction of greenhouse gas emissions.

BY adding to Article – Environment Section 2–1201 through 2–1211 to be under the new subtitle “Subtitle 12. Greenhouse Gas Emissions Reductions” Annotated Code of Maryland (2007 Replacement Volume and 2008 Supplement)

SECTION 1. BE IT ENACTED BY THE GENERAL ASSEMBLY OF MARYLAND, That the Laws of Maryland read as follows:

SUBTITLE 12. GREENHOUSE GAS EMISSIONS REDUCTIONS.

2–1201.

THE GENERAL ASSEMBLY FINDS THAT:

(1) GREENHOUSE GASES ARE AIR POLLUTANTS THAT THREATEN TO ENDANGER THE PUBLIC HEALTH AND WELFARE OF THE PEOPLE OF MARYLAND;

(2) GLOBAL WARMING POSES A SERIOUS THREAT TO THE STATE'S FUTURE HEALTH, WELL–BEING, AND PROSPERITY;

(3) WITH 3,100 MILES OF TIDALLY INFLUENCED SHORELINE, MARYLAND IS VULNERABLE TO THE THREAT POSED BY GLOBAL WARMING AND SUSCEPTIBLE TO RISING SEA LEVELS AND FLOODING, WHICH WOULD HAVE DETRIMENTAL AND COSTLY EFFECTS;

(4) THE STATE HAS THE INGENUITY TO REDUCE THE THREAT OF GLOBAL WARMING AND MAKE GREENHOUSE GAS REDUCTIONS A PART OF THE STATE'S FUTURE BY ACHIEVING A 25% REDUCTION IN GREENHOUSE GAS EMISSIONS FROM 2006 LEVELS BY 2020 AND BY PREPARING A PLAN TO MEET A LONGER–TERM GOAL OF REDUCING GREENHOUSE GAS EMISSIONS BY UP TO 90% FROM 2006 LEVELS BY 2050 IN A MANNER THAT PROMOTES NEW "GREEN" JOBS, AND PROTECTS EXISTING JOBS AND THE STATE'S ECONOMIC WELL–BEING;

(5) STUDIES HAVE SHOWN THAT ENERGY EFFICIENCY PROGRAMS AND TECHNOLOGICAL INITIATIVES CONSISTENT WITH THE GOAL OF REDUCING GREENHOUSE GAS EMISSIONS CAN RESULT IN A NET ECONOMIC BENEFIT TO THE STATE;

(6) IN ADDITION TO ACHIEVING THE REDUCTION ESTABLISHED UNDER THIS SUBTITLE, IT IS IN THE BEST INTEREST OF THE STATE TO ACT EARLY AND AGGRESSIVELY TO ACHIEVE THE MARYLAND COMMISSION ON CLIMATE CHANGE'S RECOMMENDED GOALS OF REDUCING GREENHOUSE GAS EMISSIONS BY 10% FROM 2006 LEVELS BY 2012 AND BY 15% FROM 2006 LEVELS BY 2015;

(7) WHILE REDUCTIONS OF HARMFUL GREENHOUSE GAS EMISSIONS ARE ONE PART OF THE SOLUTION, THE STATE SHOULD FOCUS ON DEVELOPING AND UTILIZING CLEAN ENERGIES THAT PROVIDE GREATER ENERGY EFFICIENCY AND CONSERVATION, SUCH AS RENEWABLE ENERGY FROM WIND, SOLAR, GEOTHERMAL, AND BIOENERGY SOURCES;

(8) IT IS NECESSARY TO PROTECT THE PUBLIC HEALTH, ECONOMIC WELL–BEING, AND NATURAL TREASURES OF THE STATE BY REDUCING HARMFUL AIR POLLUTANTS SUCH AS GREENHOUSE GAS EMISSIONS BY USING PRACTICAL SOLUTIONS THAT ARE ALREADY AT THE STATE'S DISPOSAL;

(9) CAP AND TRADE REGULATION OF GREENHOUSE GAS EMISSIONS IS MOST EFFECTIVE WHEN IMPLEMENTED ON A FEDERAL LEVEL;

(10) BECAUSE OF THE NEED TO REMAIN COMPETITIVE WITH MANUFACTURERS LOCATED IN OTHER STATES OR COUNTRIES AND TO PRESERVE EXISTING MANUFACTURING JOBS IN THE STATE, GREENHOUSE GAS EMISSIONS FROM THE MANUFACTURING SECTOR ARE MOST EFFECTIVELY REGULATED ON A NATIONAL AND INTERNATIONAL LEVEL; AND

(11) BECAUSE OF THE NEED TO REMAIN COMPETITIVE WITH OTHER STATES, GREENHOUSE GAS EMISSIONS FROM CERTAIN OTHER COMMERCIAL AND SERVICE SECTORS, INCLUDING FREIGHT CARRIERS AND GENERATORS OF ELECTRICITY, ARE MOST EFFECTIVELY REGULATED ON A NATIONAL LEVEL.

2–1202.

(A) IN THIS SUBTITLE THE FOLLOWING WORDS HAVE THE MEANINGS INDICATED.

(B) "ALTERNATIVE COMPLIANCE MECHANISM" MEANS AN ACTION AUTHORIZED BY REGULATIONS ADOPTED BY THE DEPARTMENT THAT ACHIEVES THE EQUIVALENT REDUCTION OF GREENHOUSE GAS EMISSIONS OVER THE SAME PERIOD AS A DIRECT EMISSIONS REDUCTION.

(C) "CARBON DIOXIDE EQUIVALENT" MEANS THE MEASUREMENT OF A GIVEN WEIGHT OF A GREENHOUSE GAS THAT HAS THE SAME GLOBAL WARMING POTENTIAL, MEASURED OVER A SPECIFIED PERIOD OF TIME, AS ONE METRIC TON OF CARBON DIOXIDE.

(D) "DIRECT EMISSIONS REDUCTION" MEANS A REDUCTION OF GREENHOUSE GAS EMISSIONS FROM A GREENHOUSE GAS EMISSIONS SOURCE.

(E) "GREENHOUSE GAS" INCLUDES CARBON DIOXIDE, METHANE, NITROUS OXIDE, HYDROFLUOROCARBONS, PERFLUOROCARBONS, AND SULFUR HEXAFLUORIDE.

(F) "GREENHOUSE GAS EMISSIONS SOURCE" MEANS A SOURCE OR CATEGORY OF SOURCES OF GREENHOUSE GAS EMISSIONS THAT HAVE EMISSIONS OF GREENHOUSE GASES THAT ARE SUBJECT TO REPORTING REQUIREMENTS OR OTHER PROVISIONS OF THIS SUBTITLE, AS DETERMINED BY THE DEPARTMENT.

(G) "LEAKAGE" MEANS A REDUCTION IN GREENHOUSE GAS EMISSIONS WITHIN THE STATE THAT IS OFFSET BY A CORRESPONDING INCREASE IN GREENHOUSE GAS EMISSIONS FROM A GREENHOUSE GAS EMISSIONS SOURCE LOCATED OUTSIDE THE STATE THAT IS NOT SUBJECT TO A SIMILAR STATE, INTERSTATE, OR REGIONAL GREENHOUSE GAS EMISSIONS CAP OR LIMITATION.

(H) (1) "MANUFACTURING" MEANS THE PROCESS OF SUBSTANTIALLY TRANSFORMING, OR A SUBSTANTIAL STEP IN THE PROCESS OF SUBSTANTIALLY TRANSFORMING, TANGIBLE PERSONAL PROPERTY INTO A NEW AND DIFFERENT ARTICLE OF TANGIBLE PERSONAL PROPERTY BY THE USE OF LABOR OR MACHINERY.

(2) "MANUFACTURING", WHEN PERFORMED BY COMPANIES PRIMARILY ENGAGED IN THE ACTIVITIES DESCRIBED IN PARAGRAPH (1) OF THIS SUBSECTION, INCLUDES:
(I) THE OPERATION OF SAW MILLS, GRAIN MILLS, OR FEED MILLS;
(II) THE OPERATION OF MACHINERY AND EQUIPMENT USED TO EXTRACT AND PROCESS MINERALS, METALS, OR EARTHEN MATERIALS OR BY–PRODUCTS THAT RESULT FROM THE EXTRACTING OR PROCESSING; AND
(III) RESEARCH AND DEVELOPMENT ACTIVITIES.

(3) "MANUFACTURING" DOES NOT INCLUDE:
(I) ACTIVITIES THAT ARE PRIMARILY A SERVICE;
(II) ACTIVITIES THAT ARE INTELLECTUAL, ARTISTIC, OR CLERICAL IN NATURE;
(III) PUBLIC UTILITY SERVICES, INCLUDING GAS, ELECTRIC, WATER, AND STEAM PRODUCTION SERVICES; OR
(IV) ANY OTHER ACTIVITY THAT WOULD NOT COMMONLY BE CONSIDERED AS MANUFACTURING.

(I) "STATEWIDE GREENHOUSE GAS EMISSIONS" MEANS THE TOTAL ANNUAL EMISSIONS OF GREENHOUSE GASES IN THE STATE, MEASURED IN METRIC TONS OF CARBON DIOXIDE EQUIVALENTS, INCLUDING ALL EMISSIONS OF GREENHOUSE GASES FROM THE GENERATION OF ELECTRICITY DELIVERED TO AND CONSUMED IN THE STATE, AND LINE LOSSES FROM THE TRANSMISSION AND DISTRIBUTION OF ELECTRICITY, WHETHER THE ELECTRICITY IS GENERATED IN–STATE OR IMPORTED.

2–1203.
(A) ON OR BEFORE JUNE 1, 2011, THE DEPARTMENT SHALL PUBLISH:
(1) AN INVENTORY OF STATEWIDE GREENHOUSE GAS EMISSIONS FOR CALENDAR YEAR 2006; AND
(2) BASED ON EXISTING GREENHOUSE GAS EMISSIONS CONTROL MEASURES, A PROJECTED "BUSINESS AS USUAL" INVENTORY FOR CALENDAR YEAR 2020.

(B) THE DEPARTMENT SHALL REVIEW AND PUBLISH AN UPDATED STATEWIDE GREENHOUSE GAS EMISSIONS INVENTORY FOR CALENDAR YEAR 2011 AND FOR EVERY THIRD CALENDAR YEAR THEREAFTER.

SECTION 2. AND BE IT FURTHER ENACTED, That the Laws of Maryland read as follows:

2–1204.

THE STATE SHALL REDUCE STATEWIDE GREENHOUSE GAS EMISSIONS BY 25% FROM 2006 LEVELS BY 2020.

SECTION 3. AND BE IT FURTHER ENACTED, That the Laws of Maryland read as follows:

2–1205.

(A) THE STATE SHALL DEVELOP A PLAN, ADOPT REGULATIONS, AND IMPLEMENT PROGRAMS THAT REDUCE STATEWIDE GREENHOUSE GAS EMISSIONS IN ACCORDANCE WITH THIS SUBTITLE.

(B) ON OR BEFORE DECEMBER 31, 2011, THE DEPARTMENT SHALL:
(1) SUBMIT A PROPOSED PLAN TO THE GOVERNOR AND GENERAL ASSEMBLY;
(2) MAKE THE PROPOSED PLAN AVAILABLE TO THE PUBLIC; AND
(3) CONVENE A SERIES OF PUBLIC WORKSHOPS TO PROVIDE INTERESTED PARTIES WITH AN OPPORTUNITY TO COMMENT ON THE PROPOSED PLAN.

(C) (1) THE DEPARTMENT SHALL, ON OR BEFORE DECEMBER 31, 2012, ADOPT A FINAL PLAN THAT REDUCES STATEWIDE GREENHOUSE GAS EMISSIONS BY 25% FROM 2006 LEVELS BY 2020.

(2) THE PLAN SHALL BE DEVELOPED AS THE INITIAL STATE ACTION IN RECOGNITION OF THE FINDING BY THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE THAT DEVELOPED COUNTRIES WILL NEED TO REDUCE GREENHOUSE GAS EMISSIONS BY BETWEEN 80% AND 95% FROM 1990 LEVELS BY 2050.

(D) THE FINAL PLAN REQUIRED UNDER SUBSECTION (C) OF THIS SECTION SHALL INCLUDE:
(1) ADOPTED REGULATIONS THAT IMPLEMENT ALL PLAN MEASURES FOR WHICH STATE AGENCIES HAVE EXISTING STATUTORY AUTHORITY; AND
(2) A SUMMARY OF ANY NEW LEGISLATIVE AUTHORITY NEEDED TO FULLY IMPLEMENT THE PLAN AND A TIMELINE FOR SEEKING LEGISLATIVE AUTHORITY.

(E) IN DEVELOPING AND ADOPTING A FINAL PLAN TO REDUCE STATEWIDE GREENHOUSE GAS EMISSIONS, THE DEPARTMENT SHALL CONSULT WITH STATE AND LOCAL AGENCIES AS APPROPRIATE.

(F) (1) UNLESS REQUIRED BY FEDERAL LAW OR REGULATIONS OR EXISTING STATE LAW, REGULATIONS ADOPTED BY STATE AGENCIES TO IMPLEMENT THE FINAL PLAN MAY NOT:
(I) REQUIRE GREENHOUSE GAS EMISSIONS REDUCTIONS FROM THE STATE'S MANUFACTURING SECTOR; OR
(II) CAUSE A SIGNIFICANT INCREASE IN COSTS TO THE STATE'S MANUFACTURING SECTOR.

(2) PARAGRAPH (1) OF THIS SUBSECTION MAY NOT BE CONSTRUED TO EXEMPT GREENHOUSE GAS EMISSIONS SOURCES IN THE STATE'S MANUFACTURING SECTOR FROM THE OBLIGATION TO COMPLY WITH:
(I) GREENHOUSE GAS EMISSIONS MONITORING, RECORDKEEPING, AND REPORTING REQUIREMENTS FOR WHICH THE DEPARTMENT HAD EXISTING AUTHORITY UNDER § 2–301(A) OF THIS TITLE ON OR BEFORE OCTOBER 1, 2009; OR
(II) GREENHOUSE GAS EMISSIONS REDUCTIONS REQUIRED OF THE MANUFACTURING SECTOR AS A RESULT OF THE STATE'S IMPLEMENTATION OF THE REGIONAL GREENHOUSE GAS INITIATIVE.

(G) A REGULATION ADOPTED BY A STATE AGENCY FOR THE PURPOSE OF REDUCING GREENHOUSE GAS EMISSIONS IN ACCORDANCE WITH THIS SECTION MAY NOT BE CONSTRUED TO RESULT IN A SIGNIFICANT INCREASE IN COSTS TO THE STATE'S MANUFACTURING SECTOR UNLESS THE SOURCE WOULD NOT INCUR THE COST INCREASE BUT FOR THE NEW REGULATION.

2–1206.
IN DEVELOPING AND IMPLEMENTING THE PLAN REQUIRED BY § 2–1205 OF THIS SUBTITLE, THE DEPARTMENT SHALL:
(1) ANALYZE THE FEASIBILITY OF MEASURES TO COMPLY WITH THE GREENHOUSE GAS EMISSIONS REDUCTIONS REQUIRED BY THIS SUBTITLE;

(2) CONSIDER THE IMPACT ON RURAL COMMUNITIES OF ANY TRANSPORTATION RELATED MEASURES PROPOSED IN THE PLAN;

(3) PROVIDE THAT A GREENHOUSE GAS EMISSIONS SOURCE THAT VOLUNTARILY REDUCES ITS GREENHOUSE GAS EMISSIONS BEFORE THE IMPLEMENTATION OF THIS SUBTITLE SHALL RECEIVE APPROPRIATE CREDIT FOR ITS EARLY VOLUNTARY ACTIONS;

(4) PROVIDE FOR THE USE OF OFFSET CREDITS GENERATED BY ALTERNATIVE COMPLIANCE MECHANISMS EXECUTED WITHIN THE STATE, INCLUDING CARBON SEQUESTRATION PROJECTS, TO ACHIEVE COMPLIANCE WITH GREENHOUSE GAS EMISSIONS REDUCTIONS REQUIRED BY THIS SUBTITLE;

(5) ENSURE THAT THE PLAN DOES NOT DECREASE THE LIKELIHOOD OF RELIABLE AND AFFORDABLE ELECTRICAL SERVICE AND STATEWIDE FUEL SUPPLIES; AND

(6) CONSIDER WHETHER THE MEASURES WOULD RESULT IN AN INCREASE IN ELECTRICITY COSTS TO CONSUMERS IN THE STATE;

(7) CONSIDER THE IMPACT OF THE PLAN ON THE ABILITY OF THE STATE TO:
(I) ATTRACT, EXPAND, AND RETAIN COMMERCIAL AVIATION SERVICES; AND
(II) CONSERVE, PROTECT, AND RETAIN AGRICULTURE; AND

(8) ENSURE THAT THE GREENHOUSE GAS EMISSIONS REDUCTION MEASURES IMPLEMENTED IN ACCORDANCE WITH THE PLAN:
(I) ARE IMPLEMENTED IN AN EFFICIENT AND COST–EFFECTIVE MANNER;
(II) DO NOT DISPROPORTIONATELY IMPACT RURAL OR LOW–INCOME, LOW– TO MODERATE–INCOME, OR MINORITY COMMUNITIES OR ANY OTHER PARTICULAR CLASS OF ELECTRICITY RATEPAYERS;
(III) MINIMIZE LEAKAGE;
(IV) ARE QUANTIFIABLE, VERIFIABLE, AND ENFORCEABLE;
(V) DIRECTLY CAUSE NO LOSS OF EXISTING JOBS IN THE MANUFACTURING SECTOR;
(VI) PRODUCE A NET ECONOMIC BENEFIT TO THE STATE'S ECONOMY AND A NET INCREASE IN JOBS IN THE STATE; AND
(VII) ENCOURAGE NEW EMPLOYMENT OPPORTUNITIES IN THE STATE RELATED TO ENERGY CONSERVATION, ALTERNATIVE ENERGY SUPPLY, AND GREENHOUSE GAS EMISSIONS REDUCTION TECHNOLOGIES.

2–1207.
(A) (1) AN INSTITUTION OF HIGHER EDUCATION IN THE STATE SHALL CONDUCT AN INDEPENDENT STUDY OF THE ECONOMIC IMPACT OF REQUIRING GREENHOUSE GAS EMISSIONS REDUCTIONS FROM THE STATE'S MANUFACTURING SECTOR.

(2) THE GOVERNOR SHALL APPOINT A TASK FORCE TO OVERSEE THE INDEPENDENT STUDY REQUIRED BY THIS SECTION.

(3) THE TASK FORCE SHALL INCLUDE REPRESENTATIVES OF:
(I) LABOR UNIONS;
(II) AFFECTED INDUSTRIES AND BUSINESSES;
(III) ENVIRONMENTAL ORGANIZATIONS; AND
(IV) LOW–INCOME AND MINORITY COMMUNITIES.

(4) TO THE EXTENT PRACTICABLE, THE MEMBERS APPOINTED TO THE TASK FORCE SHALL REPRESENT THE GEOGRAPHIC, RACIAL, AND GENDER DIVERSITY OF THE STATE.

(B) ON OR BEFORE OCTOBER 1, 2015, THE INSTITUTION OF HIGHER EDUCATION RESPONSIBLE FOR THE INDEPENDENT STUDY SHALL COMPLETE AND SUBMIT THE STUDY TO THE GOVERNOR AND, IN ACCORDANCE WITH §2–1246 OF THE STATE GOVERNMENT ARTICLE, THE GENERAL ASSEMBLY.

2–1208.

(A) A GREENHOUSE GAS EMISSIONS SOURCE IN THE STATE'S MANUFACTURING SECTOR THAT IMPLEMENTS A VOLUNTARY GREENHOUSE GAS EMISSIONS REDUCTION PLAN THAT IS APPROVED BY THE DEPARTMENT ON OR BEFORE JANUARY 1, 2012, MAY BE ELIGIBLE TO RECEIVE VOLUNTARY EARLY ACTION CREDITS UNDER ANY FUTURE STATE LAW REQUIRING GREENHOUSE GAS EMISSIONS REDUCTIONS FROM THE MANUFACTURING SECTOR.

(B) A VOLUNTARY GREENHOUSE GAS EMISSIONS REDUCTION PLAN MAY INCLUDE MEASURES TO:

(1) REDUCE ENERGY USE AND INCREASE PROCESS EFFICIENCY; AND

(2) FACILITATE INDUSTRY–WIDE RESEARCH AND DEVELOPMENT DIRECTED TOWARD FUTURE MEASURES TO REDUCE GREENHOUSE GAS EMISSIONS.

2–1209.

(A) ON OR BEFORE OCTOBER 1, 2015, THE DEPARTMENT SHALL SUBMIT A REPORT TO THE GOVERNOR AND, IN ACCORDANCE WITH § 2–1246 OF THE STATE GOVERNMENT ARTICLE, THE GENERAL ASSEMBLY THAT INCLUDES:

(1) A SUMMARY OF THE STATE'S PROGRESS TOWARD ACHIEVING THE 2020 EMISSIONS REDUCTION REQUIRED BY THE PLAN UNDER § 2–1205 OF THIS SUBTITLE;

(2) AN UPDATE ON EMERGING TECHNOLOGIES TO REDUCE GREENHOUSE GAS EMISSIONS;

(3) A REVIEW OF THE BEST AVAILABLE SCIENCE, INCLUDING UPDATES BY THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, REGARDING THE LEVEL AND PACE OF GREENHOUSE GAS EMISSIONS REDUCTIONS AND SEQUESTRATION NEEDED TO AVOID DANGEROUS ANTHROPOGENIC CHANGES TO THE EARTH'S CLIMATE SYSTEM;

(4) RECOMMENDATIONS ON THE NEED FOR SCIENCE–BASED ADJUSTMENTS TO THE REQUIREMENT TO REDUCE STATEWIDE GREENHOUSE GAS EMISSIONS BY 25% BY 2020;

(5) A SUMMARY OF ADDITIONAL OR REVISED REGULATIONS, CONTROL PROGRAMS, OR INCENTIVES THAT ARE NECESSARY TO ACHIEVE THE 25% REDUCTION IN STATEWIDE GREENHOUSE GAS EMISSIONS REQUIRED UNDER THIS SUBTITLE, OR A REVISED REDUCTION RECOMMENDED IN ACCORDANCE WITH ITEM (4) OF THIS SUBSECTION;

(6) THE STATUS OF ANY FEDERAL PROGRAM TO REDUCE GREENHOUSE GAS EMISSIONS AND ANY TRANSITION BY THE STATE FROM ITS PARTICIPATION IN THE REGIONAL GREENHOUSE GAS INITIATIVE TO A COMPARABLE FEDERAL CAP AND TRADE PROGRAM; AND

(7) AN ANALYSIS OF THE OVERALL ECONOMIC COSTS AND BENEFITS TO THE STATE'S ECONOMY, ENVIRONMENT, AND PUBLIC HEALTH OF A CONTINUATION OR MODIFICATION OF THE REQUIREMENT TO ACHIEVE A REDUCTION OF 25% IN STATEWIDE GREENHOUSE GAS EMISSIONS BY 2020, INCLUDING REDUCTIONS IN OTHER AIR POLLUTANTS, DIVERSIFICATION OF ENERGY SOURCES, THE IMPACT ON EXISTING JOBS, THE CREATION OF NEW JOBS, AND EXPANSION OF THE STATE'S LOW CARBON ECONOMY.

(B) THE REPORT REQUIRED UNDER SUBSECTION (A) OF THIS SECTION SHALL BE SUBJECT TO A PUBLIC COMMENT AND HEARING PROCESS CONDUCTED BY THE DEPARTMENT.

2–1210.

ON REVIEW OF THE STUDY REQUIRED UNDER § 2–1207 OF THIS SUBTITLE, AND THE REPORT REQUIRED UNDER § 2–1209 OF THIS SUBTITLE, THE GENERAL ASSEMBLY MAY ACT TO MAINTAIN, REVISE, OR ELIMINATE THE 25% GREENHOUSE GAS EMISSIONS REDUCTION REQUIRED UNDER THIS SUBTITLE.

2–1211.

THE DEPARTMENT SHALL MONITOR IMPLEMENTATION OF THE PLAN REQUIRED UNDER § 2–1205 OF THIS SUBTITLE AND SHALL SUBMIT A REPORT, ON OR BEFORE OCTOBER 1, 2020, AND EVERY 5 YEARS THEREAFTER, TO THE GOVERNOR AND, IN ACCORDANCE WITH § 2–1246 OF THE STATE GOVERNMENT ARTICLE, THE GENERAL ASSEMBLY THAT DESCRIBES THE STATE'S PROGRESS TOWARD ACHIEVING:

(1) THE REDUCTION IN GREENHOUSE GAS EMISSIONS REQUIRED UNDER THIS SUBTITLE, OR ANY REVISIONS CONDUCTED IN ACCORDANCE WITH §2–1210 OF THIS SUBTITLE; AND

(2) THE GREENHOUSE GAS EMISSIONS REDUCTIONS NEEDED BY 2050 IN ORDER TO AVOID DANGEROUS ANTHROPOGENIC CHANGES TO THE EARTH'S CLIMATE SYSTEM, BASED ON THE PREDOMINANT VIEW OF THE SCIENTIFIC COMMUNITY AT THE TIME OF THE LATEST REPORT.

SECTION 4. AND BE IT FURTHER ENACTED, That during the process outlined in § 2–1205(a) of the Environment Article, as enacted by Section 3 of this Act, the Department of the Environment shall include the Department of Agriculture, the Maryland Farm Bureau, the Maryland Association of Soil Conservation Districts, the Delmarva Poultry Industry, the Maryland Dairy Industry Association, and the Maryland Agricultural Commission in discussions on the role to be played by agriculture to reduce greenhouse gas emissions.

SECTION 4. 5. AND BE IT FURTHER ENACTED, That if any provision of this Act or the application thereof to any person or circumstance is held invalid for any reason in a court of competent jurisdiction, the invalidity does not affect other provisions or any other application of this Act which can be given effect without the invalid provision or application, and for this purpose the provisions of this Act are declared severable.

SECTION 5. 6. AND BE IT FURTHER ENACTED, That any reference in the Annotated Code of Maryland rendered incorrect or obsolete by the provisions of Section 6 of this Act shall be corrected by the publishers of the Annotated Code, in consultation with and subject to the approval of the Department of Legislative Services, with no further action required by the General Assembly.

SECTION 6. 7. AND BE IT FURTHER ENACTED, That Section 2 of this Act shall take effect October 1, 2009. It shall remain effective for a period of 7 years and 3 months, and at the end of December 31, 2016, with no further action required by the General Assembly, Section 2 of this Act shall be abrogated and of no further force and effect.

SECTION 7. 8. AND BE IT FURTHER ENACTED, That, except as provided in Section 6 7 of this Act, this Act shall take effect October 1, 2009.

Approved by the Governor, May 7, 2009.

Final Report

Analysis of Greenhouse Gas Emission Reductions

June 22, 2011




Prepared for: Maryland Department of the Environment
By: Science Applications International Corporation
Project Number: EN-001-102-003

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ABBREVIATIONS AND ACRONYMS

ACEEE	American Council for an Energy-Efficient Economy
AFW	Agriculture, Forestry & Waste
AP-42	EPA Compilation of Air Pollutant Emission Factors
BAU	Business as Usual
CAMD	Environmental Protection Agency Clean Air Markets Division
CAP	2008 Maryland Climate Action Plan
CEMS	Continuous Emission Monitoring System
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalent
DNR	[Maryland] Department of Natural Resources
eGRID	Emissions & Generation Resource Integrated Database
EGUs	Electricity Generating Units
EIA	Energy Information Administration
EPA	United States Environmental Protection Agency
ES	Energy Supply
GHG	Greenhouse Gas
GWP	Global Warming Potential
MANE-VU	Mid-Atlantic/Northeast Visibility Union
DHCD	Maryland Department of Housing and Community Development
N_20	Nitrous Oxide
NAAQS	National Ambient Air Quality Standards
NO_X	Nitrogen Oxide
RCI	Residential, Commercial, Industrial
REC	Renewable Electricity Certificate
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Portfolio Standard
SO_2	Sulfur Dioxide
TLU	Transportation & Land Use
USDA	United States Department of Agriculture

UNITS OF MEASURE

CO_2e	Carbon Dioxide Equivalent
DBH	Diameter at Breast Height
GWh	Gigawatt Hour
kWh	Kilowatt Hour
MMBTU	Million British Thermal Units
$MMTCO_2e$	Million Metric Tons of Carbon Dioxide Equivalent
MWh	Megawatt Hour
tCO_2e	Metric Tons Carbon Dioxide Equivalent
VEH-H	Vehicle-hour
VMT	Vehicle Miles Traveled
WASD	Weighted Average Source Distance

EXECUTIVE SUMMARY

Introduction and Project Overview

In April of 2007, Governor Martin O'Malley established the Maryland Commission on Climate Change (Commission) through Executive Order 01.01.2007.07. The Order charged the Commission with developing a Climate Action Plan (CAP) to discuss the drivers and consequences of climate change, to outline necessary preparations for its ensuing impacts on the State, and to establish firm benchmarks and timetables for policy implementation. The Maryland CAP was completed in 2008. The CAP consists of a variety of climate policies designed to reduce the state's greenhouse gas (GHG) emissions in from different sectors and emission sources. Shortly thereafter, the Greenhouse Gas Emissions Reduction Act of 2009 (GGRA) codified Maryland's GHG reduction goal of 25 percent by 2020 from a 2006 baseline into state law.

In 2010, the Maryland Department of the Environment (MDE) hired Science Applications International (SAIC) to review, evaluate and update the 32 quantifiable climate policies[1] that comprise the 2008 Maryland CAP to help determine the State's progress toward meeting the GGRA goal. The CAP contains the following four groups of quantifiable climate policies:

- Residential, Commercial, and Industrial Policies (RCI)
- Energy Supply (ES)
- Agriculture, Forestry, and Waste (AFW)
- Transportation and Land Use (TLU)

After discussing interrelated aspects of various policies, MDE aggregated several policies and asked SAIC to review and evaluate 22 distinct CAP policies. SAIC reviewed and evaluated the policies by taking the following actions:

1) **Policy Documentation and Analysis**: SAIC reviewed and documented 14 existing GHG policies. SAIC also added its own analysis and recommendations for improving the accuracy of measuring and tracking GHG emission reduction progress toward the goals of these policies.
2) **Policy Re-quantification**: SAIC re-modeled or re-quantified the projected GHG emission reductions in 2012, 2015, and 2020 for 8 climate policies. SAIC based its re-quantification of emissions on updated science and methodologies, new tools, and or current implementation trends. SAIC transparently documented its methodology, data sources, and assumptions for these revised GHG emission reduction projections.
3) **Air Quality Co-benefit Quantification**: SAIC quantified the air quality co-benefits in 2012, 2015, and 2020 associated with the 22 climate policies. This entailed quantifying the criteria

[1] This excludes the ten "cross cutting" policies within the 2008 Maryland CAP.

pollutant impacts of 18 of the 22 climate policies – 4 policies did not have quantifiable air quality co-benefits.

4) **Water Quality Co-Benefit Quantification:** SAIC quantified the water quality co-benefits of the 22 policies in 2012, 2015, and 2020. Specifically, SAIC modeled the impact to nitrogen deposition to the Chesapeake Bay as a result of implementing the 22 climate policies.

5) **Policy Overlap Analysis:** SAIC conducted a climate policy overlap analysis that assessed the interactions between the climate policies. In other words, this policy overlap analysis removes any "double counting" of emissions. The overlap analysis was limited to the 8 policies that SAIC re-quantified, however, since these 8 policies were some of the most effective policies in terms of GHG emission reductions, this overlap analysis is likely takes into account most of the potential overlap amongst the policies.

Report Organization

This report summarizes the findings of SAIC's review and analysis of the 22 policies contained in Maryland's 2008 CAP. The report is organized into the following 6 Chapters:

- Chapter 1: Residential, Industrial, and Commercial Policies
- Chapter 2: Energy Supply Policies
- Chapter 3: Agriculture Forestry and Waste Policies
- Chapter 4: Transportation and Land Use Policies
- Chapter 5: Policy Overlap Analysis
- Chapter 6: Water Quality Co-benefits Analysis
- Appendix – Equations Used to Estimate GHG Reductions and Air Quality Co-benefits

The methodology, assumptions, findings, and analysis related to the projected GHG and criteria pollutant emission reductions for each climate policy are contained in sub-chapters within Chapters 1 through 4. In these sub-chapters, the effect of each policy on GHG and criteria pollutant emissions is considered independently of all other policies. In Chapter 5, double counting of emission reductions between the different policies is identified, quantified, and subtracted to yield an estimate of total emission reductions across policies. In addition, SAIC has provided MDE with the raw data and detailed technical inputs for each of the 22 policies in a separate series of supporting documents. The appendix provides a list, without accompanying context, of all the equations used per policy.

Project Approach

GHG Emissions Review and Analysis

SAIC reviewed the Original Methodology and GHG emission reduction results of 14 policies by reviewing the prior MDE contractor's reports and data files. SAIC then reconstructed and documented the GHG quantification methodologies used for each of the 14 individual policies listed in Table E.1.

Table E.1- Policies Reviewed and Analyzed

Policies Reviewed and Analyzed
Energy Supply (ES)
ES 8 - Efficiency Improvements & Repowering Existing Plants
Agriculture, Forestry & Waste (AFW)
AFW 1 - Forest Management for Enhanced Carbon Sequestration
AFW 3 - Afforestation, Reforestation & Restoration of Forests & Wetlands
AFW 4 - Protection & Conservation of Agricultural Land, Coastal Wetlands & Forested Land
AFW 5 - "Buy Local" Programs
AFW 6 - Expanded Use of Forest & Farm Feedstocks & By-Products for Energy Production
AFW 7b - In-State Liquid Biodiesel Production
AFW 8 - Nutrient Trading with Carbon Benefits
Transportation & Land Use (TLU)
TLU 2 - Land Use & Location Efficiency
TLU 3 – Transit
TLU 5 - Intercity Travel
TLU 8 - Bike & Pedestrian Infrastructure
TLU 9 - Incentives, Pricing & Resource Measures
TLU 10 - Transportation Technologies

Re-Quantification of GHG Emission Reductions

Since Maryland's 2008 CAP was completed, the dynamics affecting many of the climate policies within it have shifted or changed, and in many cases the policies themselves have significantly evolved through further definition of the specific measures comprising each policy. SAIC was tasked with remodeling the GHG reduction estimates for a select number of policies in order to improve the accuracy of the GHG reduction estimates. The approach to recalculating the GHG reduction estimates varied depending on the policy, although our general approach was to estimate emission reductions in each forecast year (2012, 2015, and 2020) as the difference between emissions with and without the policy in that forecast year. Thus expected "business-as-usual" (BAU) developments, such as the general trend towards cleaner sources of electricity generation (e.g., natural gas), are captured over the forecast horizon. The year 2006 was used as the policy baseline, in the sense that we included all regulations and policies in place in or before 2006 (such as Maryland's Healthy Air Act) in our analysis. We excluded policy/regulatory developments that occurred after 2006 (except, of course, the specific policy to be analyzed). By using this approach, MDE will be able to subtract the emission reduction estimates we projected for each year from its separately-developed BAU emission forecast (also generated using a 2006 baseline) to project GHG emission levels as a result of the implementation of the full suite of policies.

The above-described general methodological approach was tailored to meet the requirements of each individual policy. The specific factors that determined how each policy was remodeled included whether or not there were substantive changes to the focus of the policy since the release of the 2008 CAP, whether or not a more accurate methodological approach existed, and whether or not updated data sets existed. Table E.2 summarizes the policies that SAIC re–quantified and the basis for the re-quantification.

It should be noted that a number of the policies include GHG emission reductions resulting from the decreased consumption of electricity. Because Maryland imports approximately 30 percent of its electricity from electric generating plants outside Maryland, policies that reduce the State's electricity consumption impact emissions both within and beyond the State's boundaries. We have included both the in-state and out-of state emission reductions in our reduction projections. Within the detailed policy analyses presented in Chapters 1 through 4, we have also broken down the in-state and out-of-state reductions separately.

The individual policy descriptions provide more detail on the specifics of how each policy was recalculated.

Table E.2- SAIC Re-Quantified Policies (All Emission Reduction Estimates Are Presented Prior to Adjustment for Overlaps Between the Policies)

Policy Number	Policy Option	Basis for Re-Quantification	Original 2020 Results ($MMTCO_2e$)	Re-Estimated 2020 Results ($MMTCO_2e$)	Difference ($MMtCO_2e$)
RCI-1	Improved Building and Trade Codes	Updated Data	2.4	5.4	3.0
RCI-4	Government Lead-By-Example	Narrowing of Policy Focus, Methodology Revision	1.3	0.2	(1.1)
RCI-10	EmPOWER Maryland*	Narrowing of Policy Focus, Methodology Revision	11.9	5.4	(6.5)
ES-3	Greenhouse Gas (GHG) Cap-and-Trade	Updated Data, Methodology Revision	16.96	12.3	(4.66)
ES-7	Renewable Portfolio Standard (RPS)**	Methodology Revision	13.8	3.0	(10.8)
AFW-2	Managing Urban Trees and Forests for GHG Benefits	Methodology Revision	1.9	1.3	(0.6)
AFW-9	Waste Management through Source Reduction (SR) and Advanced Recycling	Updated Data	29.27	6.0	(23.27)
TLU-6	Pay-As-You-Drive (PAYD) Insurance	Revised Assumptions	3.4	0.03	(3.37)

* New policy subsumes RCI 2, 3, 7, 10, and 11 from original analysis. Original Results are the sum of those policies
**New policy subsumes ES 1, 2, 5, and 7 from original analysis. Original results are the sum of those policies.

Air Quality Co-benefits Analysis

Based on the GHG emission reductions predicted by MDE's prior contractor, SAIC assessed the air quality benefits of all 22 policies and quantified the air quality co-benefits for 18 of the 22 policies as described in Table E.3 below. The remaining 4 policies did not produce any air quality co-benefits.

Table E.3- Air Quality Co-benefits Analysis

	Air Quality Co-benefits
Residential, Commercial & Industrial (RCI)	
RCI 1 - Improved Building & Trade Codes	Yes
RCI 4 - Improved Design, Construction, Appliances & Lighting	Yes
RCI 10 - EmPOWER Maryland	Yes
Energy Supply (ES)	
ES 3 - GHG Cap-and-Trade	Yes
ES 7 - Renewable Portfolio Standard	Yes
ES 8 - Efficiency Improvements & Repowering Existing Plants	Yes
Agriculture, Forestry & Waste (AFW)	
AFW 1 - Forest Management for Enhanced Carbon Sequestration	No
AFW 2 - Managing Urban Trees & Forests	Yes
AFW 3 - Afforestation, Reforestation & Restoration of Forests & Wetlands	Yes
AFW 4 - Protection & Conservation of Agricultural Land, Coastal Wetlands & Forested Land	Yes
AFW 5 - "Buy Local" Programs	Yes
AFW 6 - Expanded Use of Forest & Farm Feedstocks & By-Products for Energy Production	No
AFW 7b - In-State Liquid Biodiesel Production	Yes
AFW 8 - Nutrient Trading with Carbon Benefits	No
AFW 9 - Waste Management & Advanced Recycling	Yes
Transportation & Land Use (TLU)	
TLU 2 - Land Use & Location Efficiency	Yes
TLU 3 – Transit	Yes
TLU 5 - Intercity Travel	Yes
TLU 6 - Pay-As-You-Drive Insurance	Yes
TLU 8 - Bike & Pedestrian Infrastructure	Yes
TLU 9 - Incentives, Pricing & Resource Measures	Yes
TLU 10 - Transportation Technologies	No

Policy Overlap Analysis

SAIC treated each policy independently of all others when developing the GHG emissions reduction estimates summarized in Table E.2. Similarly, the air quality co-benefit estimates for the policies listed in Table E.3 were developed by treating each policy separately. Thus both the GHG and air quality estimates for a given policy represent the emission reductions that can be expected to occur if the policy is implemented *by itself*.

However if, as is the State of Maryland's intent, the various policies are implemented together, the resulting total emission reductions will *not* equal the sum of the reductions estimated for each policy. Rather, the various policies will interact with each other such that their combined impact on emissions will not equal the sum of their individual impacts. In some cases (particularly in the energy supply and residential, commercial and industrial sectors) the various policies compete with each other, and hence their combined impact is less than the sum of their individual impacts. In other cases (particularly in the transportation and land use sector), policies may interact synergistically as well as competitively, with the result that their combine impact may be greater than their sum of their individual impacts.

Therefore SAIC conducted an "overlap analysis" in order to assess, both qualitatively and quantitatively, the interrelationships between policies and their combined impact on GHG emissions and air quality co-benefits. In the case of GHG emissions, the overlap analysis focused on the eight policies SAIC re-estimated, as listed in Table E.2. In the case of the three AFW and TLU policies (AFW-2, Urban Trees; AFW-9, Waste Management; and TLU-6, PAYD Insurance), SAIC concluded that there were no significant overlaps or synergies. However, significant overlaps were identified and quantified in the case of the five RCI and ES policies (RCI-1, Improved Building and Trade Codes; RCI-4, Government Lead-By-Example; RCI-10, EmPOWER Maryland; ES-3, GHG Cap and Trade; and ES-7, Renewable Portfolio Standard (RPS)). The overlaps, or double counting, between these five policies occur mainly as a result of the two policies (RCI-10 and ES-3) that specify emission reduction goals *without* specifying the methods to be used to achieve those goals. These two policies in effect allow market forces to determine the specific methods that will be used to meet the goals. To the extent that the policies that *do* specify the methods to be used to meet their goals (RCI-1, RCI-4, and ES-7) may help meet the numeric goals of the market-based policies, the impact of the former "method-specific" policies on emissions may in effect be subsumed under the latter market-based policies. Consider, for example, the interactions between ES-3 (GHG Cap and Trade) and ES-7 (RPS). ES-3 sets a quantitative limit on emissions but without specifying how the market must meet that limit. When such a policy is combined with the RPS policy, which specifies explicit targets for the market penetration of renewables, then meeting the explicit RPS targets will also help the market to meet the emissions cap. Since there are no constraints specifying how the cap is to be met, the emission reductions caused by the RPS will count towards meeting the cap. In such a situation, the GHG impacts of the RPS are effectively subsumed under the cap-and-trade policy.

By dividing the GHG emission reductions estimated for each RCI and ES policy into three components (in-State electricity sector reductions, out-of-state electricity sector reductions, and reductions from direct combustion of fossil fuels in the RCI sector), and then carefully identifying overlaps within each component, SAIC quantified the extent of the overlap between the RCI and ES policies. The results of this quantitative analysis are summarized in Section 4 below.

Water Quality Co-benefits Analysis

Two types of models are required to estimate the quantity of atmospheric nitrogen that is transported to the Chesapeake Bay. One model is required to estimate the atmospheric transport, dispersion, transformation, and deposition of nitrogen species; and a second is required to estimate the delivery of deposited nitrogen to the Bay. The CALPUFF and SPARROW models were selected for this analysis because they have been used by the Maryland Department of Natural Resources and other agencies to analyze nitrogen load reductions, and have provided results that are consistent with other established modeling approaches, such as the Chesapeake Bay Program HSPF (Hydrologic Simulation Program - Fortran) watershed model. A brief description of the two models used in this analysis is as follows:

CALPUFF – This model simulates the effects of time- and space-varying meteorological conditions and pollutant transport, transformation, and removal. It uses surface, upper air, and precipitation observations as recorded at National Weather Service stations; and nitrogen oxide (NO_X) emissions obtained from the U.S. Environmental Protection Agency's (EPA) National Emissions Trends inventory (NEI). CALPUFF predicts monthly average deposition flux rates (wet and dry).

SPARROW (SPAtially Referenced Regressions on Watershed) - This hydrologic flow and nutrient transport model is used to estimate the nitrogen delivery to the Bay by simulating the migration of nitrogen over the land surface and within the stream system. It uses nutrient and land-characteristic parameters as input data. Further details of this analysis are discussed in Chapter 6.

Summary of Report Findings

Table E.4 summarizes the results of SAIC's quantitative analyses of GHG emissions reductions for the eight policies we re-estimated. The first column of this table presents the estimated 2020 emission reductions for the eight policies, summed to the sector level. The emission reduction totals shown in the first column have *not* been adjusted to reflect the interactions or overlaps between the different policies. The second column of the table presents SAIC's estimates of the overlap within each sector. Finally, the last column of the table subtracts the estimated overlaps from the unadjusted emission reduction estimates shown in the first column, to yield estimates of the actual emission reductions that would occur if all eight policies were to be implemented.

Table E.4. Summary of Overlap Estimates, and Unadjusted and Adjusted GHG Emission Reductions, Across All Sectors in 2020

Sector	Unadjusted Total Reductions in 2020 ($MMTCO_2e$)	2020 Overlap Estimate ($MMTCO_2e$)	Adjusted Total Reductions in 2020 ($MMtCO_2e$)
RCI	11.00	4.11	6.89
ES	15.30	3.04	12.26
RCI & ES	26.30	10.75	15.55
AFW	7.29*	0.00	7.29*
TLU	0.03	0.00	0.03
Grand Total	**33.62**	**10.75**	**22.87**

*Includes 1.32 $MMTCO_2e$ of carbon sequestration.

As Table E.4 indicates, overlap between the different policies is limited to the five RCI and ES policies; the three AFW and TLU policies do not have significant overlaps. Overlap accounts for 36 percent of the unadjusted GHG reductions (i.e., 4.11 out of 11.00 million metric tons carbon dioxide equivalent ($MMTCO_2e$)) in the RCI sector alone, and 20 percent of the unadjusted reductions (3.04 out of 15.30 $MMTCO_2e$) in the ES sector. Because a significant amount of overlap occurs not only *within* but acrossthe RCI and ES sectors, the estimated overlap for the RCI & ES sectors combined (see third row of Table E.4) exceeds the sum of the overlap for each sector considered separately. Overlap accounts for 41 percent of the unadjusted reductions (10.75 out of 26.3 $MMTCO_2e$) in the RCI and ES sectors combined. Across all four sectors (RCI, ES, AFW and TLU), overlap between the policies represents 32 percent (10.75 out of 33.62 $MMTCO_2e$) of the total unadjusted reductions. Taking this overlap into account, SAIC estimates the total GHG reductions that would result from the implementation of all eight policies as 22.87 $MMTCO_2e$ in 2020. The five RCI and ES policies account for 68.0 percent of this total; the two AFW policies contribute 31.9 percent; and the single TLU policy accounts for the remaining 0.1 percent of the total reductions.

The GHG emission reductions associated with the 22 policies that SAIC evaluated are summarized by policy category in Table E.5 below. In addition to providing the unadjusted sums of the emission reductions for each sector and for all 22 policies, this table also provides sector and grand totals adjusted for overlaps in the RCI and ES sectors, as estimated by SAIC and presented in Table E.4.

Table E.5. Summary of GHG Emission Reductions in 2020

Sector/Policy	2020 GHG Emission Reductions ($MMTCO_2e$)
Residential, Commercial and Industrial (RCI)	
RCI-1: Improved Building and Trade Codes	5.40
RCI-4: Government Lead-By-Example	0.20
RCI-10: EmPOWER Maryland	5.40
RCI Unadjusted Total	**11.00**
RCI Total Adjusted for Overlap	**6.89**
Energy Supply (ES)	
ES-3: GHG Cap and Trade	12.26
ES-7: Renewable Portfolio Standard	3.04
ES-8: Efficiency Improvements & Repowering Existing Plants	4.90
ES Unadjusted Total	**20.20**
ES Total Adjusted for Overlap	**12.26**
Agriculture, Forestry & Waste (AFW)	

Sector/Policy	2020 GHG Emission Reductions (MMTCO$_2$e)
AFW-1: Forest Management for Enhanced Carbon Sequestration	0.09
AFW-2: Managing Urban Trees & Forests	1.32
AFW-3: Afforestation, Reforestation & Restoration of Forests & Wetlands	0.62
AFW-4: Protection & Conservation of Agricultural Land, Coastal Wetlands & Forested Land	26.54
AFW-5: "Buy Local" Programs	0.03
AFW-6: Expanded Use of Forest & Farm Feedstocks & By-Products for Energy Production	0.54
AFW-7b: In-State Liquid Biodiesel Production	0.17
AFW-8: Nutrient Trading with Carbon Benefits	0.14
AFW-9: Waste Management & Advanced Recycling	5.97
AFW Unadjusted Total	**34.10**
Transportation & Land Use (TLU)	
TLU-2: Land Use & Location Efficiency	0.96
TLU-3: Transit	0.45
TLU-5: Intercity Travel	0.02
TLU-6: Pay-As-You-Drive Insurance	0.03
TLU-8: Bike & Pedestrian Infrastructure	0.15
TLU-9: Incentives, Pricing & Resource Measures	1.84
TLU-10: Transportation Technologies	0.20
TLU Unadjusted Total	**3.65**
Unadjusted Grand Total	**68.95**
Grand Total Adjusted for Overlap	**53.30**

Air Quality Co-benefits Findings

Each individual policy summary contains a projection of criteria pollutant co-benefits (emission reductions) in 2012, 2015, and 2020 that will result from the policy's implementation. The quantification methodology, assumptions, data sources, and findings are explained for each policy. Table E.6 summarizes SAIC's estimates of criteria pollutant emission reductions. In addition to presenting the estimated reductions for each policy and the sum of the reductions by sector and across all sectors, Table E.6 also provides grand total emission reductions adjusted for overlaps.[2]

[2] Please note that while GHG reductions are expressed in metric tons, in keeping with standard practice in the U.S. for pollution and contaminant analyses, short tons are used in the air quality co-benefit sections of the policy chapters, the air quality section of the overlap analysis in Chapter 5, and the Chesapeake Bay co-benefits analysis in Chapter 6.

Table E.6. Summary of Criteria Pollutant Emission Reductions in 2020[3]

		SO_2 (Tons)	NO_x (Tons)	CO (Tons)	VOC (Tons)	PM10 (Tons)	PM2.5 (Tons)
	Residential, Commercial & Industrial (RCI)						
RCI-1	RCI 1 - Improved Building & Trade Codes	2,700.00	1,300.00	1,300.00	1,900.00	2,000.00	1,300.00
RCI-4	RCI 4 - Improved Design, Construction, Appliances & Lighting	19.00	30.00	34.00	3.00	27.00	24.00
RCI-10	RCI 10 - EmPOWER Maryland	590.00	200.00	340.00	49.00	780.00	680.00
	RCI Total	**3,309.00**	**1,530.00**	**1,674.00**	**1,952.00**	**2,807.00**	**2,004.00**
	Energy Supply (ES)						
ES-3	ES 3 - GHG Cap-and-Trade	17,000.00	5,700.00	220.00	45.00	2,100.00	1,900.00
ES-7	ES 7 - Renewable Portfolio Standard	510.00	-81.00	1.00	9.00	410.00	380.00
ES-8	ES 8 - Efficiency Improvements & Repowering Existing Plants	8,400.00	-2,500.00	-1,200.00	-68.00	1,000.00	870.00
	ES Total	**25,910.00**	**3,119.00**	**-979.00**	**-14.00**	**3,510.00**	**3,150.00**
	Agriculture, Forestry & Waste (AFW)						
AFW-1	AFW 1 - Forest Management for Enhanced Carbon Sequestration						
AFW-2	AFW 2 - Managing Urban Trees & Forests	300.00	450.00			2,400.00	
AFW-3	AFW 3 - Afforestation, Reforestation & Restoration of Forests & Wetlands	273.00	410.00			2,200.00	
AFW-4	AFW 4 - Protection & Conservation of Agricultural Land, Coastal Wetlands & Forested Land	523.00	784.00			4,182.00	

[3] In cases where a range of reduction estimates existed the high figure was used in this table.

		SO_2 (Tons)	NO_x (Tons)	CO (Tons)	VOC (Tons)	PM10 (Tons)	PM2.5 (Tons)
AFW-5	AFW 5 - “Buy Local” Programs	0.22	9.50	220.00	10.00	0.37	0.35
AFW-6	AFW 6 - Expanded Use of Forest & Farm Feedstocks & By-Products for Energy Production						
AFW-7b	AFW 7b - In-State Liquid Biodiesel Production	8.90	-7.60	952.00	85.00	1.50	1.40
AFW-8	AFW 8 - Nutrient Trading with Carbon Benefits						
AFW-9	AFW 9 - Waste Management & Advanced Recycling	890.00	2,200.00	290.00		131.00	
	AFW Total	**1,995.12**	**3,845.90**	**1,462.00**	**95.00**	**8,914.87**	**1.75**
	Transportation & Land Use (TLU)						
TLU-2	TLU 2 - Land Use & Location Efficiency	15.00	620.00	14,000.00	660.00	25.00	23.00
TLU-3	TLU 3 – Transit	8.70	370.00	8,500.00	397.00	15.00	14.00
TLU-5	TLU 5 - Intercity Travel	0.60	26.00	600.00	28.00	1.00	1.00
TLU-6	TLU 6 - Pay-As-You-Drive Insurance	1.00	44.00	1,000.00	47.00	1.70	1.60
TLU-8	TLU 8 - Bike & Pedestrian Infrastructure	4.60	200.00	4,500.00	210.00	7.80	7.30
TLU-9	TLU 9 - Incentives, Pricing & Resource Measures	37.00	3,300.00	43,000.00	2,500.00	140.00	74.00
TLU-10	TLU 10 - Transportation Technologies						
	TLU Total	**66.90**	**4,560.00**	**71,600.00**	**3,842.00**	**190.50**	**120.90**
	Total for all Policies	**31,281.02**	**13,054.90**	**73,757.00**	**5,875.00**	**15,422.37**	**5,276.65**
	Total Adjusted for Overlaps	**22,000.00**	**15,000.00**	**75,000.00**	**5,900.00**	**13,000.00**	**3,300.00**

Chesapeake Bay Co-benefits Findings[4]

The nitrogen load reduction to the Chesapeake Bay from select climate policies for years 2012, 2015, and 2020 was estimated using the SPARROW (**SPA**tially **R**eferenced **R**egressions on **W**atershed) spreadsheet tool. The input into the SPARROW spreadsheet consisted of total NO_X emission reductions for policies re-estimated and re-documented by SAIC, adjusted for overlap. The SPARROW modeling results therefore represent the combined benefits to the Chesapeake Bay from all of the policies.

The SPARROW modeling analysis predicts that theoverall total nitrogen load reductions to the Chesapeake Bay (from all states) will be in the range of 0.94 to 0.95 million pounds in 2012. The total nitrogen load reductions will increase to the range of 1.13 to 1.14 million pounds in 2015, and increase again to the range of 1.26 to 1.5 million pounds in 2020. For the state of Maryland, the range of nitrogen load reductions in 2012 is predicted to be between 114 to 116 thousand pounds. In 2015, the range of load reductions is predicted to increase to between 145 to 148 thousand pounds, and increase again to the range of 184 to 290 thousand pounds in 2020.

[4] As noted in footnote 3 above, short tons are used here and in the Chesapeake Bay co-benefits analysis in Chapter 6.

Chapter 1: Residential, Commercial, and Industrial (RCI) Policies

The following RCI Policies were analyzed:

- RCI-1: Improved Building & Trade Codes
- RCI-4: Improved Design, Construction, Appliances, and Lighting
- RCI-10: Energy Efficiency Resources Standard (new policy subsumes RCI-2, 3, 7, 10, and 11 from original analysis).

Summary of RCI Findings for 2020

Table 1.1 presents the 2020 GHG emission reduction estimates for the above-listed three policies. As the Table indicates, Policies RCI-1 and RCI-10 are projected to yield the vast majority of the emission reductions in the RCI sector; each of these policies accounts for 49 percent of the sum of reductions across all policies. It should be noted that there are significant overlaps in the projected emission reductions not only across the three RCI policies, but between the RCI and ES policies. These overlaps arefurther discussed and quantified in Chapter 5.

Table 1.1. Summary of GHG Emission Reductions from the RCI Policies in 2020

Sector/Policy	2020 GHG Emission Reductions (MMTCO$_2$e)
Residential, Commercial and Industrial (RCI)	
RCI-1: Improved Building and Trade Codes	5.40
RCI-4: Government Lead-By-Example	0.20
RCI-10: EmPOWER Maryland	5.40
RCI Total (Unadjusted for Overlaps)	**11.00**

Table 1.2 presents the projected 2020 reductions in criteria pollutant emissions for the three RCI policies. As this table indicates, Policy RCI-1 yields the majority of the reductions in all pollutants. As is the case for GHGs, there are significant overlaps in the criteria pollutant emissions reduction estimates; the reader is referred to Chapter 5 for a discussion and quantification of these overlaps.

Table 1.2. Summary of Criteria Pollutant Emission Reductions from the RCI Policies in 2020[5]

		SO_2 (Tons)	NO_x (Tons)	CO (Tons)	VOC (Tons)	PM10 (Tons)	PM2.5 (Tons)
	Residential, Commercial & Industrial (RCI)						
RCI-1	RCI 1 - Improved Building & Trade Codes	2,700.00	1,300.00	1,300.00	1,900.00	2,000.00	1,300.00
RCI-4	RCI 4 - Improved Design, Construction, Appliances & Lighting	19.00	30.00	34.00	3.00	27.00	24.00
RCI-10	RCI 10 - EmPOWER Maryland	590.00	200.00	340.00	49.00	780.00	680.00
	RCI Total	**3,309.00**	**1,530.00**	**1,674.00**	**1,952.00**	**2,807.00**	**2,004.00**

[5] As noted in footnote 3, in keeping with standard practice in the U.S. for pollution and contaminant analyses, short tons are used in the air quality co-benefit sections of the policy chapters.

Technical Notes

PROMOD IV Model

The RCI policies rely on the PROMOD IV Model for their results. The PROMOD *IV* Model is Fundamental Electric Market Simulation software that incorporates extensive details in generating unit operating characteristics, transmission grid topology and constraints, unit commitment/operating conditions, and market system operations. PROMOD IV algorithms can be exercised in several modes, depending upon the scope, time frame, and simulation resolution that align with the decision focus. The model can assess a variety of electric market components including:

- Locational marginal price for forecasting
- Valuation
- Transmission congestion analysis
- Environmental analysis
- Generation and transmission asset valuation
- Fuel strategy
- System reliability

More information on the PROMOD IV Model can be found on their website: http://www1.ventyx.com/analytics/promod.asp

Mid-Atlantic/Northeast Visibility Union (MANE-VU) Future Emissions Inventory

All of the air quality co-benefit analyses for the RCI policies utilize the MANE-VU Future Emissions Inventory[6]. The MANE-VU Future Emissions Inventory represents a collaborative effort among northeastern and mid-Atlantic states to develop regionally consistent emissions inventories that account for projected growth and expected emissions control measures. The inventories for 2009, 2012, and 2018 are used by the states as they develop state implementation plans to meet national ambient air quality standards and progress goals to reducing regional haze. More information on MANE-VU can be found on the following website: (http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory).

[6]http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

Policy No.: RCI-1

Policy Title: Improved Building and Trade Codes and Beyond-Code Building Design and Construction in the Private Sector

SAIC was tasked with reviewing the RCI-1 policy analysis which was conducted by a prior MDE contractor (Original Methodology) and revising the methodology to include Maryland-specific data and/or other enhancements. SAIC subsequently recalculated the GHG emission reductions associated with RCI-1based upon its recommended methodology (Revised Methodology). SAIC also quantified the air quality co-benefits associated with RCI-1. SAIC's revised policy findings are described below:

1.0. GHG EMISSION REDUCTIONS

The goal of Policy RCI-1 is to improve the energy efficiency of residential and commercial buildings by ensuring rapid adoption of new building codes published by the International Code Council (ICC). Specifically, under the statewide building code known as the Maryland Building Performance Standards (MBPS), local jurisdictions with building code authority are required to adopt the most up-to-date codes within six months of their promulgation. The new codes are issued every three years, with the most recent issuance in 2009 (the 2009 International Energy Conservation Code (IECC)). Thus new codes are expected in 2012 (2012 IECC), 2015 (2015 IECC), and 2018 (2018 IECC).

Table RCI-1.1- Projected GHG Emission Reductions Resulting from RCI-1

Emissions Category	GHG Reductions (MMTCO_2e)		
	2012	2015	2020
RCI-1 Total	**0.6**	**1.9**	**5.4**
Residential Buildings:	**0.2**	**0.6**	**1.7**
Natural Gas	0.0	0.1	0.4
Distillate Oil	0.0	0.0	0.1
Biomass	0.0	0.0	0.1
In-State Electricity	0.1	0.3	0.7
Imported Electricity	0.0	0.1	0.4
Commercial Buildings:	**0.4**	**1.3**	**3.8**
Natural Gas	0.1	0.2	0.7
Distillate Oil	0.0	0.0	0.1
Biomass	0.0	0.0	0.0
In-State Electricity	0.2	0.7	1.9
Imported Electricity	0.1	0.3	1.0

Note: Totals may not equal sum of parts due to independent rounding.

1.1. Summary of Methodology

SAIC reconstructed and reviewed the Original Methodology, and found this methodology to be mathematically sound. Therefore, although we updated and/or improved a number of the data inputs (see Section 1.3); we retained the Original Methodology as the basis for developing our revised estimates. The Original Methodology followed in this report involved four steps, as follows:

1. Based on projections of new housing starts and commercial floor space, calculate the number of new and existing residential housing units, and commercial floor space, affected by the improved building codes in each year;

2. Calculate the total energy saved in each year by the buildings affected by the code in that year (from Step 1);

3. Split the total yearly energy savings calculated in Step 2 by energy/fuel type (e.g., electricity, natural gas, distillate oil, etc.);

4. By applying appropriate carbon dioxide equivalent (CO_2e) emission factors to the energy savings estimates from Step 3 (summed between 2009 and year i), and summing across all fuel/energy types, calculate the GHG emission reductions from all buildings built of renovated to code in each projection year i (where I equals 2012, 2015, or 2020).

Each of the above steps is documented in detail in the Detailed Explanation of GHG Emission Methodology Section below.

1.2. Rationale for GHG Emission Methodology

The selected method is essentially the same as the Original Methodology. It is a straightforward calculation that is mathematically correct. Data inputs to the methodology were updated and "Marylandized" to the extent possible.

1.3. Difference between Original and Revised Methodologies and Results

The Maryland Department of Housing and Community Development currently estimates that Maryland's adoption of 2009 IECC resulted in average energy efficiency improvements over the prior code (2006 IECC) of 15 percent, and that the next code (2012 IECC) will yield improvements of 30 percent relative to IECC 2006. These efficiency improvements differ from those estimated by the prior contractor and used in the Original Methodology.

Furthermore, we identified opportunities to update and/or improve some of the other input data used originally, including, most importantly, the ratio of major building renovations to new builds. The latter ratio, which is used in the methodology to determine the number of major building renovations conducted according to code in each year, was set equal to 1 in the Original Methodology as a "placeholder assumption," but based on actual permit data for Baltimore County we were able to estimate a new ratio for the residential sector. Unfortunately, when we attempted to use the same data source to estimate a ratio for the commercial sector, the result proved unreasonably large (4.4, a ratio which would imply more than one complete renovation of the entire existing building stock over the 10-year forecast period). Based on e-mail communication with Baltimore County staff, we suspect that some commercial buildings are covered by multiple renovation permits due, e.g., to multiple retail establishments undergoing renovation in the same mall or shopping center. Therefore, rather than using the ratio implied by the commercial permit data, we applied the residential permit ratio to the commercial as well as the residential sector. Our estimate of the ratio, based on the Baltimore County residential permit data, was significantly larger than the original placeholder assumption (1.5 vs. 1.0). However, whereas the prior contractor assumed that energy savings from building renovations would match those from new buildings, SAIC assumed that the energy savings from renovations would on average equal half that of the savings from new buildings.

As noted in the key assumptions for the Original Methodology, although RCI-1 applies to buildings undergoing both major and minor renovations, at least in the latter case "there would be a wide variety of measures implemented with a range of possible energy savings." We cannot in fact distinguish major from minor renovations based on the available data, but believe that energy savings from renovations will vary from levels equaling the energy savings from new buildings, all the way to negligible levels. The assumption that renovations will, on average, generate half the savings available from new buildings represents the midpoint of this range.

We considered the possibility that energy savings due to the renovation of historical buildings would average less than standard building renovations, but based on discussions with MDE it was agreed that historical renovations will not necessarily yield reduced savings. There is evidence that in at least some cases historical building renovations lead to very significant savings, so we retained the assumption that renovations would generate half the savings available from new buildings for historical as well as standard renovations.

Other inputs were also changed based on new and/or updated sources. It should be noted that while our projections of new housing starts were in the same ballpark as the projections used in the Original Methodology, we projected much larger additions to commercial floor space than the prior contractor (our estimates ranged from 4 to 6 times greater than the original estimates). The source of the original commercial floor space projections is not clear; our projections are based on U.S. aggregate projections from the Energy Information Administration's (EIA) Annual Energy Outlook 2010, scaled to Maryland based on the ratio of Maryland's 2003 total commercial floor space to the U.S. total. Furthermore, whereas the Original Methodology included an assumption that only 70 percent of new and renovated buildings would comply with the new codes, we assumed 100 percent compliance based on feedback from the Maryland Department of Housing and Community Development. The increased compliance, coupled with the increase in the commercial floor space projections, more than offset our use of smaller electricity emission factors than those used in the Original Methodology, resulting in forecasted emission reductions that are significantly larger than the reductions projected by the prior contractor.

1.4. GHG Emission Calculations

Step 1: Calculate the Total Number of New and Existing Buildings Affected Each Year:

The number of *new* buildings built in each year subject to the MBPS code is simply equal to our forecast of the number buildings built (new plus renovations requiring a permit) times a fraction representing the percentage of local jurisdictions adopting the code (see Equation 1 below). Since local jurisdictions are required to adopt the new codes within six months of their promulgation, we assumed that *all* MD jurisdictions would adopt each new code with a minimal time lag at the beginning of the year of its issuance (see Subsection 2.3, "Assumptions," for a justification of this assumption). Given this assumption, the number of new buildings built to code in each year is equal to the number of new buildings built in each year (i.e., $NBA_{i,t}$ in Equation 1 becomes equal to $NBB_{i,t}$, with $LGAR_i$ set equal to 1 in all years). Our forecasts of the number of new housing units, and commercial floor space, built in each year were developed based on Maryland-specific historical data from the U.S. Census Bureau (in the case of the residential sector) and South Atlantic Census Division-specific data from the U.S. Energy Information Administration (commercial sector). The historic data was extended into the future based on national-level building projections from the Energy Information Administration's (EIA) 2010 Annual Energy Outlook (AEO) (see Subsection 2.2, Data and Data Sources, for additional details).

Once the number of *new* buildings or commercial floor space built to code in each year was determined, this number was multiplied by the estimated ratio of renovated to new buildings to determine the number of *existing* housing units and commercial floor space renovated according to code (see equation 2 below). As noted above, the ratio of renovations to new buildings was estimated based on permit data for Baltimore County. (An attempt to obtain similar permit data for other Maryland localities was not successful.)

The specific algorithms used to complete Step 1 were as follows:

$$NBA_{i,t} = (NBB_{i,t})(LGAR_i) \quad (1)$$

$$EBA_{i,t} = (R_t)(NBA_{i,t}) \quad (2)$$

Where

$NBA_{i,t}$ = Number of new housing units, or million square feet of commercial space, of type t (residential or commercial) built to code in year i

$NBB_{i,t}$ = Total number of new housing units, or million square feet of commercial space, of type t (residential or commercial) built in year i

$LGAR_i$ = Fraction of MD localities adopting new code in year i

$EBA_{i,t}$ = Number of existing housing units, or million square feet of commercial space, of type t (residential or commercial) undergoing major renovations according to code in year i

R_t = Ratio of renovated to new buildings, of type t (residential or commercial)

Step 2: Calculate Energy Saved by Buildings Built to Code in Each Year:

In order to estimate the total energy savings resulting from the adoption of new codes in each year, the number new and renovated housing units, or commercial floor space, built or renovated to code (as determined in Step 1) was multiplied by the average estimated energy consumption of each building (in mmBtus per housing unit or square foot of commercial floor space). The latter energy consumption estimates, for 2006 (AEU_t in Equation 3 below), were derived using EIA and Census Bureau data (see Section 2.2). The resulting baseline energy consumption estimates were then multiplied by our estimates of the fractional energy savings generated by the specific IECC code in place in the given year (e.g., the fractional energy savings for 2017 was based on estimated energy savings for 2015 IECC). The fractional energy savings for the 2009 IECC and 2012 IECC were based on the estimates provided by the Maryland Department of Housing and Community Development (DHCD). Since the 2012 IECC, unlike the 2009 IECC, did not account for non-code compliance, we reduced the DCHD's energy savings estimate for the 2012 IECC based on an assumed 70 percent code compliance rate (the same assumption used by the Center for Climate Strategies(CCS)). We then assumed the energy savings to be achieved by the 2015 and 2018 IECCs would be the same as that produced by the 2012 IECC.

The specific algorithm used to complete Step 2 was as follows:

$$ES_{i,t} = [(ESG_{i,t})(NBA_{i,t}) + (RESEN)(ESG_{i,t})(EBA_{i,t})](AEU_t) \quad (3)$$

Where

$ES_{i,t}$ = Energy saved by new and renovated buildings of type t (residential or commercial) built to code in year i (mmBtus)

$ESG_{i,t}$ = Energy saved via adoption of new code by buildings of type t (residential or commercial) in year i (fraction)

RESEN = Energy saved through renovation of existing buildings, as a fraction of energy saved by new buildings

AEU_t = Average current energy use of buildings of type t (residential or commercial) (mmBtus/square foot or unit/year)

Step 3: Calculate Electricity and Direct Fuel Savings from Buildings Built to Code in Each Year:

In the third step, the total energy savings estimated in Step 2 are categorized according to specific fuel/energy type. In addition, that portion of the total savings representing electricity is adjusted upward to take into account savings resulting from the reduction in losses due to transmission, distribution, and on-site power plant use.

In equations 4 and 5 below, the total energy savings from Step 3 are split into electricity savings (Equation 4) and direct fossil fuel use savings (Equation 5) using forecasts of the future breakdown of energy consumption in Maryland's residential and commercial sectors. The forecasts were developed based on EIA base year (2006) energy consumption data for Maryland. The base year data was projected into the future using the national-level percentage growth forecasts from EIA's 2010 AEO. By applying relative (percentage) growth trends from the AEO to Maryland-specific base year data, the forecasts were in effect normalized to represent Maryland.

The specific algorithms used to complete Step 3 were as follows:

$$E_i = (ES_{i,r})(1+TD)(RE_i) + (ES_{i,c})(1+TD)(CE_i) \quad (4)$$

$$FS_{i,t} = (ES_{i,r})(RFF_{i,t}) + (ES_{i,c})(CFF_{i,t}) \quad (5)$$

Where

E_i = Total electricity saved by buildings built/renovated to code in year i (mmBtus)

$FS_{i,t}$ = Total direct fuel saved by buildings built/renovated to code in year i (mmBtus), by fuel type t (e.g., natural gas, distillate oil, etc.)

$ES_{i,r}$ = Energy saved by new and renovated residential buildings built/renovated to code in year i (from Equation 3, in mmBtus)

$ES_{i,c}$ = Energy saved by new and renovated commercial buildings built/renovated to code in year i (from Equation 3, in mmBtus)

TD = Electricity losses due to transmission and distribution (fraction)

$RFF_{i,t}$ = Fraction of total energy savings by residential buildings of fuel type t (natural gas, distillate oil, etc.), in year i

$CFF_{i,t}$ = Fraction of total energy savings by commercial buildings of fuel type t (natural gas, distillate oil, etc.), in year i

RE_i = Fraction of total energy savings by residential buildings in the form of electricity

CE_i = Fraction of total energy savings by commercial buildings in the form of electricity

Step 4: Calculate Emission Reductions from Buildings Built to Code in Each Year:

In Step 4, the yearly electricity and fossil fuel savings calculated in Step 3 were summed across years and converted to GHG emission reductions using appropriate emission factors. The resulting fuel-specific savings were summed across all fuel/energy types to yield total emission reductions from buildings built or renovated in each year. The fossil fuel emission factors were derived from the U.S. Environmental Protection Agency's Mandatory Reporting Rule. Emission factors for methane and nitrous oxide were converted to a carbon dioxide equivalent (CO_2e) basis and then added to the carbon dioxide (CO_2)emission factors to yield factors covering all relevant GHG on a CO_2e basis. The electricity emission factors were developed through a modeling analysis of Maryland's electricity sector (see Section 2.2 for more details on the modeling analysis). Separate electricity emission factors were developed for imported and in-state generated electricity; a forecast of the percentage of Maryland's total electricity demand to be met by imports provided by MDE was used to split the total electricity savings into in-state and imported electricity prior to the application of the two separate electricity emission factors.

The specific algorithm used to complete Step 4 was as follows:

$$ER_i = (EEFIS_i)\left[\sum_{y=2009 \text{ to } i} (E_y)(FIS_y)\right] + (EEFOS_i)\left[\sum_{y=2009 \text{ to } i} (E_y)(1-FIS_y)\right] + \sum_{2009 \text{ to } i,\, t} (FS_{y,t})(FEF_t) \qquad (6)$$

Where

ER_i = Total emission reductions from buildings built/renovated to code in year i (metric tons CO_2e)

FEF_t = Emission factor for fuel type t (metric tons/mmBtu)

FIS_y = Fraction of total electricity from in-state generators in year y (where y is a year between 2009 and i)

$EEFIS_i$ = Electricity emissions factor for in-state generators in year i (metric tons CO_2e/mmBtu)

$EEFOS_i$ = Electricity emissions factor for out-of-state generators in year i (metric tons CO_2e/mmBtu)

1.5. GHG Emission Data and Data Sources

Step 1 Data and Sources:

Table RCI-1.2- Step 1 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
$NBB_{i,t}$	Residential: Number of new MD housing units built in year i	2009: 14,418 2010: 25,217 2011: 19,808 2012: 24,643 2013: 25,865 2014: 26,162 2015: 27,535 2016: 28,912 2017: 29,289 2018: 29,709 2019: 30,241 2020: 30,140	U.S. Census Bureau, American Community Survey 2006 EIA Annual Energy Outlook (AEO) 2010 – Table A4	1
	Commercial: New floor space (million square feet) built in MD in year i	2009: 43 2010: 36 2011: 31 2012: 31 2013: 34 2014: 37 2015: 40 2016: 42 2017: 43 2018: 44 2019: 44 2020: 45	EIA Commercial Building Energy Consumption Survey (CBECS) 2003 – Table A4 U.S. Census Bureau Population Estimates 2003 EIA AEO 2010- Table A5	2
$LGAR_i$	Fraction of localities adopting code	100%	DHCD input (via email correspondence)	
R_t	Ratio of renovated to new buildings	1.5 for both residential and commercial buildings	Email communication with Regional Information Center Baltimore Metropolitan Council	Ratios presented are based on residential permit data for Baltimore County (3rd largest County in terms of population in MD)

Notes:

1. The percent change from the historic number of U.S. households in 2006 to each of the projection years was calculated from the AEO 2010 projections (AEO Reference Case Table 4). These percentages were then applied to the actual number of MD households in 2006 (from the American Community Survey conducted by the U.S. Census Bureau). The result was a projection of the number of new houses to be built in each year between 2006 and 2020, scaled to Maryland.

2. Historical data for 2003 commercial square footage in the South Atlantic census division was obtained from the EIA CBECS 2003 data (Table A4; this is the most recent data available). The values for the South Atlantic division were scaled to Maryland by multiplying by the ratio of the 2003 MD population to the total South Atlantic division's population. The resulting total 2003 floor space estimate for Maryland was then divided by the corresponding total for the U.S. as a whole. This fraction was then applied to the AEO 2010 projections (AEO Reference Case Table 5) of total new floor space additions for the U.S. as a whole. The result was a projection of new commercial floor space for the years 2009-20, scaled to Maryland.

Step 2 Data and Sources:

Table RCI-1.3- Step 2 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
$ESG_{i,t}$	Fractional energy savings	2010-12: 15% 2013-15: 30% 2016-18: 45% 2019-20: 60% Note the values are the same for residential and commercial buildings	2009 and 2012 values based on estimates of percentage savings for IECC 2009 and IECC 2012 provided by MD DHCD Subsequent values based on straight extrapolation of 15% improvement for the IECC 2009 and 2012 to IECC 2015 and 2018	1
AEU_t	Residential: MD energy use (million Btus/housing unit in 2006)	87.1	U.S. Census Bureau, American Community Survey 2006 EIA State Profiles – Maryland, 2006	2
	Commercial: MD Energy usage (mmBtus/million square feet in 2006)	125,782	EIA CBECS 2003 – Table A4 U.S. Census Bureau Population Estimates 2003 EIA AEO 2010-Table A5	3
RESEN	Energy saved by renovating existing buildings, as a fraction of energy saved by new buildings	0.5	SAIC assumption	

Notes:

1. Each new code is assumed to appear in the middle of the year; e.g., IECC 2012 is assumed to appear in July 2012. Furthermore, because local governments are given 6 months to adopt each new code, it is further assumed that the code does not begin to affect energy consumption until the beginning of the year *following* its promulgation. Thus IECC 2009 begins to affect energy use in 2010; IECC 2012 affects energy use beginning in 2013, etc.

2. Average energy use per housing unit was computed by dividing net residential energy consumption (from EIA's State Energy Profiles 2006) by the number of housing units in Maryland (from the 2006 American Community Survey by the U.S. Census Bureau).

3. Average energy use per million square feet in Maryland was computed as follows. First, 2003 EIA CBECS data for all commercial buildings in the South Atlantic division was apportioned to MD by estimates of the ratio of the 2003 MD population to South Atlantic division (from the U.S. Census Bureau). Then the 2003 MD CBECS data was scaled to 2006 based on the average annual U.S. percent increase in total commercial floor space from AEO 2010 (see note 2 from previous table for additional information). Finally, net commercial energy consumption (from EIA State Profiles Maryland, 2006) was divided by the estimate for 2006 MD commercial floor space.

Step 3 Data and Sources:

Table RCI-1.4- Step 3 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
TD	Transmission and Distribution (T&D) losses	8%	"Ten-Year Plan (2009-2018) of Electric Companies in Maryland." Maryland Public Service Commission. February 2010. <http://webapp.psc.state.md.us/intranet/Reports/2009-2018%20Ten%20Year%20Plan.pdf>	
RE_i	Fraction of residential energy that is electric	2009: 45% 2010: 45% 2011: 47% 2012: 47% 2013: 46% 2014: 46% 2015: 46% 2016: 47% 2017: 47% 2018: 47% 2019: 47% 2020: 48%	2006 Baseline data: EIA State Energy Data System – Maryland, Table 8 Projections: EIA AEO 2010, Supplemental Table 5	1
CE_i	Fraction of commercial energy that is electric	2009: 56% 2010: 56% 2011: 56% 2012: 57% 2013: 57% 2014: 57% 2015: 57% 2016: 57% 2017: 57% 2018: 58% 2019: 58% 2020: 58%	2006 Baseline data: EIA State Energy Data System – Maryland, Table 8 Projections: EIA AEO 2010, Supplemental Table 5	2

Variable	Definition	Value(s)	Source(s)	Notes
$RFF_{i,t}$	Fraction of residential energy use that is fuel type t	See Table RCI-1.2 below	2006 Baseline data: EIA State Energy Data System – Maryland, Table 8 Projections: EIA AEO 2010, Supplemental Table 5	1
$CFF_{i,t}$	Fraction of commercial energy use that is fuel type t	See Table RCI-1.3 below	2006 Baseline data: EIA State Energy Data System – Maryland, Table 8 Projections: EIA AEO 2010, Supplemental Table 5	2

Notes:

1. AEO Reference Case Supplemental Table 5 was used to obtain residential energy/electricity consumption by fuel type for the South Atlantic census division. The percent change in consumption by fuel type from the historic year 2006 to each of the projection years was then calculated from the AEO 2010. These percentages were then applied to the baseline MD energy consumption data by fuel type in 2006 (from EIA's State Energy Data System – Maryland, Table 8). Finally, the relative (percent) contribution of each fuel type to Maryland's total projected energy consumption in each year was calculated by dividing the consumption of the given fuel type by the total fuel consumption.

2. The same process was used as described in note 1 where commercial values were selected instead of residential values.

Table RCI-1.5- Residential Sector Energy Section Consumption, Percent of Net Energy (%)

		Petroleum			Biomass
Year	Natural Gas	Distillate Fuel Oil	Kerosene	LPG	Wood
2009	39	9	1	2	4
2010	40	9	1	2	3
2011	39	8	1	2	3
2012	39	8	1	2	3
2013	40	8	1	2	3
2014	40	8	1	2	3
2015	40	8	1	2	3
2016	41	7	0	2	3
2017	40	7	0	2	4
2018	40	7	0	2	4
2019	40	7	0	2	4
2020	40	6	0	2	4

Table RCI-1.6- Commercial Sector Energy Section Consumption, Percent of Net Energy (%)

			Petroleum		Biomass
Year	Coal	Natural Gas	Distillate Fuel Oil	LPG	Wood and Waste
2009	0	38	4	1	1
2010	0	38	4	1	1
2011	0	38	4	1	1
2012	0	37	4	1	1
2013	0	37	4	1	1
2014	0	37	4	1	1
2015	0	37	4	1	1
2016	0	38	3	1	1
2017	0	38	3	1	1
2018	0	37	3	1	1
2019	0	37	3	1	1
2020	0	37	3	1	1

Step 4 Data and Sources:

Table RCI-1.7- Step 4 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
FIS_i	Fraction of electricity from in-state generators	0.71 throughout forecast period	PSC communication	
$EEFIS_i$	In-state electricity emission factor (tonnes CO_2e/mmBtu)	2009: 0.1968 2010: 0.1968 2011: 0.2175 2012: 0.1745 2013: 0.1642 2014: 0.1552 2015: 0.1607 2016: 0.1498 2017: 0.1490 2018: 0.1424 2019: 0.1191 2020: 0.1225	PROMOD output, see below	
$EEFOS_i$	Emission factor for imported electricity (tonnes CO_2e/mmBtu)	2009: 0.2077 2010: 0.2077 2011: 0.2036 2012: 0.1951 2013: 0.1882 2014: 0.1849 2015: 0.1788 2016: 0.1748 2017: 0.1708 2018: 0.1693 2019: 0.1654 2020: 0.1625	PROMOD output, see below	
FEF_t	Emission factor for fuel type t	See Table 3 below for CO_2e emission factors by fuel type.	CO_2 emission factors: Mandatory Reporting Rule (MRR), Table C–1 to Subpart C of Part 98 CH_4 and N_2O emission factors: Mandatory Reporting Rule (MRR), Table C–1 to Subpart C of Part 98 Global Warming Potentials (GWP): 100-Year values in the IPCC Second Assessment Report(SAR) (Note: The IPCC SAR 100-Year GWPs have been adopted by the EPA's Mandatory GHG Reporting program)	Distillate Fuel Oil emission factor average values presented in MRR (No. 1-2 and 4-6).

SAIC developed the in-state and out-of-state electricity emission factors using the PROMOD production cost model. PROMOD is a well-known electricity dispatching model. To develop the emission factors SAIC used the model to simulate the operation of the PJM system under expected conditions for hourly demand, generator characteristics, fuel cost, emission costs, and transmission limitations to energy transfer across the PJM system. We used generator-specific emissions rates developed from historical Continuous Emissions Monitoring (CEMS) data. Also, we simulated the PJM system operation under two change cases: a 1 percent and a 2 percent reduction in PJM load. Our reported emissions rates are an average of the marginal emission rates for the two change cases. That is, we calculated the difference between the total CO_2 emissions in Maryland (or PJM system) for the Base Case and the total CO_2 emissions in Maryland for the 1 percent load reduction case. Dividing the decremental CO_2 output by the change in load gave us the marginal CO_2 emissions rate for Change Case 1. Then we did the same for the 2 percent load reduction case relative to the Base Case to compute a marginal CO_2 emissions rate for the 2 percent load reduction case. We averaged the two marginal CO_2 emissions rates to develop the above-documented CO_2 emissions factors in each forecast year.

Table RCI-1.8- CO_2, CH_4, N_2O and CO_2e Emission Factors for Different Fuel Types in the Maryland Fuel Supply

Fuel	CO_2**e Emission Factor (kgO2e/mmBTU)**
Coal Mixed (Commercial Sector)	95.99
Natural Gas	53.08
Distillate Fuel Oil	74.30
Kerosene	75.45
LPG	63.23
Biomass, wood and wood residuals	95.77

For coal mixed (commercial sector), coal and coke methane (CH_4) and nitrous oxide (N_2O) emissions factors were used for the conversion to CO_2e. For distillate fuel oil, kerosene and LPG, petroleum CH_4 and N_2O petroleum emission factors were used for the conversion to CO_2e. For biomass, wood and residuals, and biomass, solid products, biomass fuels solid CH_4 and N_2O emission factors were used for the conversion to CO_2e. Global Warming Potential (GWP) values were selected from the 100-year values in the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR) in order to be consistent with the reporting methodology required for United Nations Frameworks Convention on Climate Change (UNFCCC) National Communications. (Note: The IPCC SAR 100-Year GWPs have been adopted by the EPA's Mandatory GHG Reporting program.)

1.6. GHG Emission Assumptions

- The growth in the number of residential buildings and commercial floor space in MD will follow the national-level trends (as forecasted by EIA in the Annual Energy Outlook).
- MD's share of the total commercial floor space in the South Atlantic Census Division is equal to MD's share of the population in the Division.
- 2015 IECC and 2018 IECC will, like 2009 IECC 2009 and 2012 IECC, continue to generate 15 percent improvements in the energy efficiency of compliant residential and commercial buildings.

- The energy saved by renovating existing buildings will be equal to 0.5 of the energy saved by renovating new buildings.

- Electricity transmission and distribution losses average 8 percent for MD (based on the Maryland Public Service Commission's "Ten-Year Plan (2009-2018) of Electric Companies in Maryland," June 2010)).

- Compliance rates for all the new codes will equal 100 percent (this assumption is based on feedback from the Maryland Department of Housing and Community Development).

- Building codes appear at the midpoint of the year they are due (i.e., July 1), and are adopted by local governments 6 months after they appear. Thus each new code begins to affect energy consumption in the year following its appearance. Buildings undergoing renovations significant enough to require permits will be able to achieve the same level of energy savings as new buildings; e.g., buildings renovated in 2010 will, like buildings built in 2010, achieve a 15 percent savings in energy as a result of the renovations. It should however be emphasized that this assumption does *not* imply that renovated buildings are undergoing the same level of efficiency improvements as new buildings, or that the renovated buildings are as efficient as the new buildings. For new buildings, the energy efficiency improvements being achieved are in relation to the 2006 IECC. For *renovated* buildings, the efficiency improvements are relative to whichever code was in effect *at the time the building was originally built.* Thus, returning to our preceding example, a building built in 1950 that is renovated in 2010, is assumed to achieve a 15 percent savings in efficiency relative to a very low efficiency baseline (the baseline in place in 1950). Such a building, while generating a 15 percent improvement in efficiency, will not be as efficient as a new building built according to code in 2010. The assumption of equal *relative* efficiency improvements is thus designed to capture the fact that a renovation, being limited in scope, cannot bring a building up to the same average level of efficiency as a new building. The assumption of equal *relative* energy savings between new and renovated buildings is in effect a simplifying assumption (and is the same assumption applied by CCS); any attempt to improve upon this assumption would require more detailed data characterizing the buildings undergoing renovations in the State of Maryland.

1.7. GHG Emission Analysis and Recommendations

As documented in Section 1.6 above, a significant number of major assumptions were necessary to enable the calculation of emission reductions. The development of new data and Maryland-specific projections, e.g., on the number of new houses and commercial floor space, building code compliance rates, and electricity transmission and distribution (T&D) losses, would enable significant improvement in the accuracy of the emission reduction estimates.

2.0. AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated emissions reductions from RCI-1 are shown within Table RCI-1.9. All numbers for the criteria pollutants reflect a single year of emissions.

Table RCI-1.9- Emissions Reductions of Criteria Pollutants Associated with RCI-1 (tons per year)

	Across Maryland			Across Entire Domain		
Pollutant	**2012**	**2015**	**2020**	**2012**	**2015**	**2020**
SO_2	320	1,000	2,700	1,400	3,900	8,900
NO_X	130	420	1,300	410	1,200	3,800
CO	110	370	1,300	150	480	1,700
VOC	170	550	1,900	170	560	1,900
PM10-primary	180	580	2,000	230	730	2,400
PM2.5-primary	120	410	1,300	150	510	1,600

These numbers were compared against the MANE-VU inventories for 2012 and 2018 (Table RCI-1.10). The 2018 emissions were estimated by interpolating between the 2015 and 2020 estimates. Because all the values in 2012 are less than one percent, Table RCI-1.10 indicates that the criteria pollutant emissions reductions associated with this policy alone would be unlikely to improve air quality in the early years. Because the energy savings from this policy occur not only for those buildings that are newly built or renovated in each year x, but also for all buildings built or renovated between 2009 and year x, emission reductions steadily increase over time. By 2018 Table RCI-1.10 shows that emissions inventory reductions of 1 and 2 percent would be observed within Maryland for sulfur dioxide and particulate matter.

Table RCI-1.10- Percentage Reduction in Emissions Inventory Associated with RCI-1

	Across Maryland		Across Entire Domain	
Pollutant	**2012**	**2018**	**2012**	**2018**
SO_2	<1%	2%	<1%	<1%
NO_X	<1%	<1%	<1%	<1%
CO	<1%	<1%	<1%	<1%
VOC	<1%	<1%	<1%	<1%
PM10-primary	<1%	1%	<1%	<1%
PM2.5-primary	<1%	2%	<1%	<1%

Local reductions in sulfur dioxide (SO_2) emissions could result in reduced acid rain and less formation of sulfate particulate matter downwind of Maryland. Local reductions in particulate matter emissions would improve local ambient particulate matter concentrations and improve visibility.

2.2. Summary of Air Quality Co-Benefits Methodology

The PROMOD model results are used to estimate the decreased fuel consumption (in mmBtu) at various plants based on the policy's estimate of electricity consumption reduction. The plant emissions reductions are calculated by multiplying each power plant's decreased fuel consumption by the plant-specific emission factors (lb pollutant/mmBtu), and then emissions reductions are totaled over the whole domain.

2.3. Air Quality Co-Benefit Calculations

Calculate Emissions Factors Associated with Marginal Power Plant Reductions

1. From the 2009 EPA Clean Air Markets Division (CAMD) data sets, calculate the SO_2 and NO_X emissions rates per mmBtu for coal-fired power plants in EPA Regions 2, 3, 4, and 5.

2. From the 2007 Mid-Atlantic Regional Air Management Association (MARAMA) inventory for Maryland and surrounding states (DC, DE, NJ, PA, VA, and WV), find the Carbon Monoxide (CO), Volatile Organic Compound (VOC), PM10, and PM2.5 emissions rates per mmBtu for coal-fired power plants that are listed in the database.

3. Use EPA Compilation of Air Pollutant (AP-42) emissions factors for oil and natural-gas fired utility boilers. Assume no emissions from renewable and nuclear plants.

4. Calculate the emissions factors for each power plant (lb/mmBtu).

5. Calculate the emissions for each plant for base load, 1 percent reduction and 2 percent reduction by multiplying the emission factors by the change in fuel consumption rates (in mmBtu/yr) from

the PROMOD model (years 2012, 2015, and 2020—see Section 1.5, "Step 2 Data and Sources" for additional details on the PROMOD model runs referred to here).

6. If the SO_2 or NO_X emissions for Maryland power plants exceeded the Healthy Air Act limits, reduce the base load emissions to those permit limits and compute the 1 percent and 2 percent reductions as a fraction of the base load using the ratios of fuel consumption rates.

7. Sum the fuel consumption rates and the pollutant emissions in the base load, 1 percent reduction case, and 2 percent reduction case across all plants (years 2012, 2015, and 2020). Do this for both Maryland and for the entire modeling domain.

8. Compute the emissions per percent load reduction and the fuel consumption per percent load reduction for the 1 percent and 2 percent cases. Average the 1 percent and 2 percent cases.

9. Calculate the marginal electricity emissions factors (lb pollutant/mmBtu change) as the emissions per percent load reduction divided by the fuel consumption per percent load reduction.

Calculate Emissions Reductions Associated with Fuel/Electricity Consumption Reductions

1. Use the marginal electricity emissions factors.

2. Use AP-42 emission factors for commercial boilers, residential boilers, and residential wood stoves (catalytic).

3. Multiply the calculated reductions in fuel consumption (mmBtu), from the GHG emission reduction methodology (Section 1.4) by the emission factors (lb/mmBtu) to calculate the emission reductions.

2.4. Air Quality Co-Benefit Data and Data Sources

The following data sources were used for the analysis:

- PROMOD Model: (http://www1.ventyx.com/analytics/promod.asp)
- Maryland's Healthy Air Act (http://www.mde.maryland.gov/programs/Air/Documents/26-11-27_MD_Healthy_Air_Act.pdf)
- AP-42 (http://www.epa.gov/ttn/chief/ap42/index.html)
- CAMD 2009 (http://camddataandmaps.epa.gov/gdm/)
- Cite MARAMA's 2007 Regional Emissions Inventories (http://www.marama.org/RegionalEmissionsInventory/2007BaseCase/index.html)

- MANE-VU Emissions Inventory (http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory)

3.0 INTERACTION WITH OTHER POLICIES

The discussion of policy interactions is provided in Chapter 5.

Policy No.: RCI-4

Policy Title: Government Lead-By-Example

SAIC was tasked with reviewing the RCI-4 policy analysis which was conducted by a prior MDE contractor (Original Methodology) and revising the methodology to include Maryland-specific data and/or other enhancements. SAIC subsequently recalculated the GHG emission reductions associated with RCI-4 based upon its recommended methodology (Revised Methodology). SAIC also quantified the air quality co-benefits associated with RCI-4. SAIC's revised policy findings are described below:

1.0. GHG EMISSION REDUCTIONS

RCI-4 is designed to demonstrate howMaryland and municipal and county governments can "Lead by Example" by adopting policies that improve the energy efficiency of new and renovated public buildings, facilities and operations. For its RCI-4 analysis, MDE asked SAIC to quantify the GHG reductions associated with the Energy Performance Contracts (EPC) program and the Generating Clean Horizons (GCH) program. The GHG emission reductions expected from these programs are summarized below:

Table RCI-4.1- Estimated GHG Emission Reductions Resulting from RCI -4

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
RCI-4 Total	0.1	0.2	0.2
EPCs	0.1	0.1	0.1
In-State Electricity	0.0	0.0	0.0
Imported Electricity	0.0	0.0	0.0
Natural Gas	0.0	0.0	0.0
GCH	0.1	0.1	0.1
Biomass/Landfill Gas (LFG)[1]	0.0	0.0	0.0
Wind	0.1	0.1	0.1
Solar	0.0	0.0	0.0

Note: Totals may not equal sum of parts due to independent rounding.

[1] Net impact of increased use of biomass and landfill gas was a slight increase in emissions due to higher emissions per unit energy than traditional fuel mix.

Table RCI-4.2- Change in Energy Use

Sector	Electricity Use Reductions or Change to Renewable (GWh)		
	2012	2015	2020
RCI-4 Total	**171**	**274**	**409**
EPCs (Savings)	72	98	98
In-State Electricity	51	70	70
Imported Electricity	21	29	29
GCH (Renewables)	99	175	310
Biomass/LFG	11	20	36
Wind	85	144	247
Solar	3	12	27

Note: Totals may not equal sum of parts due to independent rounding.

Table RCI-4.3- Change in Fuel Use

Sector	Natural Gas Reductions (Trillion BTUs)		
	2012	2015	2020
RCI-4 Total	**.5**	**.6**	**.6**
EPCs	.5	.6	.6

Note: Totals may not equal sum of parts due to independent rounding

1.1. Summary of GHG Emission Methodology

Policy RCI-4 contains multiple elements to help the State of Maryland government "Lead by Example" in improving energy efficiency and use of renewable energy. This analysis models two distinct elements of RCI-4. First, the Energy Performance Contracts (EPC), result in direct energy savings. The Revised Methodology provides a break-down of EPC savings by natural gas, in-state electricity, and out-of-state electricity. The GHG benefits from current and expected EPCs were calculated as follows:

1. Calculate total expected energy savings for existing and expected EPC projects;
2. Calculate in-state and out-of-state emission reductions in each projection year.

The Generating Clean Horizons (GCH) project involves a power purchasing agreement, and commitment to install solar power. The Revised Methodology estimates the effect of the GCH project on total State of Maryland government electricity emissions. The policy as modeled dictates that through its power purchasing agreement, the State's electricity mix will meet the state's Renewable Portfolio Standard (RPS). The GHG benefits from the Generating Clean Horizons project were calculated as follows:

1. Calculate expected electricity consumption for the state of Maryland government in each projection year;

2. Calculate total projected renewable energy contributions in each projection year, less any pre-existing renewable energy contributions;

3. Calculate emission reductions in each project year.

Each of the above steps is documented in detail in the following subsection.

1.2. Rationale for GHG Emission Methodology

The selected method is a straightforward application of our standard emission factors to the energy savings goals of the EPCs and the renewable goals of Maryland's RPS.

1.3. Difference Between Original and Revised Methodology and Results

The Original Methodology modeled emissions reductions and energy savings from RCI-4 based on the policies proposed at that time. Since the original analysis, RCI-4 has evolved from a focus on Leadership in Energy and Environmental Design (LEED) building standards and government-wide goals to include two specific programs in the implementation phase: Energy Performance Contracts and Generating Clean Horizons.

The Revised Methodology was developed to quantify the emissions reductions and energy savings from the EPC and GCH programs specifically. These programs were not explicitly modeled within the original analysis, and therefore SAIC developed methodologies to calculate emissions reductions expected to be achieved through these programs.

1.4. GHG Emission Calculations

Energy Performance Contracts

Step 1: Calculate Total Energy Saved

MD's estimated energy savings resulting from the fourteen existing EPCs (65 million kWh, 450,000 mmBTU) were used as a starting point for this analysis. In addition, MDE provided data on the expected costs of four additional projects, and expected energy savings for one of these projects (15.7 million kWh, 70,673 mmBTU). The anticipated energy savings for the additional three projects without energy savings estimates were calculated based on their expected cost.

SAIC calculated the kWh and mmBTU savings per dollar of the fifteen projects for which energy savings data was provided as follows:

$$KWH\$ = KWH_{15} / Cost_{15}$$

And

$$mmBTU\$ = mmBTU_{15} / Cost_{15}$$

Where

$KWH\$$= average kilowatt hours saved per program dollar cost, for all fifteen EPC projects for which data was provided (KWh/$)

$mmBTU\$$ = average mmBTU saved per program dollar cost, for all fifteen EPC projects for which data was provided (mmBTU/$)

$Cost_{15}$ = total approximate cost of all fifteen EPC projects for which data was provided ($)

KWH_{15} = total electricity saved for all fifteen EPC projects for which data was provided (KWh)

$mmBTU_{15}$ = total thermal energy saved for all fifteen EPC projects for which data was provided (mmBTU)

SAIC then calculated the total energy savings for each year as the sum of the savings from the 15 projects with known savings (14 existing projects and 1 forecast project) and the 3 additional projects, using the following formula:

$$KWH_y = [KWH_{15} + (KWH\$ \text{ x } \textstyle\sum_i NEW\$_{i,y})] \text{ x } (1+TL)$$

And

$$mmBTU_y = mmBTU_{15} + (mmBTU\$ \text{ x } \textstyle\sum_i NEW\$_{i,y})$$

Where

KWH_y = total electricity saved for all EPC projects in year *y* (KWh)

$mmBTU_y$ = total thermal energy saved for all EPC projects in year *y* (mmBTU)

$NEW\$_i$ = forecast cost of each new project ($s)

TL = transmission losses (8%)

<u>Step 2: Calculate Emissions Reductions</u>

Emissions reductions accrue under three categories for the EPC program: natural gas combustion, in-state electricity, and out-of-state electricity. Natural gas emissions reductions were calculated as follows:

$$ERNG_y = mmBTU \text{ x } (53.08/1000)$$

Where

$ERNG_y$ = total annual emissions reductions from natural gas savings per year *y* (tCO_2e)

53.08 = emissions factor for natural gas ($kgCO_2e/mmBTU$)

1000 = conversion factor from kilograms to metric tons

Emissions reductions associated with in-state electricity production were calculated as follows. Note that unlike the constant emissions factor used for natural gas, the electricity emissions factors have been adjusted based on the anticipated fuel mix in each year.

$ERIE_y$ = (KWH/1000) x $EFIE_y$ x 0.71

Where

$ERIE_y$ = total annual emissions reductions from in-state produced electricity per year *y* (tCO_2e)

$EFIE_y$ = emissions factor for in-state electricity production in year *y* (tCO_2e/MWh)

1000 = conversion factor from kilowatts to megawatts

0.71 = proportion of electricity produced in-state

Emissions reductions associated with out-of-state electricity production were calculated as follows:

$EROE_y$ = (KWH/1000) x $EFOE_y$ x (1 – 0.71)

Where

$EROE_y$ = total annual emissions reductions from out-of-state produced electricity per year *y* (tCO_2e)

$EFOE_y$ = emissions factor for out-of-state electricity production in year *y* (t CO_2e/ MWh)

Generating Clean Horizons

SAIC calculated the emissions reductions associated with the Generating Clean Horizons program by forecasting State electricity consumption, and assuming that the program would result in the State meeting the renewable portfolio standard.

<u>Step 3: Calculate expected electricity consumption for the State of Maryland government in each projection year</u>

SAIC used the following equation to calculate the expected electricity consumption in each projection year for the government of the State of Maryland:

MD_y = [MD_{2009} x (MAC_y / MAC_{2009})] x (1 + TL)

Where

MD_y = projected electricity consumption, including losses for the State of Maryland's government in year *y* (KWh)

MD_{2009} = reported electricity consumption for the State of Maryland's government in 2009 (KWh)

MAC_y = EIA projection of mid-Atlantic electricity consumption for the commercial sector in year *y* (quadrillion BTU)

MAC_{2009} = EIA reported mid-Atlantic electricity consumption for the commercial sector in 2009 (quadrillion BTU)

TL = transmission losses (8%)

Step 4: Calculate additional renewable energy to meet RPS

The RPS goals specified renewable energy production from Tier 1 and Tier 2 sources. For this analysis, SAIC modeled only the Tier 1 sources, because Maryland already exceeds its Tier 2 standard, and no additional electricity from these sources is required. The Tier 1 interim goals were calculated as follows:

$$SE_y = SS_{2011} + [(SS_{2020} - SS_{2011}) / 9] (y - 2011)$$

Where

SE_y = percent of total State electricity from solar sources in year *y* (%)

SS_y = solar electricity standard in year *y*

9 = yearly increments between 2011 and 2020

y = year being modeled

And

$$NSE_y = NSS_{2011} + [(NSS_{2020} - NSE_{2011}) / 9] (y - 2011) - BNS$$

Where

NSE_y = percent of total State electricity from non-solar Tier 1 sources in year *y*

NSS_y = non-solar Tier 1 standard in year *y*

9 = yearly increments between 2011 and 2020

BNS = baseline non-solar Tier 1 renewable electricity produced in 2008

Step 5: Calculate Adjusted Marginal GHG Emissions Rate

SAIC calculated adjusted marginal GHG emission rates for solar and non-solar Tier 1 renewable energy as follows:

$$AMER_i = \sum_{m=1}^{12} \sum_{j=1}^{4} PR_j * MEF_{m,j} * MER_m \qquad (2)$$

Where

$AMER_i$ = Adjusted Marginal GHG Emissions Rate for Year i (million metric tons CO_2e per MWh)

m = month

j = Resource

PRj = Percentage of Resource j (wind, biomass, landfill gas, or hydro; solar is calculated separately)

MEF_{mj} = Monthly Energy Factor for month m for resource j (% of annual energy produced in month m)

MER_m = Marginal GHG Emissions Rate for month m (million metric tons CO_2e per MWh)

Step 6: Calculate emission reductions in each project year.

Using the values SEy and NSEy, SAIC then calculated the emissions reductions associated with sourcing electricity from solar and non-solar Tier 1 sources. This was calculated as follows:

$$ERSE_y = SE_y \text{ x } MDy \text{ x } AMER_{y,s}$$

And

$$ERNS_y = (NSE_y \text{ x } MDy \text{ x } AMER_{y,ns}) - \sum_i(NSE_{y,i} \text{ x } EF_i)$$

Where

ERSE = total annual emissions reductions in year *y* from the use of solar electricity (tCO_2e)

$AMER_{y,s}$ = annual marginal emissions factor for avoided emissions from use of solar electricity in year *y* (tCO_2e/MWh)

ERNE = total annual emissions reductions in year *y* from the use of non-solar Tier 1 electricity (tCO_2e)

$AMER_{y,ns}$ = annual marginal emissions factor for avoided emissions from use of non-solar Tier 1 electricity in year *y* (tCO_2e/MWh)

$NSE_{y,i}$ = percent of non-solar Tier 1 electricity from renewable source *i* in year *y* (%)

EF_i = emissions factor for renewable source *i*

1.5. GHG Emission Data and Data Sources

Step 1 Data and Sources:

Table RCI-4.4- Step 1 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
KWH_{14}	Total annual KWh saved for fourteen existing EPC projects	65 million KWh	DGS communication	
$mmBTU_{14}$	Total annual mmBTU saved for fourteen existing EPC projects	450,000 mmBTU	DGS communication	
$COST_{14}$	Total approximate cost for all fourteen existing EPC projects	$135 million	DGS communication	
KWH_1	Total forecast annual KWh saved for new EPC project	15,740,945	DGS communication	
$mmBTU_1$	Total forecast annual mmBTU saved for new EPC project	70,673	DGS communication	
$NEW\$_i$	Forecast cost of new EPC project *i*	$5,800,000 $6,000,000 $5,200,000	DGS communication	
TL	Transmission Losses	8%	"Ten-Year Plan (2009-2018) of Electric Companies in Maryland." Maryland Public Service Commission. February 2010. <http://webapp.psc.state.md.us/intranet/Reports/2009-2018%20Ten%20Year%20Plan.pdf>	

Step 2 Data and Sources:

Table RCI-4.5- Step 2 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
53.08	Emissions factor for natural gas ($kgCO_2e/mmBTU$)	53.08	Mandatory Reporting Rule (MRR), Table C–1 to Subpart C of Part 98	
$EFIE_y$	Emissions factor for in-state electricity production in year *y* (tCO_2e/MWh)	2012: 0.595 2015: 0.548 2020: 0.418	PROMOD output, see below	1
$EFOE_y$	Emissions factor for out-of-state electricity production in year *y* (tCO_2e/MWh)	2012: 0.665 2015: 0.61 2020: 0.554	PROMOD output, see below	1
0.71	Proportion of electricity produced in-state	0.71	PSC communication	

Notes: (1) SAIC developed the in-state and out-of-state electricity emission factors using the PROMOD production cost model. PROMOD is a well-known electricity dispatching model. To develop the emission factors SAIC used the model to simulate the operation of the PJM system under expected conditions for hourly demand, generator characteristics, fuel cost, emission costs, and transmission limitations to energy transfer across the PJM system. We used generator-specific emissions rates developed from historical CEMS data. Also, we simulated the PJM system operation under two change cases: a 1 percent and a 2 percent reduction in PJM load. Our reported emissions rates are an average of the marginal emission rates for the two change cases. That is, we calculated the difference between the total CO_2 emissions in Maryland (or PJM system) for the Base Case and the total CO_2 emissions in Maryland for the 1 percent load reduction case. Dividing the decremental CO_2 output by the change in load gave us the marginal CO_2 emissions rate for Change Case 1. Then we did the same for the 2 percent load reduction case relative to the Base Case to compute a marginal CO_2 emissions rate for the 2 percent load reduction case. We averaged the two marginal CO_2 emissions rates to develop the above-documented CO_2 emissions factors in each forecast year.

Step 3 Data and Sources:

Table RCI-4.6- Step 3 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
MD_{2009}	Reported electricity consumption for State of Maryland government in 2009 (KWh)	2009: 1,455,031,107 KWh	Maryland State E-Footprint	Web Link
MAC_y	Projection of mid-Atlantic electricity consumption for commercial sector in year *y* (quad BTU)	2012: 0.57 2015: 0.5853 2020: 0.6158	EIA AEO2011, National Energy Modeling System	Web Link
MAC_{2009}	Reported electricity consumption for mid-Atlantic in year 2009 (quad BTU)	2009: 0.549	EIA AEO2011, National Energy Modeling System	Web Link
TL	Transmission losses	8%	Original CSS assumption	

Step 4 Data and Sources:

Table RCI-4.7- Step 4 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
SSy	Solar electricity renewable portfolio standard for year *y*	2011: 0.04% 2020: 1.5%	MD RPS Legislation*	
NSSy	Non-solar electricity renewable portfolio standard for year *y*	2011: 4.96% 2020: 16.5%	MD RPS Legislation*	
BNS	Baseline biomass and LFG Tier 1 renewable electricity produced in 2008	2012: 1.3% 2015: 1.3% 2020: 1.3%	EIA, Maryland Renewable Electricity Profile: 2008	Web Link

*RPS Legislation:
Senate Bill 595 (Electricity – Net Energy Metering – Renewable Portfolio Standard – Solar Energy), April 2007; House Bill 375 (Renewable Portfolio Standard Percentage Requirements – Acceleration), April 2008; Senate Bill 277 (Renewable Portfolio Standard – Solar Energy), May 2010. See http://webapp.psc.state.md.us/intranet/ElectricInfo/home_new.cfm.

Step 5 Data and Sources:

Table RCI-4.8- Step 5 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
$AMER_j$	Adjusted Marginal GHG Emissions Rate for Year i (million metric tons CO_2e per MWh)	Non-Solar Tier 1 2012: 0.645521 2015: 0.573826 2020: 0.454513 Solar 2012: 0.603850 2015: 0.558952 2020: 0.464188	Calculated	
PRj	Percentage of resource *j*		Public Service Commission of Maryland, Renewable Energy Portfolio Standard Report of 2010, February 2010. Ventyx Energy Velocity Database	See Note (1) for values
MEF_{mj}	Monthly energy factor for month *m* for resource *j* (% of annual energy produced in month *m*)		National Renewable Energy Laboratory, PV Watts Database National Renewable Energy Laboratory, Wind Integration Datasets,	See Note (2) for values
MER_m	Marginal GHG emissions rate for month *m* (metric tonnes CO_2e per MWh)		MarketPower™ simulation model and the Promod™ dispatch model	See Note (3) for values

Notes

(1) Energy mix

The annual Energy Mix is based on 2008 compliance data for the Maryland RPS and the mix of proposed renewables is based on the Ventyx Energy Velocity Database. New renewable energy is added in the following proportion: wind – 83.5 percent, biomass – 13.3 percent, landfill gas – 3.2 percent.

Table RCI-4.9- Annual Energy Mix

Resource	Energy Mix		
	2012	2015	2020
Wind	57.7%	67.5%	74.3%
Biomass	30.2%	23.7%	19.3%
LFG	6.8%	5.5%	4.5%
Hydro	5.3%	3.3%	1.9%

(2) Monthly energy production factor for month *m* for resource *j*

The Monthly Energy Production Factor provides the amount of energy produced in each month by a particular resource relative to the rest of the year. Wind, the main resource assumed to meet the RPS, produces more energy in the winter. The wind pattern is the average of several regional wind patterns.

Table RCI-4.10- Monthly Energy Production

Month	Monthly Energy Production				
	Wind	Biomass	LFG	Hydro	Solar
1	13.7%	8.3%	8.3%	8.3%	6.9%
2	12.0%	8.3%	8.3%	8.3%	7.9%
3	8.7%	8.3%	8.3%	8.3%	9.1%
4	7.6%	8.3%	8.3%	8.3%	9.2%
5	6.4%	8.3%	8.3%	8.3%	9.4%
6	4.1%	8.3%	8.3%	8.3%	9.5%
7	5.4%	8.3%	8.3%	8.3%	9.6%
8	4.6%	8.3%	8.3%	8.3%	9.0%
9	6.7%	8.3%	8.3%	8.3%	8.3%
10	10.5%	8.3%	8.3%	8.3%	9.0%
11	7.2%	8.3%	8.3%	8.3%	6.6%
12	13.1%	8.3%	8.3%	8.3%	5.5%

(3) Marginal GHG emissions rate for month *m*

Table RCI-4.11- Marginal GHG Emissions Rate for Month *m*

Month	Marginal GHG Emissions Rate (TCO_2e/MWh)		
	2012	2015	2020
1	0.8	0.7	0.4
2	0.7	0.6	0.5
3	0.8	0.5	0.4
4	0.8	0.6	0.6
5	0.4	0.5	0.5
6	0.5	0.6	0.5
7	0.5	0.6	0.5
8	0.4	0.5	0.4
9	0.4	0.5	0.5
10	0.6	0.5	0.4
11	0.6	0.5	0.5
12	0.9	0.7	0.4

Step 6: Data and Sources:

Table RCI-4.12- Step 6 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
EF_i	Emissions factor for renewable source *i* (tCO_2e/MWh)	Wind = 0 Biomass = 1.06 LFG = 0.53	Biomass: EIA, Annual Energy Outlook 2010 with Projections to 2035 LFG: see Natural Gas	Biomass: Web Link, converted from units $kgCO_2e/mmBTU$

1.6. GHG Emission Assumptions

- The cost effectiveness of future EPC projects will be equal to the cost effectiveness of the fourteen existing projects.
- EPC projects will recognize savings at the same level for all years in which they are operational
- New EPC projects will become operational in 2013
- All thermal energy savings come from natural gas.

- The proportion of electricity produced in-state will remain constant at 71 percent.
- The State of Maryland government's electricity consumption will increase at the same rate as the Commercial sector in the Mid-Atlantic region.
- The State's use of renewable energy will be met through a linear percentage increase in the proportion of energy from 2011 to 2020.
- The current rate of 1.3 percent biomass and landfill gas Tier 1 electricity would have remained constant in the baseline, and therefore does not accrue benefit to RCI-4.
- The mix of non-solar Tier I renewables begins with the actual mix reported in 2008 compliance data (1.3 percent from biomass and landfill gas (LFG) combined). New renewables are added based on the proportion of proposed renewable resources in the PJM region, derated based on resource-specific historical success rates. The mix of renewable resources chosen was 83 percent wind, 13 percent biomass, and 3 percent landfill gas.
- Electricity from solar and wind Tier 1 renewable resources do not produce emissions.
- Emissions from biomass and landfill gas do produce emissions.
- The EPCs will meet their energy savings goals, and the Generating Clean Horizon's program will meet its renewables usage goals.

2.0. AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated emissions reductions from RCI-4 are shown in Table RCI-4.13.

Table RCI-4.13- Emissions Reductions Associated with RCI-4 (tons per year)

	Across Maryland			Across Entire Domain		
Pollutant	**2012**	**2015**	**2020**	**2012**	**2015**	**2020**
SO_2	16	17	19	570	720	670
NO_X	28	38	30	170	240	290
CO	19	25	34	40	53	83
VOC	1	2	3	3	4	5
PM10-primary	10	17	27	35	54	68
PM2.5-primary	9	16	24	25	39	56

These numbers were compared against the MANE-VU inventories for 2012 and 2018 (Table RCI-4.14). The 2018 emissions were estimated by interpolating between the 2015 and 2020 estimates. Because all the values are less than one percent, Table RCI-4.14 indicates that the criteria pollutant emissions reductions associated with this policy would be unlikely to improve air quality.

Table RCI-4.14- Percentage Reduction in Emissions Inventory Associated with Policy RCI-4

	Across Maryland		**Across Entire Domain**	
Pollutant	**2012**	**2018**	**2012**	**2018**
SO_2	<1%	<1%	<1%	<1%
NO_X	<1%	<1%	<1%	<1%
CO	<1%	<1%	<1%	<1%
VOC	<1%	<1%	<1%	<1%
PM10-primary	<1%	<1%	<1%	<1%
PM2.5-primary	<1%	<1%	<1%	<1%

2.2. Summary of Air Quality Co-Benefits Methodology

The PROMOD model results estimate the decreased fuel consumption at various plants based on marginal reductions in electricity consumption. The marginal plant emissions reductions are calculated by multiplying each power plant's decreased fuel consumption by the plant-specific emission factors (lb pollutant/mmBtu), and domain-wide emission factors are computed from the marginal calculations.

Then emissions reductions are computed by multiplying the policy's decrease in fuel consumption by the domain-wide emission factors. An assumption that electric generators would begin co-firing small quantities of biomass with coal did not lead to reduced emission factors. Emissions increases resulting from the development of landfill gas boilers were calculated by multiplying EPA's AP-42 emission factors by the increased electric demand on this sector. Additional emissions reductions from reduced natural gas consumption under EPCs were calculated using AP-42 emission factors.

2.3. Air Quality Co-Benefit Calculations

Calculate Emission Factors Associated with Marginal Power Plant Reductions

1. From the 2009 CAMD data sets, calculate the SO_2 and NO_X emissions rates per mmBtu for coal-fired power plants in EPA Regions 2, 3, 4, and 5.

2. From the 2007 MARAMA inventory for Maryland and surrounding states (DC, DE, NJ, PA, VA, and WV), find the CO, VOC, PM10, and PM2.5 emissions rates per mmBtu for coal-fired power plants that are listed in the database.

3. Use AP-42 emissions factors for oil and natural-gas fired utility boilers. Assume no emissions from renewable and nuclear plants.

4. Calculate the emissions factors for each power plant (lb/mmBtu).

5. Calculate the emissions for each plant for base load, 1 percent reduction and 2 percent reduction by multiplying the emission factors by the annual fuel consumption rates from the PROMOD model (years 2012, 2015, and 2020).

6. If the SO_2 or NO_X emissions for Maryland power plants exceeded the Healthy Air Act limits, adjust the base load emissions and adjust the 1 percent and 2 percent reductions by the fuel consumption rate ratios.

7. Sum the fuel consumption rates and the pollutant emissions in the base load, 1 percent reduction case, and 2 percent reduction case (years 2012, 2015, and 2020). Do this for both Maryland and for the entire modeling domain.

8. Compute the emissions, fuel consumption rates, and energy production per percent load reduction.

9. Calculate the marginal electricity emissions factors (lb pollutant/mmBtu change) as the emissions per percent load reduction divided by the fuel consumption rates per percent load reduction.

10. Calculate the marginal heat rates from electricity generating units (EGUs) (mmBtu/GWh) as the fuel consumption rate per percent load reduction divided by the energy production per percent load reduction.

Calculate Heat Input Reductions for EPCs

1. The total EPC energy savings (in GWh) are reported in Section 1.0

2. Multiply the total EPC energy savings for the year by the marginal heat rate from EGUs (mmBtu/GWh) for the same year to calculate the EPC heat input reduction.

Calculate Heat Input Reductions for GCHs

1. The GCH energy savings (in GWh) are reported in Section 1.0 for landfill gases, wind, and solar. Assume that co-firing coal-fired plants with less than 10 percent biomass does not significantly change the criteria pollutant emission factors (based on figure presented by Lesley Sloss of the International Energy Association(IEA) Clean Coal Centre at the 35th Annual EPA-Air & Waste Management Association (A&WMA) Annual Exchange in December 2010) from those for coal alone. Therefore, any generation capacity allotted to biomass in the GCH was treated with the same criteria pollutant emission factors that were used for PROMOD.

2. Multiply the GCH energy savings for landfill gases, wind, and solar by the marginal heat rate for EGUs for the same year to calculate the GCH heat input reduction.

Calculate Emissions Reductions Associated with RCI-4

1. Use the marginal electricity emissions factors for the electricity reductions.

2. Use AP-42 emission factors for commercial-size boilers.

3. Use AP-42 emission factors for landfill gas boilers, and assume that the GCH landfill gas boilers are all located within Maryland. To calculate the necessary landfill gas rates to meet electric demand, assume factors of 7 mmBtu/MWh for new boilers and 0.3 mmBtu/mcf landfill gases. Because landfill gas boilers would be replacing unspecified SO_2 and VOC emissions controls at the landfills but likely have negligible effects on total emissions changes, the SO_2 and VOC emissions increases were not computed.

4. Multiply the EPC and GCH heat input reductions (mmBtu) by the emission factors (lb/mmBtu) to calculate the emission reductions. Subtract out any emissions resulting from increased use of landfill gas boilers.

2.4. Air Quality Co-Benefits Data a and Data Sources

The following data sources were used for the analysis:

- PROMOD Model: (http://www1.ventyx.com/analytics/promod.asp)
- Maryland's Healthy Air Act (http://www.mde.maryland.gov/programs/Air/Documents/26-11-27_MD_Healthy_Air_Act.pdf)
- AP-42 (http://www.epa.gov/ttn/chief/ap42/index.html)
- CAMD 2009 (http://camddataandmaps.epa.gov/gdm/)
- Cite MARAMA's 2007 Regional Emissions Inventories (http://www.marama.org/RegionalEmissionsInventory/2007BaseCase/index.html)
- MANE-VU Emissions Inventory (http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory)

3.0 INTERACTION WITH OTHER POLICIES

The discussion of policy interactions is provided in Chapter 5.

Policy No.: RCI-10 (Including RCI-2, 3, 7 and 11)

Policy Title: EmPOWER Maryland

SAIC was tasked with reviewing the RCI-10 policy analysis which was conducted by a prior MDE contractor (Original Methodology) and revising the methodology to include Maryland-specific data and/or other enhancements. SAIC subsequently recalculated the GHG emission reductions associated with RCI-10 based upon its recommended methodology (Revised Methodology). SAIC also quantified the air quality co-benefits associated with RCI-10. SAIC's revised policy findings are described below:

1.0. GHG EMISSION REDUCTIONS

RCI-10 (which incorporates and subsumes old policies RCI-2, RCI-3, RCI-7, and RCI-11 in addition to RCI-10) consists of the EmPOWER Maryland Act. EmPOWER Maryland, enacted in 2008, requires utilities and the Maryland Energy Administration (MEA) to reduce the state's per capita electricity consumption by 15 percent by 2015. The 15 percent reduction is to be achieved against a 2007 baseline. The GHG emission reductions expected from this policy are summarized below:

Table RCI-10.1- Estimated GHG Emission Reductions resulting from RCI -10

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
RCI-10 Total	**3.1**	**6.4**	**5.4**
Residential			
In-State Electricity	0.9	1.8	1.4
Imported Electricity	0.4	0.8	0.8
Commercial			
In-State Electricity	0.6	1.3	1.0
Imported Electricity	0.3	0.6	0.6
Industrial			
In-State Electricity	0.6	1.3	1.0
Imported Electricity	0.3	0.6	0.5

Note: Totals may not equal sum of parts due to independent rounding.

The reductions in electricity consumption expected from RCI-10 are presented in Table RCI-10.2. Note that although RCI-10 meets its final goal of a 15 percent reduction in per capita consumption in 2015, there is a slight increase in *total* electricity use reductions between 2015 and 2020. This increase reflects the fact that Maryland's population is projected to increase between 2015 and 2020; hence the 15 percent *per capita* reduction is applied to a larger population total in 2020 than in 2015. Note also that although the reduction in electricity consumption increases between 2015 and 2020, the GHG emission reductions projected for RCI-10 decline significantly over this same period (see Table RCI-10.1). The decline in emission reductions is the result of a corresponding decline in the projected marginal emissions factors for in-State and imported electricity, as Maryland and the U.S. as a whole shift towards cleaner burning fuels and renewable.

Table RCI-10.2- Change in Electricity Use

Sector	Electricity Use Reductions (GWh)		
	2012	2015	2020
RCI-10 Total	**5,103**	**11,279**	**11,746**
Residential	2,092	4,624	4,816
Commercial	1,531	3,384	3,524
Industrial	1,480	3,271	3,406

Note: Totals may not equal sum of parts due to independent rounding.

1.1. Summary of GHG Emission Methodology

The Revised Methodology used by SAIC to estimate GHG reductions for this policy is simple and straightforward, consisting of the following three steps:

3. Calculate electricity savings from each sector (residential, commercial, and industrial) in each projection year (2012, 2015, and 2020);
4. Calculate in-state and out-of-state emission reductions in each projection year;
5. Calculate total emission reductions across all sectors and geographic boundaries.

Each of the above steps is documented in detail in the following subsection.

1.2. Rationale for GHG Emission Methodology

The selected method is a straightforward application of our standard emission factors to the EmPOWER Maryland electricity savings goal.

1.3. Difference Between Original and Revised Methodology and Results

Since at the time the original emission reduction estimates were developed Policies RCI-2, RCI-3, RCI-7, RCI-10 and RCI-11 were all separate, the Original Methodologies applied at that time are no longer relevant, or an efficient approach, to calculating reductions for the single combined policy. Therefore SAIC developed a new Revised Methodology. It is important to recognize that the new combined policy consists exclusively of the EMPOWER Maryland act; therefore other emission reduction measures contained in the original set of policy estimates for RCI-2, RCI-3, RCI-7, RCI-10, and RCI-11 are not covered or considered in the Revised Methodology.

1.4. GHG Emission Calculations

Step 1: Calculate Electricity Savings from RCI-10:

Since EmPOWER Maryland's goal is a 15 percent reduction in per capita electricity consumption, to be met in full by 2015, total electricity savings in 2015 and 2020 is simply 0.15 times Maryland's 2007 per capita electricity consumption, multiplied by projections of the state's population in those years. By 2012 we assume Maryland will have progressed approximately halfway towards the goal; hence savings in 2012 are set equal to 7 percent of the State's 2007 per capita electricity consumption. The total electricity savings in each of the three years are assumed to be distributed across the three sectors (residential, commercial, and industrial) in accordance with the current distribution of electricity use by sector (as provided to us by MDE).

The specific algorithm used to calculate total electricity savings by year and sector is as follows:

$$ES_{i,s} = (P_i)(EC_{2007}/P_{2007})(SG_i)(SF_s) \quad (1)$$

Where

$ES_{i,s}$ = Total reduction in electricity consumption (in MWh) in year i, for sector s (where s is residential, commercial, or industrial)

EC_{2007} = Total MD electricity consumption in 2007, including losses (in MWh)

P_{2007} = MD population in 2007 (in MWh)

P_i = MD projected population in year i

SG_i = RCI-10 electricity saving's goal for year i (fraction)

SF_s = Fraction of total saving's goal to be met by each sector s (where s is residential, commercial, or industrial)

Step 2: Calculate In-State and Out-of State Emission Reductions for Each Sector:

Once total electricity savings by year and sector are computed in Step 1, these savings estimates are converted to emission reduction estimates by applying the appropriate electricity emission factors. The electricity emission factors were developed through a modeling analysis of Maryland's electricity sector (see Section 2.2 for more details on the modeling analysis). Separate electricity emission factors were developed for imported and in-state generated electricity; aPSC-supplied forecast of the percentage of Maryland's total electricity demand to be met by imports was used to split the total electricity savings into in-state and imported electricity prior to the application of the two separate electricity emission factors.

The specific algorithm used to complete Step 2 was as follows:

$$ERIS_{i,s} = (ES_{i,s})(FIS_i)(EEFIS_i) \quad (2)$$

$$EROS_{i,s} = (ES_{i,s})(1\text{-}FIS_i)(EEFOS_i) \quad (3)$$

Where

$ERIS_{i,s}$ = In-State emission reductions in year i (in metric tons CO_2e) for sector s (where s is residential, commercial, or industrial)

$EROS_{i,s}$ = Emission reductions from imported electricity in year i (in metric tons CO_2e) for sector s (where s is residential, commercial, or industrial)

FIS_i = Fraction of total electricity from in-state generators in year i

$EEFIS_i$ = Electricity emissions factor for in-state generators in year i (metric tons CO_2e/MWh)

$EEFOS_i$ = Electricity emissions factor for out-of-state generators in year i (metric tons CO_2e/MWh)

Step 3: Calculate Total Emission Reductions Across All Sectors and Boundaries:

Finally, in Step 3 total emission reductions for RCI-10 in each of the projection years (2012, 2015 and 2020) are computed by summing the in-state and out-of-state reductions across all sectors.

1.5. GHG Emission Data and Data Sources

Step 1 Data and Sources:

Table RCI-10.3- Step 1 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
EC_{2007}	Total MD electricity consumption in 2007	69,299,682 MWh	MD Public Service Commission*	
SG_i	Electricity savings goal	2012: 7% 2015: 15% 2020: 15%	EmPower Goal	The 2012 goal is estimated at approximately half the EmPower Goal of a 15% reduction by 2015
P_i	MD state population in year i	2007: 5,610,000 2012: 5,902,000 2015: 6,086,840 2020: 6,339,290	U.S. Census Bureau** MD Dept. of Planning, Demographic and Socio-economic Outlook***	The 2007 value is based on a linear interpolation of data for 2000 and 2009, from the U.S. Census Bureau. The 2012 data is based on a linear interpolation of projections from 2010 and 2015 from the MD Dept. of Planning's website. The 2015 and 2020 projections are from the MD Dept. of Planning
SF_s	Fraction of goal contributed by each sector	Residential=41% Commercial=30% Industrial=29%	ACEEE****	The fractions represent current electricity use by sector

*From the Excel spreadsheet "2007 and 2008 per capita consumption data."

**U.S. Census Bureau, http://quickfacts.census.gov/qfd/states/24000.html

***MD Department of Planning, http://planning.maryland.gov/msdc/county/stateMD.pdf. (We used the website rather than the Dept. of Planning's spreadsheet "2015 EmPOWER Targets and Population" because the former source is more recent--February 2009 vs. July 2008).

****American Council for an Energy-Efficient Economy (ACEEE), "Energy Efficiency: The First Fuel for a Clean Energy Future; Resources for Meeting Maryland's Electricity Needs," February 2008, http//www.aceee.org/research-report/e082.

Step 2 Data and Sources:

Table RCI-10.4- Step 2 Data and Sources

Variable	Definition	Value(s)	Source(s)	Notes
FIS_i	Fraction of electricity from in-state generators	0.71 throughout forecast period	PSC communication	
$EEFIS_i$	In-state electricity emission factor	2012: 0.595 tonnes/MWh 2015: 0.548 tonnes/MWh 2020: 0.418 tonnes/MWh	PROMOD output, see below	
$EEFOS_i$	Emission factor for imported electricity	2012: 0.665 tonnes/MWh 2015: 0.61 tonnes/MWh 2020: 0.554 tonnes/MWh	PROMOD output, see below	

SAIC developed the in-state and out-of-state electricity emission factors using the PROMOD production cost model. PROMOD is a well-known electricity dispatching model. To develop the emission factors SAIC used the model to simulate the operation of the PJM system under expected conditions for hourly demand, generator characteristics, fuel cost, emission costs, and transmission limitations to energy transfer across the PJM system. We used generator-specific emissions rates developed from historical CEMS data. Also, we simulated the PJM system operation under two change cases: a 1 percent and a 2 percent reduction in PJM load. Our reported emissions rates are an average of the marginal emission rates for the two change cases. That is, we calculated the difference between the total CO_2 emissions in Maryland (or PJM system) for the Base Case and the total CO_2 emissions in Maryland for the 1 percent load reduction case. Dividing the decremental CO_2 output by the change in load gave us the marginal CO_2 emissions rate for Change Case 1. Then we did the same for the 2 percent load reduction case relative to the Base Case to compute a marginal CO_2 emissions rate for the 2 percent load reduction case. We averaged the two marginal CO_2 emissions rates to develop the above-documented CO_2 emissions factors in each forecast year.

1.6. GHG Emission Assumptions

1. The 15 percent electricity savings goal specified in the EmPOWER Maryland Act is to be achieved by 2015. We assume that this goal will be met, and that Maryland will reach the approximate halfway point (i.e., a 7 percent savings) by 2012.

2. Reductions are assumed to mirror current electricity use by sector

2.0. NAAQS CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated emissions reductions from RCI-10 are shown within Table RCI-10.5. All numbers for the criteria pollutants reflect a single year of emissions.

Table RCI-10.5- Emissions Reductions of Criteria Pollutants Associated with RCI-10 (tons per year)

	Across Maryland			Across Entire Domain		
Pollutant	**2012**	**2015**	**2020**	**2012**	**2015**	**2020**
SO_2	490	730	590	18,000	32,000	20,000
NO_X	230	530	200	4,700	9,200	8,300
CO	29	70	340	670	1,300	1,900
VOC	6	15	49	49	97	97
PM10-primary	270	680	780	1000	2,300	2,000
PM2.5-primary	250	620	680	720	1,600	1,700

These numbers were compared against the MANE-VU inventories for 2012 and 2018 (Table RCI-10.6). The 2018 emissions were estimated by interpolating between the 2015 and 2020 estimates. Table RCI-10.6 indicates that the criteria pollutant emissions reductions associated with this policy would be unlikely to improve air quality except through the reductions in SO_2 and later reductions in Maryland's PM2.5 emissions.

Table RCI-10.6- Percentage Reduction in Emissions Inventory Associated with RCI-10

	Across Maryland		Across Entire Domain	
Pollutant	**2012**	**2018**	**2012**	**2018**
SO_2	<1%	<1%	2%	3%
NO_X	<1%	<1%	<1%	<1%
CO	<1%	<1%	<1%	<1%
VOC	<1%	<1%	<1%	<1%
PM10-primary	<1%	<1%	<1%	<1%
PM2.5-primary	<1%	2%	<1%	<1%

Local and regional reductions in SO_2 emissions could result in reduced acid rain and less formation of sulfate particulate matter. This may result in more nitrate particulate matter formation and subsequent deposition to the Chesapeake Bay. Reductions in primary PM2.5 emissions within Maryland may lower ambient levels slightly and also improve visibility.

2.2. Summary of Air Quality Co-Benefits Methodology

The PROMOD model results estimate the decreased fuel consumption at various plants based on marginal reductions in electricity consumption. The marginal plant emissions reductions are calculated by multiplying each power plant's decreased fuel consumption by the plant-specific emission factors (lb pollutant/mmBtu), and domain-wide emission factors are computed from the marginal calculations.

Then emissions reductions are computed by multiplying the policy's decrease in fuel consumption by the domain-wide emission factors.

2.3. Air Quality Co-Benefit Calculations

Calculate Emissions Factor Associated with Marginal Power Plant Reductions

1. From the 2009 CAMD data sets, calculate the SO_2 and NO_X emissions rates per mmBtu for coal-fired power plants in EPA Regions 2, 3, 4, and 5.

2. From the 2007 MARAMA inventory for Maryland and surrounding states (DC, DE, NJ, PA, VA, and WV), find the CO, VOC, PM10, and PM2.5 emissions rates per mmBtu for coal-fired power plants that are listed in the database.

3. Use AP-42 emissions factors for oil and natural-gas fired utility boilers. Assume no emissions from renewable and nuclear plants.

4. Calculate the emissions factors for each power plant (lb/mmBtu).

5. Calculate the emissions for each plant for base load, 1 percent reduction and 2 percent reduction by multiplying the emission factors by the change in fuel consumption rates (in mmBtu/yr) from the PROMOD model (years 2012, 2015, and 2020—see Section 1.5 for additional details on the PROMOD model runs referred to here).

6. If the SO_2 or NO_X emissions for Maryland power plants exceeded the Healthy Air Act limits, reduce the base load emissions to those permit limits and compute the 1 percent and 2 percent reductions as a fraction of the base load using the ratios of fuel consumption rates.

7. Sum the fuel consumption rates and the pollutant emissions in the base load, 1 percent reduction case, and 2 percent reduction case across all plants (years 2012, 2015, and 2020). Do this for both Maryland and for the entire modeling domain.

8. Compute the emissions per percent load reduction and the fuel consumption per percent load reduction for the 1 percent and 2 percent cases. Average the 1 percent and 2 percent cases.

9. Calculate the marginal electricity emissions factors (lb pollutant/mmBtu change) as the emissions per percent load reduction divided by the fuel consumption per percent load reduction.

10. Calculate the marginal heat rate (mmBtu/MWh) as the marginal fuel consumption change divided by the marginal electricity generated.

Calculate Emission Reductions Associated with Fuel/Electricity Consumption Reductions

1. Use the marginal electricity emissions factors and the marginal heat conversions.

2. Multiply the calculated reductions in electricity demand (MWh) as computed in Step 1 of the GHG emission reduction methodology (see Section 1.4) by the marginal heat rates (mmBtu/MWh) and by the emission factors (lb/mmBtu) to calculate the emission reductions.

2.4. Air Quality Co-Benefits Data and Data Sources

The following data sources were used for the analysis:

- PROMOD Model: (http://www1.ventyx.com/analytics/promod.asp)
- Maryland's Healthy Air Act (http://www.mde.maryland.gov/programs/Air/Documents/26-11-27_MD_Healthy_Air_Act.pdf)
- AP-42 (http://www.epa.gov/ttn/chief/ap42/index.html)
- CAMD 2009 (http://camddataandmaps.epa.gov/gdm/)
- Cite MARAMA's 2007 Regional Emissions Inventories (http://www.marama.org/RegionalEmissionsInventory/2007BaseCase/index.html)
- MANE-VU Emissions Inventory (http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory)

3.0 INTERACTION WITH OTHER POLICIES

The discussion of policy interactions is provided in Chapter 5.

Chapter 2: Energy Supply (ES) Policies

The following ES Policies were analyzed:

- ES 3: GHG Cap and Trade
- ES 7: Renewable Portfolio Standard
- ES 8: Efficiency Improvements & Repowering Existing Plants

ES Policy Findings

Table 2.1 presents the 2020 GHG emission reduction estimates for the above-listed three policies. As the table indicates, Policy ES-3, the GHG Cap and Trade policy, is projected to yield the majority of the emission reductions in the ES sector; this policy accounts for 61 percent of the sum of reductions across all policies. It should be noted that there are significant overlaps in the projected emission reductions not only across the three ES policies, but between the ES and RCI policies. These overlaps are further discussed and quantified in Chapter 5.

Table 2.1. Summary of GHG Emission Reductions from the ES Sector in 2020

Sector/Policy	2020 GHG Emission Reductions ($MMTCO_2e$)
Energy Supply (ES)	
ES-3: GHG Cap and Trade	12.26
ES-7: Renewable Portfolio Standard	3.04
ES-8: Efficiency Improvements & Repowering Existing Plants	4.90
ES Total (Unadjusted for Overlaps)	**20.20**

Table 2.2 presents the projected 2020 reductions in criteria pollutant emissions for the three ES policies. As this table indicates, Policy ES-3 yields the majority of the reductions in all pollutants. As is the case for GHGs, there are significant overlaps in the criteria pollutant emissions reduction estimates; the reader is referred to Chapter 5 for a discussion and quantification of these overlaps.

Table 2.2. Summary of Criteria Pollutant Emission Reductions from the RCI Policies in 2020

		SO_2 (Tons)	NO_x (Tons)	CO (Tons)	VOC (Tons)	PM10 (Tons)	PM2.5 (Tons)
	Energy Supply (ES)						
ES-3	ES 3 - GHG Cap-and-Trade	17,000.00	5,700.00	220.00	45.00	2,100.00	1,900.00
ES-7	ES 7 - Renewable Portfolio Standard	510.00	-81.00	1.00	9.00	410.00	380.00
ES-8	ES 8 - Efficiency Improvements & Repowering Existing Plants	8,400.00	-2,500.00	-1,200.00	-68.00	1,000.00	870.00
	ES Total	**25,910.00**	**3,119.00**	**-979.00**	**-14.00**	**3,510.00**	**3,150.00**

Technical Notes:

PROMOD IV Model

The ES policies rely on the PROMOD IV Model for their results. The PROMOD *IV* Model is Fundamental Electric Market Simulation software that incorporates extensive details in generating unit operating characteristics, transmission grid topology and constraints, unit commitment/operating conditions, and market system operations. PROMOD IV algorithms can be exercised in several modes, depending upon the scope, time frame, and simulation resolution that align with the decision focus. The model can assess a variety of electric market components including:

- Locational marginal price for forecasting
- Valuation
- Transmission congestion analysis
- Environmental analysis
- Generation and transmission asset valuation
- Fuel strategy
- System reliability

More information on the PROMOD IV Model can be found on their website: http://www1.ventyx.com/analytics/promod.asp

MANE-VU Future Emissions Inventory

All of the air quality co-benefit analyses for the ES policies utilize the MANE-VU Future Emissions Inventory[7]. The MANE-VU Future Emissions Inventory represents a collaborative effort among northeastern and mid-Atlantic states to develop regionally consistent emissions inventories that account for projected growth and expected emissions control measures. The inventories for 2009, 2012, and 2018 are used by the states as they develop state implementation plans to meet national ambient air quality standards and progress goals to reducing regional haze. More information on MANE-VU can be found on the following website: (http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory).

[7]http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

Policy No.: ES-3

Policy Title: Greenhouse Gas (GHG) Cap-And-Trade (C&T)

SAIC was tasked with reviewing the ES-3 policy analysis which was conducted by a prior MDE contractor (Original Methodology) and revising the methodology to include Maryland-specific data and/or other enhancements. SAIC subsequently recalculated the GHG emission reductions associated with ES-3based upon its recommended methodology (Revised Methodology). SAIC also quantified the air quality co-benefits associated with ES-3. SAIC's revised policy findings are described below:

1. GHG EMISSION REDUCTIONS

The Regional Greenhouse Gas Initiative (RGGI) is the first market-based regulatory program in the United States to reduce carbon dioxide emissions. Ten Northeastern and Mid-Atlantic states, including Maryland, have capped and will reduce CO_2 emissions from the power sector 10 percent by 2018[8]. ES-3 embodies the RGGI carbon dioxide reduction goals for the state of Maryland.Table ES-3.1 below illustrates projected CO_2e emissions reductions in Maryland as a result of the RGGI program. By 2020, total GHG emissions reductions are 12.26 MMTCO_2e.

Table ES-3.1- GHG Emission Reductions Resulting from ES-3

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
Maryland	7.81	9.29	12.26

1.1. Summary of GHG Emission Methodology

SAIC estimated the emissions reduction due to RGGI by calculating the difference between projected Maryland electricity emissions and the RGGI cap for each year of the study period.

1.2. Rationale for GHG Emission Methodology

Since Maryland is part of RGGI and RGGI is based on an annual emissions cap emissions reductions were quantified by calculating the difference between forecasted emissions without RGGI and the RGGI cap.

1.3. Detailed Explanation of Methodology

SAIC first obtained annual Maryland electricity emissions projections from MDE for the study period. MDE produced the emissions projections based on 2006 emissions data from the EPA Clean Air Markets Division (CAMD). Since RGGI did not exist in 2006, the projections do not include any impacts from the RGGI program. MDE projected the 2006 emissions data using CAMD based output optimization assumptions, meaning that MDE didn't increase emissions greater than the actual capacity of the power plants in Maryland.

[8] http://www.rggi.org/home

SAIC then acquired the projected RGGI cap for each year of the study period. The difference between the MDE emissions projections and the RGGI cap resulted in the total GHG emissions reductions.

1.4. Difference Between Original & Revised Methodologies and Results

The Original Methodology evaluated the RGGI at multiple dollar amounts ranging from $1 per ton to $7 per ton, assuming that allowances were auctioned. In some cases, states reduced emissions by more than required by the cap in order to avoid the cost of purchasing an allowance. The Revised Methodology assumed that all emissions in Maryland are reduced by exactly the amount required to meet the cap.

The Original Methodology used projected emissions data based on 2005 data. The Revised Methodology employed an emissions forecast based on 2006 data. The 2006 data is more representative of a typical year of emissions than the 2005 data, and is about 1 $MMTCO_2$ lower than the 2005 data.

1.5. GHG Emission Reduction Calculations

The emissions reductions were calculated as the difference between the forecasted emissions without RGGI and the RGGI cap:

$$TER_i = PE_i - RC_i \qquad (1)$$

Where

TER_i = Total GHG emission reductions in year i for ES-3 (million metric tons CO_2e)

PE_i = Projected Emissions without RGGI for year i, (million metric tons CO_2e)

RC_i = RGGI Cap for year i, (million metric tons CO_2e)

Table ES-3.2: GHG Emissions with and without RGGI

Emissions Category	GHG Emissions (Million Metric Tons CO_2e)		
	2012	2015	2020
Projected Emissions (without RGGI)	41.83	42.46	42.88
RGGI Cap*	34.02	33.17	30.62
Maryland GHG Reductions from RGGI	7.81	9.29	12.26

*The RGGI cap is held constant at 34.02 million metric tons CO_2e between 2009 and 2014. However, beginning in 2015 the cap is decreased over time. This tightening of the cap beginning in 2015 is reflected in the above values shown for the cap.

1.6. GHG Emission Data and Data Sources

- Projected Emissions (PE_i) without RGGI are from MDE, and are based on 2006 in-state Maryland electricity emissions of 32.16 $MMTCO_2e$ from the EPA's Clean Air Markets Division, http://www.epa.gov/airmarket/emissions/

- RGGI Cap (RC_i) data is from the Regional Greenhouse Gas Initiative website and was converted to metric tons using 0.9072 metric tons per short tons. http://www.rggi.org/design/overview/cap

1.7. GHG Emission Assumptions

The following assumptions were used in the analysis:

- MDE's emissions projections are based on 2006 data.

- MDE chose 2006 as the base year because the Greenhouse Gas Emissions Reduction Act Requires a 2006 baseline. Furthermore, the 2006 data best represents typical emissions in Maryland and Maryland's GHG reduction targets are relative to 2006.

1.8. GHG Emission Analysis and Recommendations

Based on this analysis, RGGI has the potential to result in substantial savings.

2. AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

Table ES-3.3 presents the emissions changes that would have occurred if the ES-3 policy had not been adopted. They were calculated based on the emissions increases in criteria pollutant emissions expected if the Project Emissions listed in the first row of Table ES-3.2 occurred instead of the RGGI Cap emissions in the second row. The relationships are based on the increased power requirements at specific fossil fuel-fired power plants as calculated in the PROMOD model runs.

Table ES-3.3. Emissions *Increases* of Criteria Pollutants Associated with the Absence of Policy ES-3 (tons per year)

	Across Maryland			Across Modeling Domain		
Pollutant	**2012**	**2015**	**2020**	**2012**	**2015**	**2020**
SO_2	14,000	12,000	17,000	520,000	560,000	605,000
NO_X	6,800	9,000	5,700	140,000	160,000	250,000
CO	200	230	220	4,800	4,400	8,900
VOC	42	48	45	360	320	460
PM10-primary	2,000	2,300	2,100	7,400	7,700	9,300
PM2.5-primary	1,800	2,100	1,900	5,200	5,500	6,700

These numbers were compared against the theoretical base MANE-VU inventories for 2012 and 2018 in Table ES-3.4. The 2018 emissions were estimated by interpolating between the 2015 and 2020 estimates.

The theoretical base inventory represents the case where RGGI had not been adopted (MANE-VU emissions estimates plus emissions increases listed in Table ES-1.4). Table ES-3.4 indicates that the criteria pollutant emissions reductions associated with this policy alone would likely affect SO_2, NO_X, and particulate matter emission levels across all years by substituting high sulfur coal burning with other energy types.

Table ES-3.4- Percentage Reductions Associated with Policy ES-3 from *Theoretical Base* Emissions Inventory

	Across Maryland		**Across Modeling Domain***	
Pollutant	**2012**	**2018**	**2012**	**2018**
SO_2	12%	15%	34%	39%
NO_X	5%	7%	9%	15%
CO	<1%	<1%	<1%	<1%
VOC	<1%	<1%	<1%	<1%
PM10-primary	2%	2%	<1%	<1%
PM2.5-primary	4%	4%	1%	1%

* Note that emissions reductions are scaled against the adoption of RGGI in Maryland. Therefore, the percentages reflect the case where other states (even those outside the RGGI domain) adopt commensurate measures.

Reductions in SO_2 emissions could result in reduced acid rain and less formation of sulfate particulate matter across the entire domain. Local and regional reductions in NO_X emissions could improve local ambient ozone concentrations on days when the ozone formation rates are NO_X-controlled. Local reductions in PM10 emissions would result in improved air quality in Maryland. The PM2.5 reductions would result in improved air quality and reductions in regional haze.

2.2. Summary of Air Quality Co-Benefits Methodology

The PROMOD model results are used to estimate the increased power generation (as a percentage of the base load) at various power plants based on the estimate of increased CO_2 production in Maryland without the RGGI policy. The plant emissions increases are calculated by multiplying each power plant's increased fuel consumption by the plant-specific emission factors (lb pollutant/ percent change in power generation), and then emissions increases for the absence of policy are totaled over the whole domain.

Note that these calculations make two major assumptions, in addition to those introduced by the PROMOD modeling:

- The calculations assume that the replacement power is generated by means other than fuel burning (i.e., biomass and landfill gas burning does not replace the fossil fuel firing).

- Policy improvements in Maryland are reflected as decreased fossil fuel-fired generation in other States that fall within the PROMOD modeling domain (extending as far west as Illinois).

Because the PROMOD modeling exercise and the MANE-VU emission inventories already reflect adoption of the RGGI compact, the numbers in Table 5 reflect percentage reductions from an inventory that reflects emissions as if the RGGI policy had not been initiated.

2.3. Air Quality Co-Benefit Calculations

Calculate Emission Factors Associated with Marginal Power Plant Changes

1. From the 2009 CAMD data sets, calculate the SO_2 and NO_X emissions rates per mmBtu for coal-fired power plants in EPA Regions 2, 3, 4, and 5.

2. From the 2007 MARAMA inventory for Maryland and surrounding states (DC, DE, NJ, PA, VA, and WV), find the CO, VOC, PM10, and PM2.5 emissions rates per mmBtu for coal-fired power plants that are listed in the database.

3. Use AP-42 emissions factors for oil and natural-gas fired utility boilers. Assume no emissions from renewable and nuclear plants.

4. Calculate the emissions factors for each power plant (lb/mmBtu).

5. Calculate the emissions for each plant for base load, 1 percent reduction and 2 percent reduction by multiplying the emission factors by the change in fuel consumption rates (in mmBtu/yr) from the PROMOD model (years 2012, 2015, and 2020—see Section 2.2 above for additional details on the PROMOD model runs referred to here).

6. If the SO_2 or NO_X emissions for Maryland power plants exceeded the Healthy Air Act limits, reduce the base load emissions to those permit limits and compute the 1 percent and 2 percent reductions as a fraction of the base load using the ratios of fuel consumption rates.

7. Sum the Maryland CO_2 production rates and the pollutant emissions in the base load, 1 percent reduction case, and 2 percent reduction case across all plants (years 2012, 2015, and 2020). Do this for both Maryland and for the entire modeling domain.

8. Compute the emissions per percent load reduction and the Maryland CO_2 production rate per percent load reduction for the 1 percent and 2 percent cases. Average the 1 percent and 2 percent cases.

9. Calculate the marginal electricity emissions factors (lb pollutant/ton CO_2 change) as the emissions per percent load reduction divided by the Maryland CO_2 production rate per percent load reduction.

Calculate Emissions Increases Associated with Fuel/Electricity Consumption Changes if ES-3 Was Not Adopted

1. Use the marginal electricity emissions factors.

2. Multiply the calculated changes in Maryland CO_2 production from Table 1 by the emission factors (lb/ton CO_2 change) to calculate the emission increases.

Calculate Emissions Percentage Reductions Associated with ES-3 from Theoretical Base Emissions Inventory

1. The co-benefits of other GHG policies in this study were compared directly against the MANE-VU emissions inventory. However, the RGGI policy was already incorporated into the MANE-VU estimates and represents a significant change in the MANE-VU inventories (e.g., Table 4's 2012 value for SO_2 was 50 percent of the MANE-VU inventory).

2. The MANE-VU inventories reflect emissions projections with the assumption that RGGI was implemented. The numbers in Table 4 represent the additional emissions that would have occurred if RGGI was not adopted. The total of the MANE-VU inventory and Table 4 should reflect the theoretical base emissions inventory.

3. The numbers in Table 4 were divided by the theoretical base emissions inventory to calculate the percentage reductions.

2.4. Air Quality Co-Benefits Data and Data Sources

The following data sources were used for the analysis:

- PROMOD Model: (http://www1.ventyx.com/analytics/promod.asp)
- Maryland's Healthy Air Act (http://www.mde.maryland.gov/programs/Air/Documents/26-11-27_MD_Healthy_Air_Act.pdf)
- AP-42 (http://www.epa.gov/ttn/chief/ap42/index.html)
- CAMD 2009 (http://camddataandmaps.epa.gov/gdm/)
- MARAMA's 2007 Regional Emissions Inventories (http://www.marama.org/RegionalEmissionsInventory/2007BaseCase/index.html)
- MANE-VU Emissions Inventory (http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory)

3.0 INTERACTIONS WITH OTHER POLICIES

The discussion of policy interactions is provided in Chapter 5.

Policy No.: ES-7

Policy Title: Renewable Portfolio Standard (RPS)

SAIC was tasked with reviewing the ES-7 policy analysis which was conducted by a prior MDE contractor (Original Methodology) and revising the methodology to include Maryland-specific data and/or other enhancements. SAIC subsequently recalculated the GHG emission reductions associated with ES-7 based upon its recommended methodology (Revised Methodology). SAIC also quantified the air quality co-benefits associated with ES-7. SAIC's revised policy findings are described below:

1.0 GHG EMISSION REDUCTIONS

The Maryland Renewable Energy Portfolio Standard (RPS) has the potential to contribute to significant reductions in GHG emissions. Table 1 illustrates the projected GHG reductions from the Tier 1[9] standard. The current Tier 1 standard is to supply 20 percent of 2022 electricity from renewable resources, two percent of which would come from solar energy (Solar Carveout). The 2020 goal is 16.5 percent from non-solar Tier 1 resources and 1.5 percent from solar resources. In 2020, this is expected to result in 2.56 $MMTCO_2e$ savings from non-solar resources and 0.48 $MMTCO_2e$ savings from solar resources, compared to a scenario without an RPS.

There is also a Tier 2[10] standard, which requires energy to come from large hydroelectric or waste-to-energy facilities. This is not modeled here as the requirement is satisfied with existing facilities and therefore does not result in any additional reductions.

Table ES-7.1- GHG Emission Reductions as a Result of ES-7

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
Current Tier 1 Non-Solar	1.16	1.90	2.56
Solar Carveout	0.04	0.14	0.48
Total Current RPS	1.19	2.04	3.04

1.1. Summary of GHG Emission Methodology

SAIC's methodology is based on the assumption that new renewable resources built to fulfill the RPS would be displacing the marginal electricity resource. The marginal electricity resource is the last electricity resource called upon to meet electricity demand, assuming that resources are dispatched in order of cost with the least expensive resources dispatched first. For example, during periods of low

[9]The Maryland Tier 1 Renewable Portfolio Standard requires electricity suppliers to provide 20 percent of in-state retail electricity sales from renewable resources such as wind, solar, and biomass by 2022. The requirement began in 2006 at 1 percent, and increases gradually to 20 percent by 2022. Two percent of the final requirement is to come from solar resources.
[10]The Maryland Tier 2 Renewable Portfolio Standard requires electricity suppliers to provide 2.5 percent of in-state retail electricity sales from hydroelectric power other than pumped storage and waste-to-energy facilities. The requirement began in 2006 at 2.5 percent and remains in place through 2018. After 2018 there is no Tier 2 requirement.

demand, such as at night, the marginal electricity resource is coal, which has a low variable cost. When demand is higher, such as in the middle of the day in the summer, more expensive resources such as natural gas plants are dispatched to meet the additional demand. Thus, when new electricity is added to the system, it displaces the marginal resource, the resource that would have been the final unit to be dispatched.

SAIC's methodology was to first determine the emissions rates for the marginal resources associated with Maryland power consumption. Then, the marginal emissions rates were multiplied by the quantity of renewable energy required by the RPS to calculate the total GHG emissions avoided.

1.2. Rationale for GHG Emission Methodology

SAIC chose to calculate reductions in emissions based on marginal emissions rates rather than based on coal plant emissions rates. Marginal emissions rates were chosen because it was assumed that additional renewables would replace energy at the margin, which is a mix of coal and gas fired power, depending on the season and time of day.

1.3. Detailed Explanation of GHG Emission Methodology

SAIC first used a dispatch model to estimate the marginal emissions rate associated with Maryland power consumption for the period of the study. Since the RPS program allows the acquisition of resources from surrounding states, the entire PJM market was modeled. To simulate power market operations SAIC used a customized PowerBase™ database, the MarketPower™ simulation model and the Promod™ dispatch model, all distributed by Ventyx. The PowerBase™ database is updated by SAIC to make the database consistent with our knowledge of the North American power markets.

The MarketPower™ model performs a chronological economic dispatch of the multiple, interconnected market areas, simulating all loads and resources, transmission interconnections, and unit outages on an hourly basis. The model simulates the mothballing of un-economic plants and produces an optimized generic capacity expansion plan. The Promod™ model uses the capacity expansion plan and a detailed hourly simulation of the power markets to produce the hourly, monthly, and annual average emissions rates for individual market areas.

The monthly marginal emissions rates for each year were extracted from the dispatch model results. Monthly rates were chosen because wind in PJM, the primary renewable resource, produces more energy in winter months than in summer months. The emissions rates were applied to the energy projected to be produced from renewable resources for each of the study years. SAIC also calculated the emissions associated with biomass and landfill gas resources and reduced the projected emissions savings by those amounts.

1.4. Differences Between Original & Revised Methodologies and Results

The main difference between the CCS and SAIC methodologies is that CCS assumed renewable electricity would be replacing electricity produced by coal plants, while SAIC assumed that it would be replacing electricity produced by a mix of coal and natural gas plants.

CCS estimated GHG reductions from the RPS by comparing the difference in GHG emissions rates from coal plants to GHG emissions rates from a mix of Tier 1 renewable resources, mainly wind. The difference in emissions rates was multiplied by the energy displaced by the RPS to determine net GHG savings.

SAIC's methodology was to apply emissions rates associated with the marginal electricity resource dispatched to meet Maryland power consumption. SAIC chose the marginal resource because it is the resource that would be displaced by new renewable resources. During periods of low demand, such as at night, the marginal electricity resource is coal. When demand is higher, such as in the middle of the day in the summer, more expensive resources such as natural gas plants are called upon to meet the additional demand. Thus, over the course of a month, the average marginal resource is a mix of coal and natural gas plants. SAIC then multiplied the marginal emissions rates by the quantity of renewable energy required by the RPS to calculate the displaced GHG emissions.

The emissions reductions calculated by SAIC are lower than those calculated by CCS. This is because the GHG emissions rate for coal plants is much higher than the rate for natural gas plants. CCS used the higher coal plant GHG emissions rate to calculate emissions reductions, while SAIC used a rate based on the marginal electricity resource, which is a mix of gas and coal plants, and therefore lower than an emissions rate based solely on coal.

1.5. GHG Emission Calculations

The total emissions reductions for each year was calculated as a product of the target RPS percentage, the energy demand, and the marginal emissions rate adjusted for monthly renewable energy production profiles, less any emissions produced by the renewable energy.

$$TER_i = ED_i * TRP_i * AMER_i /1000 - REE_i \quad (1)$$

Where

TER_i = Total GHG emission reductions in year i for Policy ES-7 (million metric tons CO_2e)

ED_i = Energy Demand for year i (GWh)

TRP_i = Target RPS Percentage for year i (% of energy consumed)

$AMER_i$ = Adjusted Marginal GHG Emissions Rate for Year i (million metric tons CO_2e per MWh)

$$AMERi = \sum_{m=1}^{12} \sum_{j=1}^{4} PRj * MEFm,j * MERm \quad (2)$$

Where

m = month

j = Resource

PRj = Percentage of Resource j (wind, biomass, landfill gas, or hydro; solar is calculated separately)

MEF_{mj} = Monthly Energy Factor for month m for resource j (% of annual energy produced in month m)

MER_m = Marginal GHG Emissions Rate for month m (million metric tons CO_2e per MWh)

REE_i = Renewable Energy Emissions for year i

$$REEi = \sum_{j=1}^{4} EDi * TRPi * PRj * ERj \qquad (3)$$

Where

ER_j = GHG Emissions Rate for resource j (million metric tons CO_2e per MWh)

1.6. GHG Emission Data and Data Sources

Energy Demand

- The Energy Demand (ED_i) for Maryland is from the projected demand in *Maryland's Ten Year Plan (2009 – 2018) of Electric Companies in Maryland,* reduced by five percent to account for sales that are exempt from the RPS.
- Public Service Commission of Maryland, *Maryland's Ten Year Plan (2009 – 2018) of Electric Companies in Maryland,* February 2010. http://www.eia.doe.gov/cneaf/electricity/epm/table5_4_b.html

Table ES-7.2- Projected State Energy Demand (GWh)

	Energy Demand (GWh)		
	2012	2015	2020
Maryland Electricity Demand	62,472	64,084	68,569

Target RPS Percentage

Source:

- The RPS standards and associated annual Target RPS Percentage requirements (TRP_i) are listed in Table ES-7.3. Also included is the Total RPS Energy Demand, which is the product of the State Energy Demand (ED_i) and the Target RPS Percentage Requirement.

Table ES-7.3- Target RPS Percentage and Energy Demand

Standard	RPS Requirement		
	2012	2015	2020
Current Tier 1 Non-Solar	6.4%	10.1%	16.5%
Solar Carveout	0.1%	0.4%	1.5%
Total Tier 1 RPS	6.5%	10.5%	18.0%
Total RPS Energy Demand (GWh)	4,061	6,729	12,342

Sources:

- Database of State Incentives for Renewables and Efficiency Website, http://www.dsireusa.org/
- Maryland Commission on Climate Change (MCCC), *Maryland Climate Action Plan*, 2008. http://www.mdclimatechange.us/

Marginal GHG Emissions Rate

Table ES-7.4- Monthly Marginal GHG Emissions Rates (MER_m)

Month	Marginal GHG Emissions Rate (TCO_2e/MWh)		
	2012	2015	2020
1	0.8	0.7	0.4
2	0.7	0.6	0.5
3	0.8	0.5	0.4
4	0.8	0.6	0.6
5	0.4	0.5	0.5
6	0.5	0.6	0.5
7	0.5	0.6	0.5
8	0.4	0.5	0.4
9	0.4	0.5	0.5
10	0.6	0.5	0.4
11	0.6	0.5	0.5
12	0.9	0.7	0.4

Source:

- MarketPower™ simulation model and the Promod™ dispatch model

Energy Mix

The annual Energy Mix is based on 2008 compliance data for the Maryland RPS and the mix of proposed renewables is based on the Ventyx Energy Velocity Database. New renewable energy is added in the following proportion: wind – 83.5 percent, biomass – 13.3 percent, landfill gas – 3.2 percent. Table ES-7.5 displays the renewable energy mix and the associated energy production.

Table ES-7.5- Percentage Energy Mix (PRj) for the Tier 1 RPS Requirement and associated energy production

Resource	Energy Mix		
	2012	2015	2020
Energy Percentage			
Wind	57.7%	67.5%	74.3%
Biomass	30.2%	23.7%	19.3%
LFG	6.8%	5.5%	4.5%
Hydro	5.3%	3.3%	1.9%
Energy Production (GWh)			
Wind	2,307	4,371	8,412
Biomass	1,206	1,535	2,179
LFG	274	354	511
Hydro	212	212	212

Sources:

- Public Service Commission of Maryland, *Renewable Energy Portfolio Standard Report of 2010*, February 2010.
- Ventyx Energy Velocity Database

Monthly Energy Factor

The Monthly Energy Factor (MEF_{mj})provides the amount of energy produced in each month by a particular resource relative to the rest of the year. Wind, the main resource assumed to meet the RPS, produces more energy in the winter. The wind pattern is the average of several regional wind patterns.

Table ES-7.6- Monthly Energy Factor

Month	Monthly Energy Production				
	Wind	Biomass	LFG	Hydro	Solar
1	13.7%	8.3%	8.3%	8.3%	6.9%
2	12.0%	8.3%	8.3%	8.3%	7.9%
3	8.7%	8.3%	8.3%	8.3%	9.1%
4	7.6%	8.3%	8.3%	8.3%	9.2%
5	6.4%	8.3%	8.3%	8.3%	9.4%
6	4.1%	8.3%	8.3%	8.3%	9.5%
7	5.4%	8.3%	8.3%	8.3%	9.6%
8	4.6%	8.3%	8.3%	8.3%	9.0%
9	6.7%	8.3%	8.3%	8.3%	8.3%
10	10.5%	8.3%	8.3%	8.3%	9.0%
11	7.2%	8.3%	8.3%	8.3%	6.6%
12	13.1%	8.3%	8.3%	8.3%	5.5%

Sources:

- National Renewable Energy Laboratory, PV Watts Database, http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/.
- National Renewable Energy Laboratory, Wind Integration Datasets, http://www.nrel.gov/wind/integrationdatasets/eastern/methodology.html.

1.7. GHG Emission Assumptions

The mix of renewables begins with the actual mix reported in 2008 compliance data. New renewables are added based on the proportion of proposed renewable resources in the PJM region, derated based on resource-specific historical success rates. The mix of renewable resources chosen was 83 percent wind, 13 percent biomass, and 3 percent landfill gas.

Wind and hydro are assumed to have an emissions rate of 0. Biomass and landfill gas are assumed to have emissions rates of 1.0612 tCO_2/MWh and 0.5306 tCO_2/MWh, respectively

1.8. GHG Emission Analysis and Recommendations

The addition of renewable electricity displaces gas and coal electricity, which generally have higher GHG emissions than renewable electricity. Wind, solar, and hydroelectric resources all have zero emissions. Landfill gas and biomass resources have relatively higher emissions, but due to their smaller contribution to the projected renewable electricity portfolio, the ultimate affect is a reduction in GHG emissions. Thus, this analysis illustrates the potential of moderate GHG emissions reductions due to the Tier 1 RPS.

2.0 AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated emissions reductions from ES-7 are shown within Table 7. All numbers for the criteria pollutants reflect a single year of emissions. Because the landfill gas boilers were assumed to be built in Maryland (in order to meet Maryland's RPS) to replace other boilers that may have higher efficiencies or more effective controls (e.g., Selective Catalytic Reduction (SCR)), the emissions reductions of criteria pollutants within Maryland were not always greater than zero.

Table ES-7.7- Emissions Reductions of Criteria Pollutants Associated with ES-7 (tons per year)

	Across Maryland			Across Entire Domain		
Pollutant	**2012**	**2015**	**2020**	**2012**	**2015**	**2020**
SO_2	280	330	510	9,900	14,000	18,000
NO_X	-9	71	-81	2,500	4,100	6,900
CO	-6	2	1	350	570	1,600
VOC	3	7	9	28	45	85
PM10-primary	140	300	410	570	1,000	1,800
PM2.5-primary	130	270	380	390	740	1,400

These numbers were compared against the MANE-VU inventories for 2012 and 2018 (Table 8). The 2018 emissions were estimated by interpolating between the 2015 and 2020 estimates. Table 8 indicates that the criteria pollutant emissions reductions associated with this policy alone would likely only affect SO_2 emission levels in the early years by substituting high sulfur coal with other energy types. By 2018 Table 8 shows that small emissions inventory reductions for sulfur dioxide and particulate matter could be achieved through the RPS policy.

Table ES-7.8. Percentage Reduction in Emissions Inventory Associated with ES-7

	Across Maryland		Across Entire Domain	
Pollutant	**2012**	**2018**	**2012**	**2018**
SO_2	<1%	<1%	1%	2%
NO_X	<1%	<1%	<1%	<1%
CO	<1%	<1%	<1%	<1%
VOC	<1%	<1%	<1%	<1%
PM10-primary	<1%	<1%	<1%	<1%
PM2.5-primary	<1%	1%	<1%	<1%

Reductions in SO_2 emissions could result in reduced acid rain and less formation of sulfate particulate matter across the entire domain. Local reductions in particulate matter emissions would improve local ambient particulate matter concentrations and improve visibility.

2.2. Summary of Air Quality Co-Benefits Methodology

The PROMOD model results estimate the decreased fuel consumption at various plants based on marginal reductions in electricity consumption. The marginal plant emissions reductions are calculated by multiplying each power plant's decreased fuel consumption by the plant-specific emission factors (lb pollutant/mmBtu), and domain-wide emission factors are computed from the marginal calculations.

Then emissions reductions are computed by multiplying the policy's decrease in fuel consumption by the domain-wide emission factors. An assumption that electric generators would begin co-firing small quantities of biomass with coal did not lead to reduced emission factors. Emissions increases resulting from the development of landfill gas boilers were calculated by multiplying EPA's AP-42 emission factors by the increased electric demand on this sector.

2.3. Air Quality Co-Benefit Calculations

Calculate Emissions Factors Associated with Marginal Power Plant Reductions

1. From the 2009 CAMD data sets, calculate the SO_2 and NO_X emissions rates per mmBtu for coal-fired power plants in EPA Regions 2, 3, 4, and 5.

2. From the 2007 MARAMA inventory for Maryland and surrounding states (DC, DE, NJ, PA, VA, and WV), find the CO, VOC, PM10, and PM2.5 emissions rates per mmBtu for coal-fired power plants that are listed in the database.

3. Use AP-42 emissions factors for oil and natural-gas fired utility boilers. Assume no emissions from renewable and nuclear plants.

4. Calculate the emissions factors for each power plant (lb/mmBtu).

5. Calculate the emissions for each plant for base load, 1 percent reduction and 2 percent reduction by multiplying the emission factors by the change in fuel consumption rates (in mmBtu/yr) from the PROMOD model (years 2012, 2015, and 2020—see Section **2.2** for additional details on the PROMOD model runs referred to here).

6. If the SO_2 or NO_X emissions for Maryland power plants exceeded the Healthy Air Act limits, reduce the base load emissions to those permit limits and compute the 1 percent and 2 percent reductions as a fraction of the base load using the ratios of fuel consumption rates.

7. Sum the fuel consumption rates and the pollutant emissions in the base load, 1 percent reduction case, and 2 percent reduction case across all plants (years 2012, 2015, and 2020). Do this for both Maryland and for the entire modeling domain.

8. Compute the emissions per percent load reduction and the electric generation per percent load reduction for the 1 percent and 2 percent cases. Average the 1 percent and 2 percent cases.

9. Calculate the marginal electricity emissions factors (lb pollutant/MWh change) as the emissions per percent load reduction divided by the electric generation per percent load reduction.

Calculate Emissions Reductions Associated with Fuel/Electricity Consumption Reductions

1. Use the marginal electricity emissions factors.

2. Assume that co-firing coal-fired plants with less than 10 percent biomass does not significantly change the criteria pollutant emission factors (based on figure presented by Lesley Sloss of the IEA Clean Coal Centre at the 35th Annual EPA-A&WMA Annual Exchange in December 2010) from those for coal alone. Therefore, any generation capacity allotted to biomass in the RPS was treated with the same emission factors that were used for PROMOD.

3. Use AP-42 emission factors for landfill gas boilers, and assume that the RPS landfill gas boilers are all located within Maryland. To calculate the necessary landfill gas rates to meet electric demand, assume factors of 7 mmBtu/MWh for new boilers and 0.3 mmBtu/mcf landfill gases. Because landfill gas boilers would be replacing unspecified SO_2 and VOC emissions controls at the landfills but likely have negligible effects on total emissions changes, the SO_2 and VOC emissions increases were not computed

4. Multiply the calculated quantities of renewable electricity generation (MWh) from Table 5 by the emission factors (lb/MWh) to calculate the emission reductions.

2.4. Air Quality Co-Benefits Data and Data Assumptions

The following data sources were used for the analysis:

- PROMOD Model: (http://www1.ventyx.com/analytics/promod.asp)
- Maryland's Healthy Air Act (http://www.mde.maryland.gov/programs/Air/Documents/26-11-27_MD_Healthy_Air_Act.pdf)
- AP-42 (http://www.epa.gov/ttn/chief/ap42/index.html)
- CAMD 2009 (http://camddataandmaps.epa.gov/gdm/)
- Cite MARAMA's 2007 Regional Emissions Inventories (http://www.marama.org/RegionalEmissionsInventory/2007BaseCase/index.html)

- MANE-VU Emissions Inventory (http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory)

3.0 INTERACTION WITH OTHER POLICIES

The discussion of policy interactions is provided in Chapter 5.

Policy No.: ES-8

Policy Title: Efficiency Improvements and Repowering of Existing Power Plants

SAIC was tasked with reviewing the ES-8 policy analysis which was conducted by a prior MDE contractor (Original Methodology). SAIC conducted a thorough examination of the methodologies, assumptions, data sources, and results and subsequently described the methodology and results as well as provided SAIC's observations and recommendations. SAIC also quantified the air quality co-benefits associated with ES-8. SAIC's findings are described below:

1.0 GHG EMISSION REDUCTIONS

The purpose of ES-8 is to improve efficiency at existing power plants and repower existing coal plants with natural gas. The goals for this policy include advocating for regulations to incentivize efficiency improvements, such as setting a carbon price or the EPA developing new regulations to install carbon reducing technology.

The potential GHG reductions were analyzed for two aspects of the Efficiency Improvements and Repowering of Existing Power Plants policy. The first was co-firing biomass at existing coal plants, reaching eight percent of energy input by 2015. The second was repowering several coal plants with natural gas-fired combined cycle (NGCC) technology by 2020. Table ES-8.1 illustrates the GHG emission reductions resulting from ES-8:

Table ES-8.1- GHG Emission Reductions Resulting from ES-8

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
Biomass Cofiring	1.2	2.0	2.0
Coal Plant Repowering	0.5	1.4	2.9

1.1. Summary of GHG Emission Methodology

The reduction in GHG emissions from the co-firing coal with biomass option was determined by calculating the emissions produced by the eight percent of coal generation to be replaced by biomass generation. This is the quantity of emissions avoided. To calculate the GHG reductions from repowering existing coal plants with NGCC, the emissions between coal and natural gas were compared and the net reduction that switching 30 percent of coal plants to natural gas would produce was calculated.

1.2. Rationale for GHG Emission Methodology

This methodology of displacing coal with other fuel sources was chosen as a straightforward way to calculate potential emissions savings of repowering plants. The differences in emissions rates were applied to the fuel quantities to determine emissions reductions.

1.3. Detailed Explanation of GHG Emission Methodology

To evaluate the biomass co-firing option, it was assumed that co-firing would begin in 2010 and increase linearly until 2015, when it would contribute to eight percent of energy input at existing coal plants. The emissions from co-fired biomass were compared to coal plants to determine the quantity of GHG reductions.

For the calculation of GHG reductions from repowering existing coal plants with NGCC, it was assumed NGCC would replace coal at a rate of three percent a year beginning in 2011. Ultimately, the goal is to repower 30 percent of eligible coal stations as NGCC by 2020. As in the biomass analysis, coal emissions were compared with NGCC emissions to determine the quantity of GHG reductions.

1.4.GHG Emission Calculations

The same methodology to calculate emissions reductions for the Biomass Co-firing Option was used to calculate emission reductions from the Coal Plant Re-Powering Option:

1. For each year of the study, the coal electricity production was multiplied by the percentage assumed to be replaced by the alternative fuel (either natural gas or biomass) to calculate the total coal fueled generation replaced.

   $$CGR_i = CG_i * PR_i \quad (1)$$

   Where

   CGR_i = Coal Generation Replaced for year i (GWh)

   CG_i = Coal Generation for year i (GWh)

   PR_i = Percentage of coal generation Replaced for year i (%)

2. Then, the quantity of Coal Generation Replaced was multiplied by the emissions rate for coal to determine the quantity of coal emissions reduced.

   $$CER_i = CGR_i * CER_i \quad (2)$$

   Where

   CER_i = Coal Emissions Reduction for year i ($MMTCO_2e$)

   CGR_i = Coal Generation Replaced for year i (GWh)

   CER_i = Coal Emissions Rate ($MMTCO_2e$ per GWh)

3. Next, for the Coal Plant Re-Powering Option, the quantity of the replacement natural gas generation (which is the equal to the coal generation replaced) was multiplied by the emissions rate for natural gas to determine the amount of emissions increased by the alternative fuel. This step was unnecessary for the Biomass Co-firing Option because biomass was assumed to have an emissions rate of 0.

$$NGE_i = CGR_i * NGER_i \qquad (3)$$

Where

NGE_i = Natural Gas Emissions for year i ($MMTCO_2e$)

CGR_i = Coal Generation Replaced for year i (GWh)

$NGER_i$ = Natural Gas Emissions Rate ($MMTCO_2e$ per GWh)

4. Finally, the difference between the quantity of emissions reduced by the decrease in coal use and the quantity of emissions augmented by the increase in natural gas use or biomass use (assumed to be 0) determined the net amount of emissions reductions.

Coal Plant Repowering Option: $NER_i = CER_i - NGE_i \qquad (4)$
or

Biomass Cofiring Option: $NER_i = CER_i \qquad (5)$

Where

NER_i = Net Emissions Reduction for year i ($MMTCO_2e$)

CER_i = Coal Emissions Reduction for year i ($MMTCO_2e$)

NGE_i = Natural Gas Emissions for year i ($MMTCO_2e$)

1.5. GHG Emission Data and Data Sources

- EIA Annual Energy Outlook 2007
- Maryland Commission on Climate Change, *Climate Action Plan,* Appendix D, Greenhouse Gas & Carbon Mitigation Working Group Policy Option Documents, August 2008. Available at http://www.mde.state.md.us/programs/Air/ClimateChange/Documents/www.mde.state.md.us/assets/document/Air/ClimateChange/Appendix_D_Mitigation.pdf

- Maryland Power Plant Research Program (PPRP). 2006. The Potential for Biomass Co-firing in Maryland. Available at http://esm.versar.com/PPRP/bibliography/PPES_06_02/PPES_06_02.pdf

1.6. GHG Emission Assumptions

Table ES-8.2- Table of Assumptions and Inputs

Table of Assumptions and Inputs		2012	2015	2020
CCS Base Case Forecast (before policies are enacted)				
	Coal Generation (GWh)	25,901	25,901	25,901
	Natural Gas Generation (GWh)	1,006	1,006	1,006
	Coal Emissions ($MMTCO_2e$)	24.98	24.86	24.66
	Natural Gas Gross Emissions ($MMTCO_2e$)	0.6	0.6	0.6
	Coal Emissions Rate ($MMTCO_2e$/GWh)	0.0010	0.0010	0.0010
	Natural Gas Emissions Rate ($MMTCO_2$/GWh)	0.0006	0.0006	0.0006
Biomass Co-Firing Option				
	Co-Firing Target Percentage	5%	8%	8%
	Coal Generation Replaced by Biomass (GWh)	1,243	2,072	2,072
	Coal Emissions Reduction ($MMTCO_2e$)	1.2	2.0	2.0
Coal Plant Repowering Option				
	Repowering Target Percentage	6%	15%	30%
	Coal Generation Replaced by Natural Gas (GWh)	1,554	3,885	7,770
	Coal Emissions Reduction ($MMTCO_2e$)	1.5	3.7	7.4
	Natural Gas Emissions Increase ($MMTCO_2$)	1.0	2.3	4.5
	Net Emissions Reduction ($MMTCO_2$)	0.5	1.4	2.9

The Original Methodology assumed that historical generation and emissions quantities would remain constant and that all increases in demand would be met with imports. It also assumed biomass to have zero GHG emissions.

1.7. GHG Emission Analysis and Recommendations

The Original Methodology assumed that biomass has net zero GHG emissions. This is not consistent with MDE's policy on biomass, which is to quantify biomass emissions from combustion. To reflect MDE's policy accurately, this analysis should include biomass GHG emissions.

The Original Methodology did not analyze the potential GHG reductions from efficiency improvements. Emissions savings could result from decreased station load and/or improved heat rate. Plant-wide efficiency measures could reduce the energy requirements of plant operations, thereby increasing net output per unit of fuel. Process improvements could potentially increase the efficiency of the power generation process and reduce net plant heat rate. Improvements in efficiency and heat rates would reduce the quantity of GHG emissions per unit of generation. These improvements would also be consistent with recent EPA best available control technology guidance related to the Clean Air Act Prevention of Significant Deterioration and Title V GHG Tailoring Rule.

Finally, the Original Methodology's assumption that biomass could replace 8 percent of the coal consumed by Maryland's coal-fired power plants may be unrealistic in light of the fact that only two of the State's coal units have existing Title V permits for co-firing. A more realistic assumption could be developed by assessing the potential for biomass co-firing at these two units.

2.0 AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

Although the policy introduces measures for reducing CO_2 emissions, this policy will have less significant effects on criteria pollutant emissions. Introduction of small amounts of biomass to the feed at coal-fired plants does not significantly change the criteria pollutant emission factors (based on figure presented by Lesley Sloss of the IEA Clean Coal Centre at the 35th Annual EPA-A&WMA Annual Exchange in December 2010) from those for coal alone.

The estimated emissions reductions from Policy ES-8 are shown within Table ES-8.3. All numbers for the criteria pollutants reflect a single year of emissions. As a policy to repower Maryland's electricity generators, all of the emissions changes were assigned to Maryland and not the surrounding states. The emissions changes are due to replacement of Maryland's coal-fired power plants (already complying with the Healthy Air Act) with NGCCs (assuming water-steam injection controls).

Table ES-8.3- Emissions Reductions of Criteria Pollutants Associated with ES-8 (tons per year)

	Across Maryland			Across Entire Domain		
Pollutant	**2012**	**2015**	**2020**	**2012**	**2015**	**2020**
SO_2	2,600	5,000	8,400	2,600	5,000	8,400
NO_X	-460	-1,100	-2,500	-460	-1,100	-2,500
CO	-250	-610	-1,200	-250	-610	-1,200
VOC	-12	-30	-68	-12	-30	-68
PM10-primary	290	740	1,000	290	740	1,000
PM2.5-primary	260	660	870	260	660	870

These numbers were compared against the MANE-VU inventories for 2012 and 2018 (Table ES-8.4). The 2018 emissions were estimated by interpolating between the 2015 and 2020 estimates. Table ES-8.4 indicates that the criteria pollutant emissions reductions associated with this policy alone would significantly affect SO_2 emission levels by substituting high sulfur coal with natural gas. By 2018 Table ES-8.4 shows that emissions inventory reductions for sulfur dioxide and particulate matter could be achieved through the repowering policy.

Table ES-8.4- Percentage Reduction in Emissions Inventory Associated with ES-8

	Across Maryland		Across Entire Domain	
Pollutant	**2012**	**2018**	**2012**	**2018**
SO_2	2%	9%	<1%	1%
NO_X	<1%*	-2%	<1%*	<1%*
CO	<1%*	<1%*	<1%*	<1%*
VOC	<1%*	<1%*	<1%*	<1%*
PM10-primary	<1%	1%	<1%	<1%
PM2.5-primary	1%	2%	<1%	<1%

*The change was between -1% and +1%.

Reductions in SO_2 emissions could result in reduced acid rain and less formation of sulfate particulate matter downwind of Maryland. Increases in local NO_X emissions may result in higher local ozone concentrations. Local reductions in particulate matter emissions would improve local ambient particulate matter concentrations and improve visibility.

2.2. Summary of Air Quality Co-Benefits Methodology

The PROMOD model results estimate the decreased fuel consumption at various plants based on marginal reductions in electricity consumption. The marginal plant emissions reductions are calculated by multiplying each power plant's decreased fuel consumption by the plant-specific emission factors (lb pollutant/mmBtu), and Maryland coal-fired plant emission factors are computed from the marginal calculations.

Then emissions reductions are computed by multiplying the policy's decrease in coal consumption by the emission factors. An assumption that electric generators would begin co-firing small quantities of biomass with coal did not lead to reduced emission factors. Emissions increases resulting from the development of NGCCs in Maryland were calculated by multiplying EPA's AP-42 emission factors by the increased electric demand on this sector.

2.3. Air Quality Co-Benefits Calculations

Calculate Emissions Factors Associated with Marginal Power Plant Reductions

1. From the 2009 CAMD data sets, calculate the SO_2 and NO_X emissions rates per mmBtu for coal-fired power plants in EPA Regions 2, 3, 4, and 5.

2. From the 2007 MARAMA inventory for Maryland and surrounding states (DC, DE, NJ, PA, VA, and WV), find the CO, VOC, PM10, and PM2.5 emissions rates per mmBtu for coal-fired power plants that are listed in the database.

3. Calculate the emissions factors for each Maryland coal-fired power plant (lb/mmBtu).

4. Calculate the emissions for each plant for base load, 1 percent reduction and 2 percent reduction by multiplying the emission factors by the change in fuel consumption rates (in mmBtu/yr) from the PROMOD model (years 2012, 2015, and 2020—see section **2.2** for additional details on the PROMOD model runs referred to here).

5. If the SO_2 or NO_X emissions for Maryland power plants exceeded the Healthy Air Act limits, reduce the base load emissions to those permit limits and compute the 1 percent and 2 percent reductions as a fraction of the base load using the ratios of fuel consumption rates.

6. Sum the fuel consumption rates and the pollutant emissions in the base load, 1 percent reduction case, and 2 percent reduction case across all Maryland coal-fired plants (years 2012, 2015, and 2020).

7. Compute the emissions per percent load reduction and the electric generation per percent load reduction for the 1 percent and 2 percent cases. Average the 1 percent and 2 percent cases.

8. Calculate the marginal electricity emissions factors (lb pollutant/MWh change) for Maryland coal-fired plants as the emissions per percent load reduction divided by the electric generation per percent load reduction.

Calculate Emissions Reductions Associated with Fuel/Electricity Consumption Changes

1. Use the marginal electricity emissions factors (lb pollutant/MWh change). Multiply them by the coal generation reduction described in Table 2 to calculate the emissions reductions from Maryland's coal-fired power plants.

2. Assume that co-firing coal-fired plants with less than 10 percent biomass does not significantly change the criteria pollutant emission factors (based on figure presented by Lesley Sloss of the IEA Clean Coal Centre at the 35th Annual EPA-A&WMA Annual Exchange in December 2010) from those for coal alone. Therefore, any generation capacity allotted to biomass co-firing was treated with the same emission factors that were used for PROMOD.

3. The AP-42 factor for CO_2 from natural gas-fired turbines was 110 lb/mmBtu, and this factor was used to calculate the heat rates (12300, 12000, and 11600 Btu/kWh in 2012, 2015, and 2020) of the NGCCs described in Table 2. The natural gas replacements of coal (GWh) were multiplied by the heat rates to calculate NGCC heat input (mmBtu). The AP-42 emission factors for natural gas-fired turbines with water-steam injection controls were multiplied by the NGCC heat input to calculate NGCC emissions.

4. Subtract the NGCC emissions increases from the coal-fired emissions reductions to calculate the overall emissions reductions from this policy.

2.4. Air Quality Co-Benefit Data and Data Sources

The following data sources were used for the analysis:

- PROMOD Model: (http://www1.ventyx.com/analytics/promod.asp)
- Maryland's Healthy Air Act (http://www.mde.maryland.gov/programs/Air/Documents/26-11-27_MD_Healthy_Air_Act.pdf)
- AP-42 (http://www.epa.gov/ttn/chief/ap42/index.html)
- CAMD 2009 (http://camddataandmaps.epa.gov/gdm/)
- MARAMA's 2007 Regional Emissions Inventories (http://www.marama.org/RegionalEmissionsInventory/2007BaseCase/index.html)
- MANE-VU Emissions Inventory (http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory)

3.0 INTERACTION WITH OTHER POLICIES

This policy has the potential to interact with AFW-6, AFW-7b, and ES-3. AFW-6 stipulates greater use of biomass feedstocks from agricultural and forest residues, dedicated energy crops, and $CH_4$from manure and litter. As reported in Appendix D of the Maryland CAP,[11] AFW-6 overlaps with policy ES-8 which evaluates the GHG reduction benefits from increased biomass use at existing plants when economical. The analysis noted that the quantity of biomass needed for ES-8 may be limited by that needed for AFW-6. To avoid double counting, the 2008 Climate Action Plan allocated all emission reductions from biomass-to-energy production to ES-8.

Regarding AFW-7b, the first observation is that the goal to substitute fossil diesel with biodiesel is quite modest, and unlikely to cause much competition for feedstocks to co-fire in electricity generation. Secondly, while there is some potential for overlap in the feedstocks for co-firing to produce electricity and to produce biodiesel, it is most likely that the feedstocks for electricity generation will be mostly from forest residues, and those for biodiesel from agricultural crops like soybean. Lastly, the overarching assumption in all policies is that the individual policy goals will be achieved, which nullifies any remaining potential for overlap.

[11] Appendix D of the Maryland CAP, Greenhouse Gas & Carbon Mitigation Working Group: Policy Option Documents

ES-3 subsumes ES-8 since the cap specified in ES-3 encompasses both supply and demand side measures to reduce GHG emissions. Any action taken to implement ES-8 will thus be captured as part of the very wide policy possibilities of ES-3.[12]

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Chapter 3: Agriculture, Forestry, and Waste (AFW) Policies

The following AFW Policies were analyzed:

- AFW 1: Forest Management for Enhanced Carbon Sequestration
- AFW 2: Managing Urban Trees and Forests
- AFW 3: Afforestation, Reforestation and Restoration of Forests and Wetlands
- AFW 4: Protection and Conservation of Agricultural Land, Coastal Wetlands and Forested Land
- AFW 5: "Buy Local" Programs
- AFW 6: Expanded Use of Forest and Farm Feedstocks and By-Products for Energy Productions
- AFW 7b: In State Liquid Biodiesel Production
- AFW 8: Nutrient Trading with Carbon Benefits
- AFW 9: Waste Management and Advanced Recycling

AFW Policy Findings

Table 3.1 presents the 2020 GHG emission reduction estimates for the above-listed nine policies. SAIC developed the reduction estimates for AFW-2 and AFW-9; the estimated reductions for the other seven policies are from the CAP. As the table indicates, Policy AFW-4 is projected to yield the majority of the emission reductions in the AFW sector; this policy accounts for 78 percent of the sum of reductions across all policies. Policy AFW-9 accounts for an additional 18 percent of the emission reductions. The remaining seven policies combined account for only 4 percent of the sum of the reductions.

SAIC reviewed the two policies we re-estimated (AFW-2 and AFW-9) for overlaps; we did not identify any significant overlaps for these two policies (see Chapter 5). However, it is possible that the emission reduction estimates for the other seven policies overlap to some extent.

[12]Chapter 5 provides a more detailed discussion of the interaction between ES-3 and other ES policies, which is similar to the interaction with ES-8.

Table 3.1. Summary of GHG Emission Reductions from the AFW Sector in 2020

Sector/Policy	2020 GHG Emission Reductions ($MMTCO_2e$)
Agriculture, Forestry & Waste (AFW)	
AFW-1: Forest Management for Enhanced Carbon Sequestration	0.09
AFW-2: Managing Urban Trees & Forests	1.32
AFW-3: Afforestation, Reforestation & Restoration of Forests & Wetlands	0.62
AFW-4: Protection & Conservation of Agricultural Land, Coastal Wetlands & Forested Land	26.54
AFW-5: "Buy Local" Programs	0.03
AFW-6: Expanded Use of Forest & Farm Feedstocks & By-Products for Energy Production	0.54
AFW-7b: In-State Liquid Biodiesel Production	0.17
AFW-8: Nutrient Trading with Carbon Benefits	0.14
AFW-9: Waste Management & Advanced Recycling	5.97
AFW Total (Unadjusted for Overlap)	**34.10**

Table 3.2 presents the projected 2020 reductions in criteria pollutant emissions for the nine AFW policies. As this table indicates, Policies AFW-2, AFW-3, AFW-4, and AFW-9 are all significant contributors to the emission reductions in SO_2, NO_X, and PM10, while AFW-7b accounts for the majority of the reductions in CO, VOC, and PM2.5. As discussed in Chapter 5, the criteria pollutant reduction estimates for the nine AFW policies do not appear to overlap either each other, or the reduction estimates for policies in other sectors, to any significant extent.

Table 3.2. Summary of Criteria Pollutant Emission Reductions from the AFW Policies in 2020

		SO_2 (Tons)	NO_x (Tons)	CO (Tons)	VOC (Tons)	PM10 (Tons)	PM2.5 (Tons)
	Agriculture, Forestry & Waste (AFW)						
AFW-1	AFW 1 - Forest Management for Enhanced Carbon Sequestration						
AFW-2	AFW 2 - Managing Urban Trees & Forests	300.00	450.00			2,400.00	
AFW-3	AFW 3 - Afforestation, Reforestation & Restoration of Forests & Wetlands	273.00	410.00			2,200.00	
AFW-4	AFW 4 - Protection & Conservation of Agricultural Land, Coastal Wetlands & Forested Land	523.00	784.00			4,182.00	
AFW-5	AFW 5 - "Buy Local" Programs	0.22	9.50	220.00	10.00	0.37	0.35
AFW-6	AFW 6 - Expanded Use of Forest & Farm Feedstocks & By-Products for Energy Production						
AFW-7b	AFW 7b - In-State Liquid Biodiesel Production	8.90	-7.60	952.00	85.00	1.50	1.40
AFW-8	AFW 8 - Nutrient Trading with Carbon Benefits						
AFW-9	AFW 9 - Waste Management & Advanced Recycling	890.00	2,200.00	290.00		131.00	
	AFW Total	**1,995.12**	**3,845.90**	**1,462.00**	**95.00**	**8,914.87**	**1.75**

Policy No.: AFW-1

Policy Title: Forest Management for Enhanced Carbon Sequestration

SAIC was tasked with reviewing the AFW-1 policy analysis which was conducted by a prior MDE contractor (Original Methodology). SAIC conducted a thorough examination of the methodologies, assumptions, data sources, and results and subsequently described the methodology and results as well as provided SAIC's observations and recommendations. SAIC also quantified the air quality co-benefits associated with AFW-1. SAIC's policy review and evaluation of the Original Methodology is below:

1.0 GHG EMISSION REDUCTIONS

AFW-1 seeks to encourage the management activities needed to keep forests healthy and vigorous on private and public forest lands in the state of Maryland. The overarching goal is to restore, enhance, and sustain the economic, social, and ecological values of these forests. Specific goals include: improving sustainable forest management on 25,000 acres of private land by 2020; improving sustainable forest management on all state-owned resource lands by 2020, and as per a recent policy update by the Maryland Department of Natural Resources (DNR); and third-party certify 50 percent of State-owned forest lands as sustainably managed. The policy also addresses invasive species.

The analysis quantified the increased carbon sequestration from forest management based upon the difference between intensively managed and non-managed stands of forests as modeled by the United States Department of Agriculture (USDA) Forest Service (USFS). The resulting GHG emission reductions from the enhanced sequestration of $CO_2$from forest management activities are as follows:

Table AFW-1.1. GHG Emission Reductions Resulting from AFW-1

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
Annual Carbon Sequestration from Sustainably Managed Forests	0.036	0.058	0.094

1.1. Summary of GHG Emission Methodology

The analysis used USFS data to compare the CO_2 removed from the air by intensively managed and normally managed forests. It then assumed that sustainably managed forests would behave similarly to intensively managed forests in terms of the amount of CO_2 removed from the air. An estimated acreage of state owned and private lands that would change their forest management practices as a result of AFW-1 was multiplied by an enhanced CO_2 rate of removal (carbon sequestration) to determine the GHG emission reductions. [13]

1.2. Rationale for GHG Emission Methodology

The methodology used determined a set of annual carbon storage values for different forest types in Maryland as described in Step 2 in the GHG Emission Calculation section below. The validity of this

[13] As detailed in 1.3.2, the actual factor used did not result from this methodology. It is unclear how the actual factor was determined.

approach is highly dependent upon the validity of the assumptions. The calculations of overall carbon benefits are inconsistent with the stated methodology of the prior contractor.

1.3. GHG Emission Calculations

The increased carbon sequestration from sustainable forest management was calculated as follows:

Step 1: Determine the Difference between Sequestration in Intensively Managed versus "Average" Loblolly stands

Assuming that intensively managed loblolly stands are equivalent to sustainably managed loblolly stands, the Original Analysis used USFS sequestration tables in GTR-NE-343,[14] and noted that intensively managed stands store 5 percent more carbon than average stands from years 0 through 90.

> Average Annual Sequestration = 1/90 (Sequestration at year 90 - Sequestration at Year 0)

> Difference = Average Annual Sequestration in Intensive Stands - Average Annual Sequestration in "Average" Stands (Expressed as a percentage difference = 5%)

Step 2: Applied Percentage Increase to Other Forest Types

Using USFS GTR-NE-343 data, determined the average annual sequestration (as in Step 1) for oak-hickory, oak-pine, and loblolly-shortleaf pine stands, to be 0.8, 0.604, and 0.662 tons carbon/acre/year, respectively. Applied the 5 percent increase from Step 1 proportionally according to forest distribution in Maryland of 63 percent oak-hickory, 10 percent oak-pine and 11 percent loblolly-shortleaf pine.[15]

> Enhanced Average Annual Sequestration per Forest Type = Carbon Storage of Forest Type * Percentage Increase (e.g., 0.8 * 1.05 for oak-hickory)

> Weighted Annual Sequestration per Forest Type = Fraction of Forest Type * Enhanced Average Annual Sequestration per Forest Type (e.g., 0.63 * 0.8 * 1.05 for oak-hickory)

> Average Annual Sequestration Across Forest Types = Sum of Annual Sequestration per Forest Type (for oak-hickory, oak-pine, and loblolly-shortleaf pine)

> Overall Average Annual Sequestration = 0.63 * 0.8 * 1.05 + 0.1 * .604 * 1.05 + 0.11 * 0.662 * 1.05 = 0.669 tons C/acre/year.

Step 3: Determined Annual Acreage for Applying Sustainable Forest Management Practices

Based on USFS Forestry Inventory Analysis data, determine the area of state owned forests to be 749,975 acres. To meet policy goals, simulated the linear implementation of sustainable forest management on 57,690 and 1,923 acres of existing state owned and private forests annually.

> Annual Target for Implementation (Public) = 749,975/13 = 57,960 acres

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[14]Smith et al., Ibid.
[15]The citation provided in the prior analysis is incomplete. It is "USDA USFS Northern Global Change Program," available at http://www.fs.fed.us/ne/global/pubs/books/epa/states/MD.htm," which is a site with several different documents. The particular document cited in the prior analysis is unclear.

Annual Target for Implementation (Private) = 25,000/13 = 1,923 acres

Step 4: Calculated Increased Carbon Sequestration

Used an implied (back calculated by SAIC) annual increase in carbon storage of 1.2 * 10^-7 $MMTCO_2e$/year over 2008 through 2020. (The Original Methodology appears to have made some calculation errors. The rate here should be 0.67 * 44/12 * 10^-6 = 2.46 * 10^-6 $MMTCO_2e$.)

1.4. GHG Emission Data and Data Sources

The quantification used data from USFS GTR-NE-343[16]

1.5. GHG Emission Assumptions

The assumptions made in the quantification of sequestered carbon are not all evident since a significant part of the methodology is not made explicit, as mentioned in Section 1.3 above. Those assumptions that appear to have been made are as follows:

- Intensively managed, high productivity stands are equivalent to sustainably managed stands of loblolly-shortleaf pines
- Annual carbon storage rates derived from the loblolly-shortleaf pine association can be applied to oak-hickory and oak-pine forest associations
- Both sets of assumptions above are likely to have resulted in overestimates of the GHG benefits of this policy

1.6. GHG Emission Analysis and Recommendations

The methodology attempts to estimate a carbon sequestration rate for different types of sustainably managed forests in Maryland by applying the factor derived from loblolly-shortleaf pines to the other types. The derivation of this rate was initially based upon 90 year average carbon storage values for intensively managed loblolly-shortleaf pine association to give a value of 0.579 tons carbon/acre/year. Then, the 5 percent value determined in Step 1 above, was applied to a 65 year average carbon storage value for loblolly-shortleaf pines without a clear rationale.

It is also unclear why, even if the 5 percent value is valid for the loblolly-shortleaf pine forest association, it would also apply to oak-hickory and oak-pine forest associations. Oak-hickory composes the majority of Maryland forests and loblolly-shortleaf pines a much smaller fraction. The justification for applying a rate determined from a less common forest type to a more common forest type is unclear, as is that for applying a conifer rate (loblolly-shortleaf pines) to a deciduous forest type (oak-hickory).

[16] The data sets included in this USFS document encompass several forest type and age classes within each type, and, are, as such too large for inclusion in this report itself. Step 2 above details the intermediate calculations used to derive the average annual sequestration.

In the future, it would be more accurate to derive annual carbon storage values for all forest types (loblolly-shortleaf pines, oak-hickory, and oak-pine) under sustainable management, possibly through comparison with similar management in other areas of the country or field trials. Then, these annual carbon storage values could be compared to the annual carbon storage values of the same forests under existing management to derive the increase in annual carbon storage under sustainable management. Finally, the difference could be multiplied to the acreage under planned sustainable management to determine the increase in carbon sequestration through the sustainable forest management of Maryland forests.

2.0 AIR QUALITY CO-BENEFITS

This policy has no significant National Ambient Air Quality Standards (NAAQS)co-benefits because, unlike other AFW policies (e.g., AFW-2, AFW-3 and AFW-4) it does not result in an increase in the area of forested land within the State. Since the geographic extent of the tree canopy does not change under this policy, there is no net change in pollutant removal. The approach used to quantify the air quality co-benefits of the various AFW forestry policies considers the benefit of additional forested acreage.

3.0 INTERACTION WITH OTHER POLICIES

AFW-1 involves improved forest management on private and public lands. While other AFW policies also involve interventions in forests, the nature of these policies is such that there is little to no interaction with AFW-1. AFW-3 includes afforestation and reforestation, but this involves adding or replacing lost forested areas, and not enhancing their management as in AFW-1. One component of AFW-4 is the conservation and protection of forests, especially upland forests most susceptible to conversion to settlements. This does not involve any change to the management of these forests, as in AFW-1. AFW-6 seeks to increase the use of forestry residues for use as a biomass feedstock, but AFW-6 does not include any forest management measures.

Policy No.: AFW-2

Policy Title: Managing Urban Trees and Forests for Greenhouse Gas (GHG) Benefits

SAIC was tasked with reviewing the AFW-2 policy analysis which was conducted by a prior MDE contractor (Original Methodology) and revising the methodology to include Maryland-specific data and/or other enhancements. SAIC subsequently recalculated the GHG emission reductions associated with AFW-2 based upon its recommended methodology (Revised Methodology). SAIC also quantified the air quality co-benefits associated with AFW-2. SAIC's revised policy findings are described below:

1.0 GHG EMISSION REDUCTIONS

Policy AFW-2 is designed to increase urban tree canopy (UTC) from 28 percent to 38 percent by 2020, enhancing green infrastructure, and improving urban wood recovery. The UTC reduces GHG emissions directly from new carbon sequestration resulting from the new trees and indirectly from the reduction in electricity used for cooling due to the shade and local climate effects of the trees. The GHG reductions are listed in Table AFW-2.1 below:

Table AFW-2.1: GHG Emission Reductions Resulting from AFW-2

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
AnnualCarbon Sequestration by Planted Trees	0.16	0.45	1.32
Reduced Electricity Demand for Cooling and Heating	*De minimis*		

1.1. Summary of GHG Emission Methodology

SAIC used an urban forestry model[17] to determine the year-to-year carbon sequestration and heating/cooling effects of a representative sample of tree species in Maryland. An average sequestration value for each year (from 2009 – 2020) was calculated and applied to the number trees needed each year to meet AFW-2 policy objectives. The methodology took into account the growth of the trees (and thus sequestration) from year to year. The heating/cooling effects of the new tress proved to be *de minimis*.

The following five steps were used to quantify GHG reductions for AFW 2:

Step 1. Identify a representative sample set of Maryland trees

Step 2. Determine the carbon sequestration per calendar year from 2008 through 2020 for each cohort of trees planted in a given year, and calculate an average annual GHG reduction

Step 3. Determine the number of trees that would need to be planted annually, based on the difference between the current UTC of 28 percent and the UTC policy target of 38 percent

[17]U.S. Department of Agriculture Forest Service's Center for Urban Forestry carbon calculator (CTCC)

Step 4. Determine the total GHG reductions from carbon sequestration for 2012, 2015, and 2020 by multiplying the results of Step 2 and Step 3

Step 5. Determine the total GHG reductions from decreased electricity demand

1.2. Rationale for GHG Emission Methodology

The Center for Urban Forestry Carbon Calculator (CTCC) model was used because it is based on actual field measurements of a wide variety of trees in multiple regions of the country, thus enabling a more Maryland specific analysis, rather than a generic approach. The trees available for modeling for Maryland corresponded sufficiently well to the "Marylanders Plant Trees" recommended list, and provided specific annual values for GHG reductions as the trees grew over time. The i-Tree set of tools, also developed by USFS, would have been potentially more applicable, and are frequently used in municipal inventories of carbon sequestration by urban trees. However, policy AFW-2 involves trees to be mostly planted in the future, and with no clear manner of determining what those tree species will be. Since i-Tree requires the input of data on the trees to be analyzed, it was not possible to use i-Tree for this analysis, and CTCC, which comes pre-loaded with field data based on thousands of trees samples in urban settings, was used instead.

An alternative approach would be to apply an average sequestration rate derived from existing trees, but this has the large disadvantage of not accounting for the growth of trees. Since, under AFW-2, the trees would be planted in between 2008 to 2020, age-specific GHG reduction values are needed. It is necessary to know, for example, the sequestration of a red maple from 2008-2009 (year one to two), 2009-2010 (year two to three), 2010-2011 (year three to four), and so on, until 2020. Additionally, the chosen methodology allowed the determination of the GHG reduction per tree for each age cohort. By way of illustration, we were able to create data for red maples planted in 2008 and follow their annual sequestration until 2020, similarly for red maples planted in 2009 through 2020, those planted in 2010 through 2020, and so on.

Summing the carbon sequestration benefits of all the tree species over each calendar year provided a good estimation of what the average GHG reduction benefits would be over time, providing policy makers with continuous annual GHG sequestration, critical to tracking policy benefits over time, and, naturally providing the same information for the key years of 2012, 2015, and 2020. This analysis can also be easily extended beyond 2020 with minimum effort, which is an advantage for policymakers considering the extension of this policy.

1.3. Difference Between Original & Revised Methodologies and Results

The Original Methodology used a current and policy target UTC of 40.1 percent and 50 percent, respectively, and thus determined that 20 percent more urban trees (or 22 million trees) were needed.[18]Assuming uniform tree planting in between 2008 and 2020 indicated a planting rate of 1.7

[18]The prior analysis misinterpreted the "2020 Forest Conservation Goals for Maryland Summary" of November 2007, which states that 50% of the areas developed before 1984 should have urban canopy goals by 2020, and not that the policy goal is a UTC of 50%. The number of trees provided in the following source is 82.6 million: USFS. Urban and community forests of the Southern Atlantic region: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia. Gen. Tech. Rep. NRS-50. Newtown Square,

million trees per year. Sequestration was calculated based on an implied sequestration rate of 0.0223 metric tons/tree/yr. The source of this factor is unclear.[19] GHG reductions from heating and cooling effects were determined with reference to a USFS study based on evergreen trees.[20] An implied GHG emissions reduction rate of 0.0635 mt/tree/yr (the source of which is not stated) was applied to the 1.7 million trees to be grown annually from 2008 through 2020. The overall GHG reduction was determined by adding the GHG reductions from carbon sequestration to the reductions associated with heating/cooling effects.

In contrast, the Revised Methodology used an urban forestry model[21] to determine the year-to-year carbon sequestration and heating/cooling effects of a representative sample of tree species in Maryland. The policy assumptions for current and future UTCs were 28 percent and 38 percent resulting in a lower baseline number of trees in the Revised Methodology, as opposed to 40 percent and 50 percent in the Original Methodology. The percentage difference between the initial and target UTC was 25 percent for the Original Methodology and is 37.5 percent for the Revised Methodology. Thus, the Revised Methodology projects an increase of 2.27 million new trees per year to meet the policy objectives, as compared to the 1.7 million trees per year projected in the Original Methodology. The requirement for these additional trees and a more justifiable average annual sequestration rate, which accounted for tree growth over time , resulted in substantially more GHG reductions from new sequestration. The Revised Methodology found the GHG reductions from reduced cooling and heating demands to be *de minimis*, in contrast to the Original Methodology which used an implied GHG reductions rate approximately three times larger than its own sequestration rate. The GHG reductions benefit in the Original Methodology for 2012, 2015, and 2020 are all approximately three times as high as the sequestration benefit, which is not possible. The extremely high GHG reductions benefit explains why the Original Methodology produced results higher than the Revised Methodology.

The Original Methodology predicted total GHG emission reductions of 0.7289, 1.1663 and 1.8952 $MMTCO_2e$ for 2012, 2015, and 2020, respectively. The corresponding results for the Revised Methodology are 0.16, 0.45, and 1.32 $MMTCO_2e$ for 2012, 2015, and 2020 respectively.

1.4. GHG Emission Calculations

The following Steps describe the quantification approach summarized in Section 1.1 above:

Step 1: Identify a Representative Sample of Maryland Trees:

PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 85 p. pp.41-42. http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs50.pdf.

[19]2008. Maryland Commission on Climate Change. Climate Change Action Plan. Appendix D - Greenhouse Gas & Carbon Mitigation Working Group. p.17. The **implied value** of 0.0223 metric tons per tree per year was determined for the current analysis by dividing sequestration by the number of planted trees.
[20]E.G. McPherson and J.R. Simpson. 1999. CO_2 reduction through urban forestry: guidelines for professional and volunteer tree planters. USDA USFS Pacific Southwest Research Station. General Technical Report PSW-GTR-171.
[21]U.S. Department of Agriculture Forest Service's Center for Urban Forestry carbon calculator (CTCC)

The model used to determine GHG sequestration chosen was the USFS Center for Urban Forestry carbon calculator (CTCC), which includes pre-loaded sequestration values for numerous species of urban trees[22]. The CTCC is programmed in an Excel spreadsheet. It is designed to provide carbon-related information for a single tree located in one of sixteen U.S. climate zones. CTCC outputs can be used to estimate GHG benefits for existing trees or to forecast future benefits. Tree size data are based on growth curves developed from samples of 650 - 1000 street trees for each of about 20 predominant species per region. The CTCC uses biomass equations to derive total CO_2 stored, and annual CO_2 sequestration.[23] To determine effects of tree shade on building energy performance (heating and cooling), over 12,000 simulations were conducted using different combinations of tree sizes, locations, and building vintages. Effects of tree shade require user input of azimuth (compass direction of tree relative to house), distance of tree from house, housing vintage, heating equipment, and cooling equipment.

The "Marylanders Plant Trees" program provides a recommended list of tree species.[24] The first set of tree species considered for analysis were those common to the "Marylanders Plant Trees" list and the CTCC. Given that the carbon sequestration, as well as the shade and climate effects of trees are dependent upon their size and shape, this list was further refined to ensure that the selected trees for analysis were representative of as many of the following tree types as possible: deciduous (large, medium, small), broad leaf evergreen (large, medium, small), and conifers (large, medium, small). The list of species selected for analysis is listed in Table AFW-2.2 below.

[22]USDA Forest Service. Climate Change Resource Center - Urban Forests and Climate Change. http://www.fs.fed.us/ccrc/topics/urban-forests/ctcc/. SAIC considered the i-Tree set of tools developed by the USFS and collaborating organizations (http://www.itreetools.org/) for this analysis, but in the absence of data on the trees to be planted, it was not feasible to use it, and the CTCC, also developed by USFS was selected, since it includes field data on a number of tree species.

[23]The CTCC calculates volume from dbh, then weight using density values, next carbon as a known proportion of the mass of trees, and finally CO_2.

[24]Marylanders Plant Trees - Recommended Tree List for Marylanders Plant Trees. http://www.trees.maryland.gov/pickatree.asp#trees

Table AFW-2.2. – List of Tree Species by Type Used for Modeling Average GHG Reductions and Inferred Age at Planting (Based on 2 inch dbh)

Tree Type	Tree Species	Inferred Age at Planting (years)
Broadleaf deciduous		
Large	Maple, Red (*Acer Rubrum*)	1
	Oak, Northern Red (*Quercus rubra*)	1
	Oak, White (*Quercus alba*)	3
	Oak, Willow (*Quercus phellos*)	4
	Sweetgum, American (*Liquidambar styraciflua*)	3
Medium	Birch, River (*Betula nigra*)	2
Small	Crabapple Spp. (*Malus spp.*)	2
Broadleaf evergreen		
Large	N/A	N/A
Medium	Magnolia, Southern (*Magnolia grandiflora*)	3
Small	Holly, American (*Ilex opaca*)	4
Conifer		
Large	Pine, Loblolly (*Pinus taeda*)	4
Medium	Redcedar, Eastern (*Juniperus virginiana*)	3
Small	N/A	N/A

Step 2: Determine Carbon Sequestration Per Calendar Year:

The first step in using the CTCC is determining the age of the trees at planting. Based on informal contacts with the Maryland Nursery and Landscape Association, a diameter at breast height (dbh) of 2 inches was assumed for newly planted trees. This 2 inch dbh was used to infer an age at planting using the CTCC. Then, the carbon sequestration was modeled using the CTCC for each of the tree species chosen, providing year-over-year data on GHG reductions for each species from 2008 through 2020, as shown in Table AFW-2.3. This table provides both the total carbon storage, which is cumulative sequestration over time, and annual sequestration. The annual sequestration was used for the subsequent steps of the calculations.

Table AFW-2.3. Annual GHG Sequestration for Chosen Tree Species from 2008 through 2020[25]

Carbon Storage Values from CUFR Calculator (kg CO_2/tree) and Carbon Sequestration Values (kg CO_2/tree)														
Tree Species		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Maple, Red (*Acer Rubrum*)	Cumulative Storage	15.5	24.8	36.9	52	70.3	92	117.6	147.1	181	219.4	262.7	311.2	365.1
	Annual Sequestration		9.3	12.1	15.1	18.3	21.7	25.6	29.5	33.9	38.4	43.3	48.5	53.9
Oak, Northern Red (*Quercus rubra*)	Cumulative Storage	4.9	15.5	33.8	60.8	97.3	144	201.4	270.1	350.3	442.4	546.8	663.5	792.9
	Annual Sequestration		10.6	18.3	27	36.5	46.7	57.4	68.7	80.2	92.1	104.4	116.7	129.4
Oak, White (*Quercus alba*)	Cumulative Storage	8.1	18.7	35.4	51.3	91.4	132.6	183.9	246.2	320.3	407	507.1	621.4	750.6
	Annual Sequestration		10.6	16.7	15.9	40.1	41.2	51.3	62.3	74.1	86.7	100.1	114.3	129.2
Oak, Willow (*Quercus phellos*)	Cumulative Storage	13.9	31.4	57.5	93.1	138.9	195.2	262.6	341.5	432	534.4	648.8	775.5	914.3
	Annual Sequestration		17.5	26.1	35.6	45.8	56.3	67.4	78.9	90.5	102.4	114.4	126.7	138.8
Sweetgum, American (*Liquidambar styraciflua*)	Cumulative Storage	7.8	17.6	32.6	53.4	80.8	115.4	157.7	208.1	267.3	335.5	413.4	501.1	599.3
	Annual Sequestration		9.8	15	20.8	27.4	34.6	42.3	50.4	59.2	68.2	77.9	87.7	98.2
Birch, River (*Betula nigra*)	Cumulative Storage	8.5	21.2	41.9	71.9	112.8	165.6	231.8	312.3	408.4	521	651.3	800.3	968.8
	Annual Sequestration		12.7	20.7	30	40.9	52.8	66.2	80.5	96.1	112.6	130.3	149	168.5

[25]For each tree species, the top line is the annual carbon storage in kilograms per tree, and the second line is the annual sequestration calculated for every year after 2008. 2008 is the earliest possible year of planting, hence sequestration can only be calculated for the following year, and so on.

Carbon Storage Values from CUFR Calculator (kg CO_2/tree) and Carbon Sequestration Values (kg CO_2/tree)														
Tree Species		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Crabapple spp. (Malus spp.)	Cumulative Storage	3.5	14	34.9	67.7	112.9	170.7	240.8	322.8	416.3	520.7	635.7	760.6	895.1
	Annual Sequestration		10.5	20.9	32.8	45.2	57.8	70.1	82	93.5	104.4	115	124.9	134.5
Magnolia, Southern (*Magnolia grandiflora*)	Cumulative Storage	2.9	5.7	9.8	15.5	22.9	32.3	44	58	74.8	94.4	117.1	143.1	172.7
	Annual Sequestration		2.8	4.1	5.7	7.4	9.4	11.7	14	16.8	19.6	22.7	26	29.6
Holly, American (*Ilex opaca*)	Cumulative Storage	9.7	13.9	18.9	24.9	32	40.2	49.6	60.3	72.3	85.7	100.6	117.1	135.2
	Annual Sequestration		4.2	5	6	7.1	8.2	9.4	10.7	12	13.4	14.9	16.5	18.1
Pine, Loblolly (*Pinus taeda*)	Cumulative Storage	4	10	19.8	34	53.2	78	108.8	146	190.2	241.7	300.9	368.1	443.7
	Annual Sequestration		6	9.8	14.2	19.2	24.8	30.8	37.2	44.2	51.5	59.2	67.2	75.6
Redcedar, Eastern (*Juniperus virginiana*)	Cumulative Storage	9.5	18.2	30	45.2	63.8	86	111.9	141.6	175.3	212.9	254.7	300.7	350.9
	Annual Sequestration		8.7	11.8	15.2	18.6	22.2	25.9	29.7	33.7	37.6	41.8	46	50.2
Total Annual Sequestration			**102.7**	**160.5**	**218.3**	**306.5**	**375.7**	**458.1**	**543.9**	**634.2**	**726.9**	**824**	**923.5**	**1026**
Average Annual Sequestration			**9.34**	**14.59**	**19.85**	**27.86**	**34.15**	**41.65**	**49.45**	**57.65**	**66.08**	**74.91**	**83.95**	**93.27**

Step 3: Determine Annual Number of Trees to be Planted:

According to the DNR, the current UTC is 28 percent and Maryland-specific USFS data states the current number of urban trees as 82.6 million. Applying the policy target UTC of 38 percent, a 35.7 percent increase in trees would be required or 29.5 million trees more to reach 112 million trees by 2020. This would require an average annual planting of 2.27 million trees in urban areas.[26]

Number of trees needed per year ={(38-28)/28 = 35.7%}*82.6 million*1/13 = 2.27 million

Step 4: Determine Total GHG Reductions from Sequestration:

The average annual carbon sequestration determined in Step 2 was multiplied by 2.27 million trees (from Step 3) and converted to metric tons of $CO_2$to determine the annual GHG reduction for each cohort. This data is provided in Table AFW-2.4. The table shows the year of planting in the rows, and the calendar years in the columns. The values from left to right for "year of planting" rows 2008 through 2020 provide the annual sequestration values from the year of planting through 2020. To illustrate, the values from left to right in year of planting (row) 2008 provide the annual sequestration of trees planted in 2008 through 2020 (e.g., 63,250.45metric tons of $CO_2$is the annual sequestration in calendar year 2012 for the trees planted in 2008).

Determining the annual sequestration of all trees in a given years involves summing the values in a given calendar year (column). So, for calendar year 2012, the total annual sequestration is the sum of (all in metric tons of CO_2)63,250.45 (planted in 2008), 45,049.18(planted in 2009), 33,121.36(planted in 2010), and 21,193.55(planted in 2011), giving 162,614.55..

[26]Current and policy target UTC provided by MD DNR (email from Marian Honeczy of March 24th, 2011). Current tree population from: USFS. Urban and community forests of the Southern Atlantic region: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia. Gen. Tech. Rep. NRS-50. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 85 p. pp.41-48. http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs50.pdf.

Table AFW-2.4- Total Annual GHG Reductions from Sequestration (Metric Tons CO_2)

Year of Planting (rows)/Calendar Year (columns)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
2008	21,193.55	33,121.36	45,049.18	63,250.45	77,530.82	94,535.18	112,241.18	130,875.82	150,005.73	170,043.64	190,576.82	211,729.09
2009		21,193.55	33,121.36	45,049.18	63,250.45	77,530.82	94,535.18	112,241.18	130,875.82	150,005.73	170,043.64	190,576.82
2010			21,193.55	33,121.36	45,049.18	63,250.45	77,530.82	94,535.18	112,241.18	130,875.82	150,005.73	170,043.64
2011				21,193.55	33,121.36	45,049.18	63,250.45	77,530.82	94,535.18	112,241.18	130,875.82	150,005.73
2012					21,193.55	33,121.36	45,049.18	63,250.45	77,530.82	94,535.18	112,241.18	130,875.82
2013						21,193.55	33,121.36	45,049.18	63,250.45	77,530.82	94,535.18	112,241.18
2014							21,193.55	33,121.36	45,049.18	63,250.45	77,530.82	94,535.18
2015								21,193.55	33,121.36	45,049.18	63,250.45	77,530.82
2016									21,193.55	33,121.36	45,049.18	63,250.45
2017										21,193.55	33,121.36	45,049.18
2018											21,193.55	33,121.36
2019												21,193.55
2020												21,193.55
Total Sequestered in Calendar Year	**21,193.55**	**54,314.91**	**99,364.09**	**162,614.55**	**240,145.36**	**334,680.55**	**446,921.73**	**577,797.55**	**727,803.27**	**897,846.91**	**1,088,423.73**	**1,321,346.36**

Step 5: Determine Total GHG Reductions from Reduced Electricity Demand:

The CTCC also provides GHG reductions from heating and cooling effects of trees with the input of specific assumptions, including GHG emissions factors. The CTCC was used to estimate GHG reductions using annual blended emissions factors (Maryland and PJM in CO_2e/kWh) determined by SAIC, and CTCC heating emissions factors, for each species of tree from Table AFW-2.2.[27] The GHG effects of the trees were small (in the order of 1-3 kg/tree/year) especially in the early years of tree growth. Even the trees at maximum age (i.e., in year 2020) provided very low GHG impacts as shown in Table AFW-2.5. The average GHG effect across all species was -1.2 kg CO_2e even at maximum age.[28] The corresponding value from Table AFW-2.3 for carbon sequestration is 93.3 kg CO_2e, an order of magnitude higher. Given the numerous assumptions in a study of this nature, it was determined that the heating and cooling effects were therefore *de minimis*, and that their final contribution would be negligible compared to the carbon sequestration.

Table AFW-2.5- GHG Reductions from Shade and Local Climate Effects (kg of carbon per tree) in Year 2020

Tree Species	GHG Reduction (kg CO_2/tree)
Maple, Red (*Acer Rubrum*)	-0.8
Oak, Northern Red (*Quercus rubra*)	8.2
Oak, White (*Quercus alba*)	5.7
Oak, Willow (*Quercus phellos*)	5.4
Sweetgum, American (*Liquidambar styraciflua*)	4.8
Birch, River (*Betula nigra*)	-0.3
Crabapple Spp. (*Malus spp.*)	-1.6
Magnolia, Southern (*Magnolia grandiflora*)	-11.4
Holly, American (*Ilex opaca*)	-1.7
Pine, Loblolly (*Pinus taeda*)	-7.2
Redcedar, Eastern (*Juniperus virginiana*)	-12.8
Average GHG Effect (kg CO_2/tree)	**-1.2**

[27]The input assumptions were azimuth=SE, distance of tree from house = 20-40 feet, housing vintage = 1950-1980, heating equipment = natural gas, and cooling equipment = heat pump. The azimuth was chosen based on repeating the energy analyses with all other factors remaining constant and using the azimuth which provided a GHG reduction value closest to the average of all different directions (N, NE, E, SE, S, SW, W, NW). The tree distance values were <20, 20-40, 40-60, and >60 feet. 20-40 was chosen based on size of lawns and general homeowner preferences. The housing vintage choices were <1950, 1950-1980, and >1980. The mid value was used. Heating and cooling equipment were chosen based on discussions with the U.S. Energy Information Administration (DOE).
[28]The negative value indicates that, on average, for the sample set of trees chosen, under the assumptions input to the model, the reduced energy for cooling due to shade, and heating due to windbreak effects, are outweighed by the increased heating needed due to shading in the winter (insulation). This is also possibly attributable to the differential efficiency of heating and cooling equipment, with the latter generally being more efficient.

1.5. GHG Emission Data and Data Sources

- Recommended Tree List for Marylanders Plant Trees (to determine list of trees for analysis)
- USFS CTCC pre-loaded sequestration values (to determine list of trees for analysis)
- Current UTC of 28 percent and target UTC of 38 percent determined from MD Forestry Service
- USFS General Technical Report NRS-50 (for number of urban trees)

1.6. GHG Emission Assumptions

This analysis uses the following assumptions:

- Current UTC is 28 percent and policy target UTC is 38 percent
- Data provided in USFS General Technical Report NRS-50 of 82.6 million urban trees is valid
- The sample set of trees (see Table 1) is a representative sample for the trees planted over the implementation of the policy
- The tree saplings will have an initial dbh of 2 inches
- The CTCC model which uses tree growth curves based on hundreds of samples of each species and thousands of heating/cooling simulations is applicable for the purposes of this analysis
- For estimating heating and cooling GHG reductions, the following parameters are valid: azimuth=SE, distance of tree from house = 20-40 feet, housing vintage = 1950-1980, heating equipment = natural gas, and cooling equipment = heat pump.

2. AIR QUALITY CO-BENEFITS

The estimated emissions reductions from AFW-2 are shown in the following table:

Table AFW-2.6- Emissions Reductions in Maryland Associated with AFW-2

	Statewide (tons/year)		
Pollutant	**2012**	**2015**	**2020**
SO_2	120	190	300
NO_X	180	280	450
PM10-primary	930	1,500	2,400

These numbers were compared against the MANE-VU inventories for 2012 and 2018. The reductions for SO_2 and NO_X are all less than four-tenths of a percent, indicating that the co-benefits associated with this policy for those pollutants would be unlikely to improve air quality. The value for PM is 0.78 and 1.5 percent in 2012 and 2018, respectively and this policy could contribute to an improvement PM air quality.

Table AFW-2.7- Percentage Reduction in State Emissions Inventory Associated with AFW-2

Reductions	Maryland (%)	
Pollutant	**2012**	**2018**
SO_2	0.11	0.31
NO_X	0.14	0.39
PM10-primary	0.78	1.5

2.1. Summary of Air Quality Co-Benefits Methodology

For AFW-2 the benefits to attainment/maintenance of the PM, NO_X, and SO_2 NAAQS is related to the amount of air pollutant that the trees will remove from the ambient air. The method for estimating these reductions was based on empirical data that was derived from an urban park. Emission reduction factors were derived from the park data and applied to the additional forest acreage resulting from this policy. The reductions were then compared to the projected statewide emission inventories to determine the significance of the reductions.

2.2. Rationale for Air Quality Co-Benefits Methodology

The methodology for determining co-benefits for the PM, NO_X, and SO_2 NAAQS was based on urban park data. This methodology was chosen because it was readily available and provided a simple and straightforward means to estimating the ambient air pollutant reductions. There may be models that produce estimates based on more details and considers more parameters; however, given the small reductions involved, the lack of detailed data, and the uncertainty associated with such models, it was not believed that the additional effort would produce more reliable estimates. It is recognized that using data derived from an “urban park” does not consider rural environments, tree species, forest density, site-specific meteorology, and other variables. But given the minimal reductions that are estimated it is unlikely that a more refined approach would produce more accurate estimates.

2.3. Air Quality Co-Benefits Calculations

The removal from the atmosphere of airborne pollutants by a 212 hectare urban park has been estimated to be 48, 9, and 6 pounds per day for PM, NO_X and SO_2, respectively. Pollutant reduction factors were derived as in the following example for PM:

> 48 lb-PM/212 hectare-day x 0.404 hectare/acre x 365 day/yr x .0005 ton/lb = 0.017 ton-PM/acre-yr

The reduction for each pollutant was the product of the pollutant reduction factor and the estimated additional acreage of forest. The calculation for PM in 2020 is as follows:

> 0.017 ton-PM/acre-yr x 250,000 acres = 4,200 ton-PM/yr

The potential co-benefit of those emission reductions listed in Table 6 is the absolute reductions in Table 5 compared to the statewide emission inventory.

2.4. Air Quality Co-Benefits Data and Data Sources

- **Urban park emissions.** Identified Benefits of Community Trees and Forests by Dr. Rim D. Coder, University of Georgia, October 1996
- **Statewide emission inventory.** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory
- Trees density.Dwyer, J.F., Nowak, D.J., Noble, M.H., and Sisinni, S.M. in review, Connecting People with Ecosystems in the 21st Century: An Assessment of our Nation's Urban Forests. Draft Urban Forest RPA. It was cited on http://www.coloradotrees.org/benefits.htm
- Tree mechanism for removing pollutants. Encyclopedia of the Earth, http://www.eoearth.org/, Environmental effects of urban trees and vegetation

2.5. Air Quality Co-Benefits Assumptions

- It was assumed that all the "urban park" PM was PM**10**. Particle size distribution was not provided for PM in the "urban park" data.

3. INTERACTION WITH OTHER POLICIES

AFW-2 does not interact with any other AFW policies as it is the only policy which includes urban tree planting. While the emissions reductions benefits of the planted trees could be included aspotential measures under RCI-10 (Energy Efficiency Resource Standard) and ES-3 (GHG Cap and Trade), the analysis determined that the GHG reductions benefits from reduced heating and cooling are *de minimis*, and therefore the potential interaction with these policies is negligible.

Policy No.: AFW-3

Policy Title: Afforestation, Reforestation, and Restoration of Forests and Wetlands

SAIC was tasked with reviewing the AFW-3 policy analysis which was conducted by a prior MDE contractor (Original Methodology). SAIC conducted a thorough examination of the methodologies, assumptions, data sources, and results and subsequently described the methodology and results as well as provided SAIC's observations and recommendations. SAIC also quantified the air quality co-benefits of this policy. The results of SAIC's review of the Original Methodology and the quantification of related co-benefits is below:

1.0. GHG EMISSION REDUCTIONS

As described in Appendix D of the Maryland CAP, AFW-3 seeks to increase forest cover through afforestation and reforestation in forests, agricultural areas, and wetlands. The goals are to offset the loss of 900 acres each month to development, (June 2008 through December 2020); establish riparian buffers at a rate of 360 miles/year to 2020 until 70 percent of all stream miles in the state are buffered, and increase wetland areas wherever feasible. Updated performance targets provided by the Maryland Department of Natural Resources (DNR) further elaborate upon these policy objectives to: establish or restore 16,678 acres of wetlands, protect 250,000 acres of forest by 2020, and afforest and/or reforest of 10,000 acres.

The analysis did not quantify the establishment or restoration of wetlands, rather, it calculated the carbon sequestration from afforestation to offset development as well as riparian buffers as follows:

Table AFW-3.1. Annual GHG Emission Reductions Estimated from AFW-3

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
AFW-3 Total	**0.217**	**0.366**	**0.624**
Afforestation to Offset Development	0.209	0.346	0.574
Riparian Buffer Afforestation	0.008	0.020	0.050

1.1. Summary of Methodology

The analysis used USFS data for forest types chosen as similar to current Maryland forests. It used different forest types to estimate the CO_2 removed from the air through "afforestation to offset development," and "riparian buffer afforestation". Using the acreages for both aspects of this policy, specific CO_2 rates of removal were applied to determine the GHG emission benefits.

1.2. Rationale for GHG Emission Methodology

The analysis used USFS General Technical Report GTR-NE-343 to determine carbon sequestration rates from afforestation for offsetting development and riparian buffers. Applying weighted rates based upon the composition of two broad areas for afforestation – offsetting development and riparian buffers – to the targeted acreages for afforestation provided estimates of carbon sequestration.

1.3. GHG Emission Calculations

The analysis quantified GHGs from two aspects of AFW-3:

- Afforestation to Offset Development
- Afforestation for Riparian Buffers

The methodologies employed for each aspect are discussed separately below.

A) Afforestation to Offset Development Calculations

Step 1: Determine the Average Annual Sequestration for Different Forest Types

The Original Analysis used USFS sequestration tables in GTR-NE-343 to determine average annual carbon sequestration in oak-hickory, oak-pine, and loblolly-shortleaf pine stands from year 0 to year 45, as 1.2, 1, and 0.9 tons carbon/acre/year.[29]

Average Annual Sequestration = 1/45 (Sequestration at year 45 - Sequestration at Year 0)

Step 2: Create a weighted annual average of carbon sequestration.

The Original Analysis used a forest composition for Maryland forests of 70 percent oak-hickory, 15 percent oak-pine, and 15 percent loblolly-shortleaf pine, and created a weighted annual average carbon sequestration rate from the average annual sequestration for oak-hickory, oak-pine, and loblolly-shortleaf pine stands (from Step 1), as follows:

Weighted Annual Sequestration per Forest Type = Fraction of Forest Type * Average Annual Sequestration per Forest Type (e.g., for oak-hickory = 0.7 * 1.2 = 0.84 tons/acre/year)

Average Annual Sequestration Across Forest Types = Sum of Weighted Annual Sequestration per Forest Type = 0.7 * 1.2 + 0.15 * 1 + 0.15 * 0.9 = 1.155 tons/acre/year

Step 3: Determine the acreage in each year.

Based on policy goals of offsetting 900 acres monthly, determined the annual target acreages for seven months in 2008 (program implementation began in June) and twelve months from 2009 through 2020. This resulted in 6,300 acres (900 acres * 7 months) for 2008, and 10,800 acres for all other years.

Step 4: Calculate the annual and cumulative carbon sequestration for all program years.

Multiply the per acre carbon sequestration rate determined in Step 2 by the acreage in each year (from Step 3) to give the annual carbon sequestration for all program years.

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[29] J.E. Smith, L.S. Heath, K.E. Skog, and R.A. Birdsey. 2006. Methods for calculating forest ecosystem and harvested carbon with standards estimates for forest types of the United States. USDA United States Forest Service (USFS) Northern Research Station. General Technical Report GTR-NE-343. http://www.treesearch.fs.fed.us/pubs/22954 (ne_gtr343.pdf)

Total Annual Sequestration (in a given year) = Average Annual Sequestration * CO_2/C mass ratio * Annual Acreage * 1 * 10^-6 MMt/Mt (e.g., for 2008 = 1.155 * 44/12 * 6,300 * 10^-6 = 0.027 $MMTCO_2e$)

B) Afforestation for Riparian Buffers Calculations

Step 1: Determined annual acreage for afforestation.

Using Chesapeake Bay Program goals for the afforestation of riparian areas of 900 miles per year by 2020 and assuming that 40 percent of these riparian buffers would be established in Maryland, determine an annual acreage for afforestation.[30]

Total Policy Acreage = 900 miles * 50 feet * 1.894*10^-4 miles/foot * 640 acres/square mile * 0.4 = 2,182 acres.

Annual Acreage = 2,182 acres / 13 years = 168 acres / year

Step 2: Determined the forest composition of riparian buffer areas

The analysis used by the prior contractor assumed that the forest composition of riparian buffer areas could be represented by a mix of 50 percent elm-ash-cottonwood and 50 percent loblolly-pine forest types. This assumption was based on the prior contractor's conclusion that the two most common species in riparian buffers statewide are loblolly pine and green ash.[31]

Step 3: Determine a weighted annual average carbon sequestration rate.

As in Step 1 and Step 2 of Section 1.3.2, use 45 year carbon storage rates of loblolly pines and elm-ash-cottonwood to determine a weighted annual average carbon sequestration rate of 0.9 tons C/acre/year.

Step 4. Determine the annual and cumulative carbon sequestration

As in step 4 of Section 1.3.2, multiply the per acre carbon sequestration rate (Step 3) by the acreage (Step 1) to produce the annual and cumulative carbon sequestration.

1.4. GHG Emission Data and Data Sources

The GHG emission quantification used data from:

- USFS GTR-NE-343
- Chesapeake Bay Program goals
- Maryland DNR Forest Service Research Report DNR/FS-01-01

[30] 2007. Chesapeake Bay Program. Chesapeake Bay Program Announces Forest Conservation Goals for Watershed. http://www.chesapeakebay.net/press_ec2007forests.aspx

[31] April 2001. Maryland DNR Forest Service. Riparian Forest Buffer Survival and Success in Maryland, Maryland DNR Forest Service Research Report DNR/FS-01-01. http://dnrweb.dnr.state.md.us/download/forests/rfb_survival.pdf

1.5. GHG Emission Assumptions

- Offsetting of development acres would be completely achieved by afforestation without any part of the offsetting being done through reforestation.
- Composition of Maryland forests is 70 percent oak-hickory, 15 percent oak-pine, and 15 percent loblolly-shortleaf pine, and that afforestation would be implemented in these proportions.
- Afforestation in riparian buffers is equivalent, in carbon sequestration terms, to a 50 percent elm-ash-cottonwood and 50 percent loblolly-pine forest types. Equating riparian vegetation to this mix risks overestimating the GHG benefits, especially due to the use of loblolly-pine data.
- For both offsetting development and riparian buffers, assumed that average sequestration rates based on existing trees can be applied to newly planted trees and that this rate can be applied independent of tree age.

1.6. GHG Emission Analysis and Recommendations

AFW-3 encourages afforestation actions to offset development and to support riparian buffers. The analysis applied a per area sequestration rate from USFS General Technical Report GTR-NE-343 to determine the carbon sequestration. This method assumes that the trees would sequester carbon at the same rate over the life of the policy, and that these rates would be those of the simulated forest stands which form the basis of GTR-NE-343.

Within this policy, saplings are planted, grow and sequester carbon over different time spans, depending upon when they are planted. Maryland plans to use the predicted GHG emission reductions in 2012, 2015, and 2020 to measure its progress against the policy's ultimate goals. Determining accurate carbon sequestration values involves tracking the planting and growth of several age cohorts of trees, i.e., knowing for example the per acre sequestration of the oak-hickory forest type planted in 2008-2009 (first year of growth), 2009-2010 (second year of growth), 2010-2011 (third year of growth), and so on, until 2020. This analysis should be repeated for each age cohort, i.e., white oak forest type species planted in 2008 (growth over 2008-2020), those planted in 2009 (growth over 2009-2020) through 2020, and so on. Summing the carbon sequestration benefits of the various forest types over each calendar year would provide more accurate GHG reductions/carbon sequestration benefits on an annual basis, providing policy makers both with meaningful GHG reduction estimates for the key policy years of 2012, 2015, and 2020.

2.0 AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated emissions reductions from AFW-3 are shown in the following table:

Table AFW-3.2- Emissions Reductions in Maryland Associated with AFW-3

	Statewide (tons/year)		
Pollutant	**2012**	**2015**	**2020**
SO_2	92	160	273
NO_X	140	240	410
PM10-primary	740	1300	2200

These numbers were compared against the MANE-VU inventories for 2012 and 2018. The reductions for SO_2 and NO_X are all less than four-tenths of a percent, indicating that the co-benefits associated with this policy for those pollutants would be unlikely to improve air quality. The value for PM is greater than 1 percent in 2018 and this policy could contribute to an improvement PM air quality.

Table AFW-3.3- Percentage Reduction in State Emissions Inventory Associated with AFW-3

Reductions	Maryland (%)	
Pollutant	**2012**	**2018**
SO_2	0.086	0.28
NO_X	0.10	0.34
PM10-primary	0.6	1.4

2.2. Summary of Air Quality Co-Benefits Methodology

The benefits to attainment/maintenance of the PM, NO_X, and SO_2 NAAQS in AFW 3 is related to the amount of air pollutant that the trees will remove from the ambient air. The method for estimating these reductions was based on empirical data that was derived from an urban park. Emission reduction factors were derived from the park data and applied to the additional forest acreage resulting from this policy. The reductions were then compared to the projected statewide emission inventories to determine the significance of the reductions.

2.3. Rationale for Air Quality Co-Benefits Methodology

The methodology for determining co-benefits for the PM, NO_X, and SO_2 NAAQS was based on urban park data. This methodology was chosen because it was readily available and provided a simple and straightforward means to estimating the ambient air pollutant reductions. There may be models that produce estimates based on more details and considers more parameters; however, given the small reductions involved, the lack of detailed data, and the uncertainty associated with such a models it was not believed that the additional effort would produce more reliable estimates. It is recognized that using data derived from an "urban park" does not consider rural environments, tree species, forest density, site-specific meteorology, and other variables. But given the minimal reductions that are estimated it is unlikely that a more refined approach would produce more accurate estimates.

2.4. Air Quality Co-Benefits Calculations

The removal from the atmosphere of airborne pollutants by a 212 hectare urban park has been estimated to be 48, 9, and 6 pounds per day for PM, NO_X and SO_2, respectively. Pollutant reduction factors were derived as in the following example for PM:

> **Equation 1: 48 lb-PM/212 hectare-day x 0.404 hectare/acre x 365 day/yr x .0005 ton/lb = 0.017 ton-PM/acre-yr**

The reduction for each pollutant was the product of the pollutant reduction factor and the estimated additional acreage of forest. The calculation for PM in 2020 is as follows:

> **Equation 2: 0.017 ton-PM/acre-yr x 130,500 acres = 2,200 ton-PM/yr**

The potential co-benefit of those emission reductions listed in Table 2 is the absolute reductions in Table 1 compared to the statewide emission inventory.

2.5. Air Quality Co-Benefits Data and Data Sources

- Urban park emissions**:**Identified Benefits of Community Trees and Forests
  by Dr. Rim D. Coder, University of Georgia, October 1996

- Statewide emission inventory**:** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

2.6. Air Quality Co-Benefits Assumptions

- It was assumed that all the "urban park" PM was PM**10**. Particle size distribution was not provided for PM in the "urban park" data. Ignoring the larger PM, which may have been present, only raises the estimated reductions for PM**10**. Since those reductions are de minimis anyway, it does not change the conclusions.

- Research has shown that biogenic emissions produce NO_X limited atmospheric chemistry over the entire Eastern U.S. region. http://www.epa.gov/appcdwww/apb/biogenic.htm. Model uncertainties range from ± 50 percent for summertime isoprene emission estimates (the most important compound emitted from U.S. deciduous forests) to over a factor of 10 for some oxygenated VOC such as hexenol.

3.0 INTERACTION WITH OTHER POLICIES

AFW policies that could interact with AFW-3 are AFW-1 and AFW-4. AFW-1 involves improved forest management on private and public lands. AFW-3 includes afforestation and reforestation, but this involves adding or replacing lost forested areas, and not enhancing their management as in AFW-1. One component of AFW-4 is the conservation and protection of forests, especially upland forests most susceptible to conversion to settlements. This does not involve any addition of forests as in AFW-3, and instead focuses upon preventing the conversion of existing forests. There is thus no interaction with AFW-1 and AFW-4.

Policy No.: AFW-4

Policy Title: Protection and Conservation of Agricultural Land, Coastal Wetlands, and Forested Land

SAIC was tasked with reviewing the AFW-4 policy analysis which was conducted by a prior MDE contractor (Original Methodology). SAIC conducted a thorough examination of the methodologies, assumptions, data sources, and results and subsequently described the methodology and results as well as provided SAIC's observations and recommendations. SAIC also quantified the air quality co-benefits of this policy. The results of SAIC's review of the Original Methodology and the quantification of related co-benefits is below:

1.0 GHG EMISSION REDUCTIONS

AFW-4 contains measures designed to conserve agricultural, forest, and coastal wetlands, as a means of mitigating and adapting to climate change. The measures included in policy AFW-4 include: (1) protecting 962,000 acres of productive agricultural lands ensuring no net loss by 2020,[32] (2a) retaining existing levels of forest cover in the Maryland at 2.6 million acres past 2020 and (2b) protecting an additional 250,000 acres of forest by 2020, (3) assessing coastal wetlands as a sink or source of GHGs and evaluating the impact of climate change upon the extent of coastal wetlands, and (4) protecting priority coastal zones using a living shoreline. The analysis quantified measures (1) and (2).

Table AFW-4.1- Annual GHG Emission Reductions Resulting from AFW-4

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
AFW-4 Total	**10.190**	**16.319**	**26.536**
(1) Protecting Agricultural Lands (962,000 acres)	0.106	0.170	0.276
(2a) Avoiding deforestation (250,000 acres by 2020)[33]	9.810	15.710	25.545
(2b) Sequestration in protected forests	0.274	0.439	0.715

1.1. Summary of GHG Emission Methodology

The analysis used estimates of the carbon in agricultural soils and in forest vegetation to determine how emissions of carbon dioxide into the air could be reduced through AFW-4. Maintaining agricultural lands and forests in their current form would prevent the emissions that occur when farms or forests are cleared. For agricultural lands, the analysis quantified the loss of carbon from the soils by multiplying the estimated carbon content of the soils by the area of agricultural lands targeted under the policy.

[32]This is the updated acreage from November 2010. The value in Appendix D was 1.2 million acres.
[33]The original analysis presented annual values in Table I-15 of Appendix D. The 2012 and 2015 values were determined using the cumulative totals up to that year.

There are two carbon benefits when forests are not cleared for development (or any other purpose), and both were quantified. The first benefit is that when forests are cleared, there is an immediate release of CO_2 into the atmosphere, therefore, when forests are not cleared, this CO_2 is not released to the atmosphere. This is calculated by determining the quantity of carbon in the area of the forest targeted by the policy.

The second carbon benefit relates to the continuous removal of CO_2 from the atmosphere by the forest vegetation through photosynthesis (also termed "carbon sequestration"). When the forest is cleared, this ongoing removal of carbon dioxide is lost. This loss is calculated by determining how fast carbon is absorbed by the forests and applying this rate of carbon removal to the forest areas targeted under the policy. The calculations for agricultural soils and forests are repeated for each year of the policy (2008-2020) and then added together to provide annual carbon benefits.

1.2. Rationale for GHG Emission Methodology

Protecting agricultural lands – The analysis assumed a soil carbon density and multiplied it by an annual rate of agricultural loss calculated to be 11,813 acres per year (see 1.3 A Step 1) and not the policy target for the avoided conversion of agricultural lands. As mentioned in the "Assumptions" section 1.5 Abelow, it is unclear why a calculated annual rate of agricultural land loss was used instead of an average annual conversion rate based on the life of the policy target of 962,000 acres (November 2010 update) or the 1.2 million acres specified in Appendix D of the Maryland CAP.[34]

Avoided deforestation – The analysis determined carbon density from United States Department of Agriculture (USDA) Forest Inventory and Analysis (FIA) data for non-soil total forest carbon and multiplied it by annual policy targets.

Sequestration in protected forests – The analysis determined a single sequestration rate using USDA GTR-NE-343 and applied it to annual policy targets for preventing forest conversion for development use.

1.3. GHG Emission Calculations

The Original Methodology quantified three aspects of this policy:

- Protecting agricultural lands
- Avoided deforestation
- Sequestration in protected forests

The methodologies employed for each aspect are discussed separately below.

A) Protecting Agricultural Lands

The following methodology was used to quantify GHG emission reductions from protected agricultural lands:

[34] Assuming linear implementation of the policy, the calculation would be 962,000/13 or 74,000 acres annually. With the CAP value of 1.2 million acres it would be 92,308 acres annually. The prior contractor used 11,813 acres annually.

Step 1: Determine agricultural land lost to development.

Citing the USDA National Resources Inventory (NRI) data, determined that the agricultural land lost to development is 11,813 acres/year.[35]

Step 2: Determine annual land lost to development.

Divided this 11,813 acres value by 13 (2008-2020) to give an annual loss of 909 acres of agricultural land to development.

Step 3: Assume that when agricultural land is converted to development, 50 percent of the land would be cleared, and that 75 percent of the soil carbon in the top eight inches of the soil would be lost.

Step 4: Assume a soil carbon content of 0.017 million metric tons of carbonper 1,000 acres.[36]

Step 5: Determine loss of soil carbon per acre.

From Step 3 and Step 4, determined a loss of soil carbon of 2.3375 * 10^-5 $MMTCO_2$ per acre when agricultural land is converted for development use.

From Step 4, 0.017 MMTC per 1000 acres = 1.7*10^-5 MMTC /acre

Loss of Soil Carbon Per Acre (as CO_2) = Soil Carbon Content * Fraction of Land Cleared * Fraction of Carbon Lost * CO_2/C mass ratio

Loss of Soil Carbon Per Acre (as CO_2) = 1.7*10^-5 MMTC * 0.5 * 0.75 * 44/12 = 2.3375 * 10^-5 $MMTCO_2$/acre.

Step 6: Determine avoided emissions from preventing the conversion of agricultural land to development.

Citing AFW-4 policy goals, multiplied the annual target for avoided agricultural land conversion (from Step 2) by the per acre soil carbon loss (Step 5) to determine the avoided emissions from preventing the conversion of agricultural land to development use.

Avoided Emissions = Annual Target for Avoided Land Conversion * Loss of Soil Carbon per acre

(For example for the first year, 909 acres of agricultural land not lost to development = 909 acres * 2.3375*10^-5 $MMTCO_2$/acre = 0.021 $MMTCO_2$)

B) Avoided Deforestation

The following methodology was used to quantify GHG emission reductions from avoided deforestation:

Step 1: Determine amount of land cleared for residential development.

Using American Housing Survey and NRI data for Maryland, determined that 67 percent of the land is cleared during conversion of forestland to residential development.[37]

[35]Currently available NRI data for Maryland states that the amount of land in crop production for Maryland decreased from 1,794,700 acres in 1982 to 1,616,000 acres in 1997, which is an annual rate of 11,913 acres. USDA Natural Resources Conservation Service (NRCS). NRI. Maryland. http://www.md.nrcs.usda.gov/technical/nritext.html

[36]The source of this value is unclear.

Step 2: Assumed that 100 percent of the non-soil total forest carbon would be lost in this 67 percent of the previously forested area.

Step 3: Determine a per acre value of non-soil forest carbon.

Citing FIA data for Maryland, and based upon Steps 1 and 2 above, determined a per acre value of 27.9 metric tons of non-soil forest carbon.

Non-soil forest carbon = Total Forest Carbon – Soil Carbon

Non-soil forest carbon = 73.9 - 25.5 = 48.4 metric tons carbon per acre[38]

Carbon lost from Forest to Development Conversion = Fraction of Land Cleared * Fraction of Carbon Lost * Non-soil Forest Carbon

Carbon lost from Forest to Development Conversion = 0.67 * 1 * 48.4 = 32.43 tons carbon per acre. (This value is different from the 27.9 used in the original analysis which could be attributable to the updating of the FIA data since the original study.)

Step 4: Determine the tons of CO_2 lost per acre from development.

Convert the 27.9 metric tons of carbon (from Step 3) to CO_2 to determine the tons of CO_2 lost per acre from forest converted to development.

CO_2 lost from Forest to Development Conversion = Carbon lost from Forest to Development Conversion * CO_2/C mass ratio = 27.9 metric tons C * 44/12 metric ton CO_2/metric ton C = 102.3 metric tons CO_2 per acre.

Step 5: Determine annual target acreages of avoided forest to residential conversion

Based upon policy goals of protecting 96,000 acres by 2012, and a total of 250,000 acres by 2020; determined yearly target acreages of 19,200 for 2008 through 2012 (96,000 divided by 5), and 19,250 for 2013 through 2020 (250,000 less 96,000, divided by 8).

Step 6: Determine tons of CO_2 avoided.

Multiplied the target annual acreages (from Step 5) with the tons of carbon dioxide that would be lost per acre (from Step 4) to determine the tons of carbon dioxide emissions avoided.

Avoided Emissions = Acreage * CO_2 "Lost" from Forest to Development Conversion (e.g., for 2008 = 19,200 acres * 102.3 metric tons CO_2 per acre = 1,964,160 tons CO_2 or 1.96 $MMTCO_2$)

C) Sequestration in Protected Forests

The following methodology was used to quantify GHG emission reductions from sequestration in protected forests:

Step 1: Citing FIA, use a forest distribution for Maryland of 63 percent oak-hickory types, 11 percent oak-pine and 10 percent natural loblolly-shortleaf pine stands.[39]

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[37]The source of how this 67% value was determined is unclear.
[38]The analysis did not provide details on the data used, but the current USDA Forest Inventory and Analysis (FIA) database provides a value of 73.9 metric tons per acre total forest carbon and 25.5 metric tons per acre soil carbon for public forests in Maryland. Source: USDA USFS FIA. http://www.fia.fs.fed.us/Forest%20Carbon/default.asp.
[39] The exact source of this forest type distribution is unclear.

Step 2: Determine average annual carbon sequestration

The Original Analysis used USFS sequestration tables in GTR-NE-343 to determine average annual carbon sequestration for oak-hickory, oak-pine, and loblolly-shortleaf pine stands from year 25 to year 75, as 0.8, 0.7, and 0.5 tons carbon/acre/year.[40]

Average Annual Sequestration = 1/50 (Sequestration at year 75 - Sequestration at Year 25)

Step 3: Determined an average annual sequestration rate for forests not converted to development

The Original Analysis used a forest composition for Maryland forests of 70 percent oak-hickory, 15 percent oak-pine, and 15 percent loblolly-shortleaf pine, and created a weighted annual average carbon sequestration rate from the average annual sequestration for oak-hickory, oak-pine, and loblolly-shortleaf pine stands (from Step 3), as follows:

Weighted Annual Sequestration per Forest Type = Fraction of Forest Type * Average Annual Sequestration per Forest Type (e.g., for oak-hickory = 0.75 * 0.8 = 0.6 tons/acre/year)

Average Annual Sequestration Across Forest Types = Sum of Weighted Annual Sequestration per Forest Type = 0.75 * 0.8 + 0.15 * 0.7 + 0.15 * 0.5) = 0.78 metric tons C/acre/year[41]

In CO_2 terms = 0.78 * 44/12 = 2.86 tons CO_2 / acre / year

Step 4: Determine the annual and cumulative sequestration.

Multiplied the annual target acreages identified in Step 5 of Section B above by the weighted average annual sequestration rate from Step 3 to determine the annual and cumulative sequestration of forestlands not cleared for development use.

Annual Sequestration = Acreage * Average Annual Sequestration Across Forest Types (e.g., for 2008 = 19,200 * 2.86 * 1* 10^-6 $MMTCO_2$= 0.055 $MMTCO_2$)

1.4. GHG Emission Data and Data Sources

- USDA National Resources Inventory. Maryland. http://www.md.nrcs.usda.gov/technical/nritext.html#Crop%20and%20Pasture%20Trends
- J.E. Smith, L.S. Heath, K.E. Skog, and R.A. Birdsey. 2006. Methods for calculating forest ecosystem and harvested carbon with standards estimates for forest types of the United States. USDA United States Forest Service (USFS) Northern Research Station. General Technical Report GTR-NE-343. http://www.treesearch.fs.fed.us/pubs/22954 (ne_gtr343.pdf)

[40] J.E. Smith, L.S. Heath, K.E. Skog, and R.A. Birdsey. 2006. Methods for calculating forest ecosystem and harvested carbon with standards estimates for forest types of the United States. USDA United States Forest Service (USFS) Northern Research Station. General Technical Report GTR-NE-343. http://www.treesearch.fs.fed.us/pubs/22954 (ne_gtr343.pdf)

[41] This equation is implied from the existing analysis.

1.5. GHG Emission Assumptions

The assumptions are presented separately by each part of the analysis

A) Protecting Agricultural Lands - Assumptions

- 50 percent of the land is cleared upon conversion of agricultural land for development use
- Only carbon from soil is lost and that there would be no change in the levels of aboveground carbon stocks
- 75 percent of the soil carbon in the top eight inches of the soil is lost when agricultural land is converted to development use
- Soil carbon value is 0.017 million metric tons of carbon per 1,000 acres
- Although the policy goal is to maintain 962,000 acres of agricultural land, the analysis was conducted based upon a land conversion rate of 11,813 acres per year over the life of the policy (2008-2020)
- Policy implementation would be linear

B) Avoided Deforestation - Assumptions

- 67 percent of the land is cleared during conversion of forestland to residential development
- 100 percent of the vegetation carbon stocks would be lost in the event of forest conversion to developed uses
- No appreciable carbon sequestration would occur in soils or biomass following development
- Policy implementation would be linear

C) Sequestration in Protected Forests - Assumptions

- A single sequestration rate determined from oak-hickory, oak-pine, and loblolly-shortleaf pine forest types is applicable to the forest conservation efforts
- Policy implementation would be linear

1.6. GHG Emission Analysis and Recommendations

For calculating the emissions avoided by protecting agricultural lands, the assumed value used for soil carbon and its source is unclear. Soil carbon values for the non-urban to urban land use conversion are available in scientific literature.[42] A more accurate analysis would use more specific data.

To improve the accuracy of the agricultural findings for policy (1), SAIC recommends that 74,000 acres annually (based on a total goal of 962,000 acres of cropland over the life of the policy) be used in the calculations rather than the 11,813 acre value of yearly land converted from cropland to development use.

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[42] For example, see “2002. Pouyata, R. et al. Soil carbon pools and fluxes in urban ecosystems . Environmental Pollution 116:S107-S118.”

The approach to calculating the avoided deforestation is generally sound, based upon FIA data for the state of Maryland. However, both the avoided deforestation and sequestration analyses relied upon linear implementation of the initiatives, which, given the variety of implementation mechanisms proposed, is unlikely. The USDA GTR-NE-343 "look-up" tables are based upon the FORCARB model and likely lack the degree of accuracy sufficient for an analysis of this nature. Using values from limited forest types and extending them statewide provides a rough first approximation of sequestration. A more accurate analysis may be possible through the use of more detailed information on forest types and their sequestration rates.

2.0 AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated emissions reductions from AFW-4 are shown in the following table:

Table AFW-4.2- Annual Emissions Reductions (based on Cumulative Acreage) in Maryland Associated with AFW-4

	Statewide (tons/year)		
Pollutant	**2012**	**2015**	**2020**
SO_2	201	322	523
NO_X	301	482	784
PM10-primary	1,606	2,572	4,182

These numbers were compared against the MANE-VU inventories for 2012 and 2018. The reductions for SO_2 and NO_X are all less than four-tenths of a percent of the projected MANE-VU inventories, indicating that the co-benefits associated with this policy for those pollutants would be unlikely to improve air quality. The value for PM is greater than 1 percent of the projected MANE-VU inventory in 2018 and this policy could contribute to an improvement PM air quality.

Table AFW-4.3- Percentage Reduction in State Emissions Inventory Associated with AFW-4

Reductions	Maryland (%)	
Pollutant	**2012**	**2018**
SO_2	0.19	0.54
NO_X	0.2	0.67
PM10-primary	1.3	2.6

2.2. Summary of Air Quality Co-Benefits Methodology

For Policy AFW-4 the benefits to attainment/maintenance of the PM, NO_X, and SO_2 NAAQS is related to the amount of air pollutant that the trees will remove from the ambient air. The method for estimating these reductions was based on empirical data that was derived from an urban park.[43] Emission reduction factors were derived from the park data and applied to the additional forest acreage resulting from this policy. The reductions were then compared to the projected statewide emission inventories to determine the significance of the reductions.

2.3. Rationale for Air Quality Co-Benefits Methodology

The methodology for determining co-benefits for the PM, NO_X, and SO_2 NAAQS was based on urban park data. This methodology was chosen because it was readily available and provided a simple and straightforward means to estimating the ambient air pollutant reductions. There may be models that produce estimates based on more details and considers more parameters; however, given the small reductions involved, the lack of detailed data, and the uncertainty associated with such a models it was not believed that the additional effort would produce more reliable estimates. It is recognized that using data derived from an “urban park” does not consider rural environments, tree species, forest density, site-specific meteorology, and other variables. But given the minimal reductions that are estimated it is unlikely that a more refined approach would produce more accurate estimates.

2.4. Air Quality Co-Benefits Calculations

The removal from the atmosphere of airborne pollutants by a 212 hectare urban park has been estimated to be 48, 9, and 6 pounds per day for PM, NO_X and SO_2, respectively. Pollutant reduction factors were derived as in the following example for PM:

48 lb-PM/212 hectare-day x 0.404 hectare/acre x 365 day/yr x .0005 ton/lb = 0.017 ton-PM/acre-yr

[43] Although this policy is more likely to impact rural forests than urban parks, both AFW-4 and urban parks represent similar vegetation (trees and grasses). Granted that there are likely to be differences in the air quality impacts of urban versus rural tree stands, there were no available studies indicating that calculation methods for AFW-4 should deviate from those for other AFW policies.

The reduction for each pollutant was the product of the pollutant reduction factor and the estimated additional acreage of forest that avoids deforestation as a result of Policy AFW 4. The calculation for PM in 2015 is as follows:

0.017 ton-PM/acre-yr x 153,750 acres = 2,572 ton-PM/yr

The potential co-benefit of those emission reductions listed in Table 2 is the absolute reductions in Table 1 compared to the statewide emission inventory.

2.5. Air Quality Co-Benefits Data and Data Sources

- **Urban park emissions.** Identified Benefits of Community Trees and Forests by Dr. Rim D. Coder, University of Georgia, October 1996
- **Statewide emission inventory.** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

2.7. Air Quality Co-Benefits Assumptions

- It was assumed that all the "urban park" PM was PM10. Particle size distribution was not provided for PM in the "urban park" data.

3. INTERACTIONS WITH OTHER POLICIES

AFW policies that could interact with AFW-4 are AFW-1, AFW-3, and AFW-5. One component of AFW-4 is the conservation and protection of forests, especially upland forests most susceptible to conversion to settlements. AFW-1 involves improved forest management to enhance carbon sequestration on existing private and public lands, and while conserved lands could be targeted for improved forest management, the avoided carbon emissions from conversion (AFW-4), the sequestration in protected forests (AFW-4), and the enhanced carbon sequestration from improved management (AFW-1) are separate. The last category would only consist of the additional sequestration achieved through improved forest management. AFW-3 includes afforestation and reforestation, but this involves adding or replacing lost forested areas, and not preventing the conversion of existing forests. The implementation of the portion AFW-5 (Buy Local) calling for 80 percent of Maryland's food supply to be grownlocally by 2050 is related to the portion of policy AFW-4 that deals with protecting agricultural lands. However, since AFW-4 focuses

AFW-4 also has synergistic interactions with TLU-2 (Land Use & Location Efficiency), since TLU-2 encourages high density development and discourages urban sprawl, which will protect forests susceptible to conversion to settlements. Thus, TLU-2 and AFW-4 will have a synergistic effect, as noted in Chapter 5. Since the emissions reductions from these two policies are calculated using two distinct methodologies (reduced VMT for TLU-2 and the prevention of the release of carbon from cleared forests for AFW-4), the emission reductions for the two policies may be summed.

Policy No.: AFW-5

Policy Title: "Buy Local" Programs for Sustainable Agriculture, Wood and Wood Products

SAIC was tasked with reviewing the AFW-5 policy analysis which was conducted by a prior MDE contractor (Original Methodology). SAIC conducted a thorough examination of the methodologies, assumptions, data sources, and results and subsequently described the methodology and results as well as provided SAIC's observations and recommendations. SAIC also quantified the air quality co-benefits of this policy. The results of SAIC's review of the Original Methodology and the quantification of related co-benefits is below:

1.0 GHG Emission Reductions

AFW-5, as described in Appendix D of the Maryland CAP and the November 2010 Maryland Commission on Climate Change Report Update, includes several measures designed to reduce GHGs associated with the production and transport of agricultural goods imported from other states or countries by replacing them with locally produced goods. The policy goals included in AFW-5 are: (1) increasing the number of local farmers' markets in Maryland 25 percent by 2015 and 50 percent by 2020, (2) increasing the locally grown and produced portion of food consumed by Marylanders to 80 percent by 2050, and (3) replacing 20 percent of imported wood with wood locally grown and processed by 2015 and 50 percent by 2050. The analysis quantified policy goal (1).

Table AFW-5.1- GHG Emission Reductions Resulting from AFW-5

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
AFW-5 Total	**.009**	**.015**	**0.031**

1.1. Summary of GHG Emission Methodology

The analysis estimated GHG reductions associated with increasing the number of local farmers' markets in Maryland by scaling up the results of a 2001 Iowa study by the Leopold Center entitled "Food, Fuel, and Freeways: An Iowa perspective on how far food travels, fuel usage, and GHG emissions[44]" that determined fuel usage and CO_2 emissions associated with different food systems in Iowa. Results of the Iowa study were scaled to Maryland by using a comparison of the two states' populations and linked to AFW- 5 using the percentage increase in farmers' markets called for in the policy.

1.2. Rationale for GHG Emission Methodology

[44]Pirog, R., Van Pelt, T., Enshayan, K., Cook, E., 2001, *Food, Fuel, and Freeways: An Iowa perspective on how far food travels, fuel usage, and greenhouse gas emission,* Leopold Center for Sustainable Agriculture, June 2001.

The methodology chosen for determining GHG reductions associated with AFW-5 focused on reductions in what is often called "food-miles." Food-miles represent the distance food travels from production to the consumer; locally produced food travels a shorter distance then conventionally produced food, resulting in transportation related GHG reductions. There is however a dearth of comprehensive studies of food-miles that could be used as the basis for estimating GHG reductions associated with local food production. The 2001 Leopold Center report, while Iowa-specific, is one of the only well documented U.S. studies available to use as a basis for estimating GHG reductions from food-miles. The analysis was based on the Leopold Center study because no comparable local Maryland-specific data was readily available.

1.3. GHG Emission Reduction Calculations

The methodology used to apply the results of the 2001 Leopold Center study to Maryland is described stepwise below.

Step 1: Determine annual fuel use and CO_2 emissions from a conventional food system

Citing the Leopold Center study discussed in Section 1.2 above, the analysis determined the annual fuel use and CO_2 emissions associated with transporting 10 percent of Iowa's total annual per capita consumption of 28 fresh produce items by the conventional tractor-trailer food system to be 368,102 gallons of diesel fuel resulting in 3,807 metric tons of CO_2.

Step 2: Determine annual fuel use and CO_2 emissions from a local food system

Citing the Leopold Center study, determined the annual fuel use and CO_2 emissions associated with transporting 10 percent of Iowa's total annual per capita consumption of the same 28 produce items (from step 1 above) by the local food system to be 49,359 gallons ofdiesel fuel resulting in 439 $mtCO_2$.

Step 3: Determine 2006 populations

Citing the US Census Bureau Quick Facts, determined the 2006 population of Iowa to be 2,982,085 and the 2006 population of Maryland to be 5,615,727.

Step 4: Determine a population conversion factor to compare Maryland's population to Iowa's

The analysis divided the Maryland population by the Iowa population from Step 3 to determine a population conversion factor of 1.88.

Step 5: Determine CO_2 emissions resulting from 10 percent of Maryland's food consumption of produce transported by a conventional food system

The analysis multiplied the Iowa conventional tractor-trailer food system CO_2 figure of 3,807 metric tons of CO_2 (Step 1) by the population conversion factor of 1.88 (Step 4) to determine CO_2 emissions resulting from 10 percent of Maryland's annual food consumption of select produce being transported through a conventional tractor-trailer food system to be 7,169 $mtCO_2$ per year.

Step 6: Determine CO_2 emissions resulting from 10 percent of Maryland's food consumption of produce transported by a conventional food system

The analysis multiplied the Iowa local food system CO_2 figure of 439 mtCO_2 (Step 2) by the population conversion factor of 1.88 (Step 4) to determine an estimate of CO_2 emissions resulting from 10 percent of Maryland's annual food consumption of select produce being transported through a local food system to be 826 mtCO_2 per year.

Step 7: Determine CO_2 reductions from sourcing 10 percent of Maryland's produce locally

The analysis subtracted the Maryland local food system CO_2 estimate of 826 mtCO_2 (Step 6) from the Maryland conventional tractor-trailer food system CO_2 estimate of 7,169 mtCO_2 (Step 5) to determine CO_2 reductions from sourcing 10 percent of Maryland produce locally to be 6,343 mtCO_2 per year.[45]

Step 8: Estimate the avoided CO_2 emissions from sourcing 100 percent of Maryland's produce locally

The analysis divided the CO_2 reductions from sourcing 10 percent of Maryland produce locally of 6,343 mtCO_2 (Step 7) by 10 percent to estimate CO_2 emissions avoided by sourcing 100 percent of Maryland's produce locally to be 63,426 mtCO_2 per year.[46]

Step 9: Determine the annual GHG emission reductions resulting from a 25 percent increase in the number of local farmers' markets by 2015

The analysis multiplied the estimate of total annual CO_2 emission reductions resulting from 100 percent local produce of 63,426 mtCO_2 (step 8) by 25 percent to determine that emission reductions of 15,856 mtCO_2 a year would result from a 25 percent increase in the number of local farmers' markets by 2015.[47]

Step 10: Determine the annual GHG emission reductions resulting from a 50 percent increase in the number of local farmers' markets by 2020

The analysis multiplied the estimate of annual CO_2 emission reductions resulting from 100 percent local produce production of 63,426 mtCO_2 (Step 8) by 50 percent to determine that emission reductions of 31,713 mtCO_2 a year would result from a 50 percent increase in the number of local farmers' markets by 2020.

1.4. GHG Emission Data and Data Sources

- Pirog, R., Van Pelt, T., Enshayan, K., Cook, E., 2001, *Food, Fuel, and Freeways: An Iowa perspective on how far food travels, fuel usage, and greenhouse gas emission,* Leopold Center for Sustainable Agriculture, June 2001.
- United States Census Bureau Quick Facts http://quickfacts.census.gov/qfd/index.html

45 The calculations in the "MD AFW Quantification" spreadsheet does not describe the fact that the Leopold Center study was based on 28 fruit and vegetable types and therefore give the impression that this figure covers all produce.

46 Resulting figure presented here varies slightly from the calculation described in this step due to rounding that occurred in the original calculations in the "MD AFW Quantification" spreadsheet. 63,426 mtCO_2 is the number that was used to determine the GHG reductions.

47 The emission reductions associated with AFW-5 calculated in the prior study actually give a theoretical estimate of reductions that would occur from sourcing different percentages of select produce locally and not reductions from an increase in the number of farmers markets; although the two items are linked they are not the same thing. This is further described in section 1.3.4.

1.5. GHG Emission Assumptions

The analysis makes the following assumptions:

- GHG reductions associated with transportation of produce are the chief source of quantifiable emission reductions associated with AFW-5.
- The relative food mix and assumptions about transport modes looked at in the Leopold Center study is an appropriate proxy for the Maryland food mix and food systems.
- A percentage increase in selected locally sourced produce is commensurate to the same percentage increase in the number of farmers' markets.
- The local region has the ability to supply the amount of agricultural products necessary to achieve the goals of AFW-5.

1.6. GHG Emission Analysis and Recommendations

To understand the effort necessary to reproduce the methodology in the Leopold Center paper to produce Maryland specific results, it is useful to understand the basic approach and some of the data sources used in that study. In order to estimate GHG emissions associated with both the Iowa conventional food system and the Iowa local food system, the Leopold Center began by estimating a per truck weighted average source distance (WASD)[48] for 28 different fresh fruit and vegetable commodities for each food system (conventional and local).

For the conventional food system the WASDs were determined by using USDA Agricultural Marketing Service data for the 28 selected produce items from the Chicago Terminal Market. The USDA data included the modes of transportation, origin, and amount consumed from each location of origin for the 28 items.[49]

To estimate the WASD associated with the Iowa local farm system (which includes farmer's markets and community supported agriculture programs) the study used data on total pounds of each of the 28 produce items delivered, delivery location, and address of growers. That data was collected from three local food projects that were all funded by the Leopold Center.

Iowa specific per capita annual consumption by weight of each of the 28 food commodities was also determined using USDA data. Assumptions were made about the mode of transport for each food system and the efficiency of that mode based on the data collected (tractor trailer was estimated for the conventional system and light truck for the local food system). That data was used in conjunction with the WASDs to determine the number of truckloads, resulting vehicle miles traveled and fuel necessary to transport 10 percent of Iowa's per capita consumption of the 28 selected commodities for each food system.

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[48] WASD is a figure that reports combined information on average miles from production to consumption for a product type (e.g., apples).

[49] The Leopold report states that the last year USDA collected this data was 1998. Similar data from 1998 is referenced in the Iowa study for the Jessup, MD Market Terminal.

While it would be possible given the appropriate data to reproduce the Leopold study in Maryland, it is important to recognize that there are GHG emissions related to how (e.g., organic vs. non-organic), where (e.g., in a heated greenhouse vs. a field), and when (e.g., in-season or out-of-season) food is produced, that may prove to be a more significant component of the carbon footprint of various food types than food-miles. In addition, the Leopold Study cites a 2001 report called "From Farm to Table: Making the Connection in the Mid-Atlantic Food System" which found that the average pound of produce distributed by the Maryland Market Terminal traveled 1,685 miles.[50] The 1,685 miles figure is only 47 miles higher than the average WASD reported in the Leopold study for the conventional food system. Therefore it may be that a Maryland version of the Leopold study would not produce significantly different results.

Further analysis of additional emissions benefits related to factors such as organic or non-organic may be challenging since there is no simple or standardized approach to their GHG quantification, and the necessary data is likely unavailable. As the body of knowledge in those areas develops, Maryland may want to develop more standard data sets that can be used to measure the efficacy of specific projects designed to increase consumption of local and sustainable food (and which may also be useful to researchers working on life-cycle analysis of local food).

The November 2010 Maryland Commission on Climate Change Report Update suggests that some of these measurement efforts are currently in development. Additional metrics such as annual increase in numbers of visitors to farmers' markets, number of participants in community supported agriculture programs, number of community gardens, and percentage of organic vs. non-organic food being distributed through government programs may also be useful but would likely require local partners to collect the data.

Finally it is also important to recognize that the majority of emission reductions associated with AFW-5 are based on avoiding transportation related GHG emissions that would occur outside of Maryland and should be noted as such.

[50] Hora, Matthew, and Jody Tick. 2001. "From Farm to Table: Making the Connection in the Mid-Atlantic Food System." Capital Area Food Bank of Washington D.C. report.

2.0. AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated criteria pollutant emission reductions from AFW-5 are shown in the following table:

Table AFW-5.2- NAAQS Emissions Reductions in Maryland Associated with AFW-5

	Statewide (tons/year)		
Pollutant	**2012**	**2015**	**2020**
SO_2	0.06	0.11	0.22
NO_X	5.6	6.9	9.5
CO	74	120	220
VOC	4.3	6.1	10
PM10 – primary	0.25	0.29	0.37
PM2.5 – primary	0.13	0.19	0.35

These numbers were compared against the MANE-VU inventories for 2012 and 2018 in Table AFW-5.3. Because all the values are less than two-tenths of a percent, the table indicates that the criteria pollutant emissions reductions associated with this policy would be unlikely to significantly improve air quality.

Table AFW-5.3: Percentage Reduction in State NAAQS Emissions Inventory Associated with AFW-5

Reductions	**Maryland (%)**	
Pollutant	**2012**	**2018**
SO_2	< .02	< .02
NO_X	< .02	< .02
CO	< .02	< .02
VOC	< .02	< .02
PM10-primary	< .02	< .02
PM2.5-primary	< .02	< .02

2.2. Summary of Air Quality Co-Benefits Methodology

The NAAQS co-benefits quantification methodology builds on the approach used in Section 1.0, and also applied the results of the 2001 Leopold Center study to Maryland as described below:

<u>Step 1: Develop a co-benefit factor</u>

A co-benefit factor was developed from the Leopold Center study discussed in 1.2 above. The annual fuel use and CO_2 emissions associated with transporting 10 percent of Iowa's total annual per capita consumption of 28 fresh produce items were determined to be 368,102 gallons ofdiesel fuel resulting in 3,807 metric tons of CO_2 and 49,359 gallons of diesel fuel resulting in 439 mtCO_2 for a conventional tractor-trailer food system and a local food system, respectively.

Step 2: Develop a fuel reduction factor

A fuel reduction factor was developed by calculating the ratio of the change in CO_2 to the change in fuel consumption (from Step 1) resulting in a factor of 1.06E-08 $MMTCO_2$/gal

Step 3: Determine fuel reductions

The fuel reduction factor in Step 2 was applied to the 2012, 2015, and 2020 CO_2 emission reductions of 0.009, 0.015, and 0.031 $MMTCO_2$ resulting in fuel reductions of 851,748, 1,419,580, and 2,933,798 gallons of fuel.

Step 4: Convert fuel reductions to Vehicle Miles Traveled (VMT)

Using a Heavy-Duty Truck Fuel Economy Presentation that cited 7.8 miles per gallon as the base fuel economy for Platform trucks, Delivery vans, Super-duty pickups, etc. (10,000 – 26,000 lbs gross vehicle weight (GVW)) the fuel reductions translated to 6.6, 11, and 23 million (mVMT) reductions in 2012, 2015, and 2020.

Step 5: Determine statewide VMT

Statewide VMT estimates of 55,631 and 78,989 mVMT were estimated for 2009 and 2030, respectively. An estimate of 59,000, 62,000 and 68,000 mVMT in 2012, 2015 and 2020, respectively were determined by linear interpolation.

Step 6: Determine percent of statewide VMT reduced from fuel reductions

Determined that statewide VMT reductions in Step 4 represented 0.01, 0.02 and 0.03 percent of Maryland statewide VMT estimates, in 2012, 2015 and 2020, respectively.

Step 7: Calculate the NAAQS reductions

When those percent reductions from Step 6 are applied to the total state mobile source inventory, the NAAQS emission reductions listed in Table 1 are derived. The potential co-benefit of those emission reductions listed in Table 2 is the absolute reductions in Table 1 compared to the statewide emission inventory.

2.3. Air Quality Co-Benefits Data and Data Sources

- **Statewide VMT estimates.** A Presentation Smart Growth & Transportation, Funding/Investment, Blue Ribbon Commission on Transportation Funding, Richard E. Hall, American Institute of Certified Planners (AICP), Secretary, Maryland Department of Planning, November 15, 2010
- **Statewide emission inventory.** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

- **Fuel Efficiency for Trucks.** Policy Discussion – Heavy-Duty Truck Fuel Economy Presentation by Drew Kodjak, National Commission on Energy Policy 10th Diesel Engine Emissions Reduction (DEER) Conference August 29 - September 2, 2004

2.4. Air Quality Co-Benefits Assumptions

- It was assumed that the reduction in VMT would result in a proportional reduction in the mobile source inventory. The platform trucks, delivery vans, and super-duty pickups probably contribute more per VMT than light duty vehicles (LDV), which are the largest fraction of the total mobile source emissions. However, as shown in Table 2, the impacts of this policy are so small that even an order of magnitude increase in the emission contribution from those vehicles would still result in an insignificant impact.

- It was assumed that the reductions in VMT would occur in state but it is likely that they would be mostly out of state since it is a shift from imported to local goods. We had no basis for refining the estimate with the in-state/out-of-state proportions.

3.0 INTERACTION WITH OTHER POLICIES

The quantified portion of AFW-5 (increasing the number of farmers' markets in Maryland) will not affect other policies, nor will it be affected by other policies.

The implementation of the portion AFW-5 calling for 80 percent of Maryland's food supply to be grown locally by 2050 is related to the portion of policy AFW-4 "Protection & Conservation of Agricultural Land, Coastal Wetlands & Forested Lands" that deals with protecting agricultural lands. Implementation of the AFW-4 policy would contribute toward meeting the AFW-5 goal of 80 percent local food production (note that further study is required to determine the amount of land that would be necessary to fully meet the AFW-5 goal).

The portion of AFW-5 related to replacing the amount of imported wood products with locally grown wood products is related to policy AFW-1 "Forest Management for Enhanced Carbon Sequestration"; however, since this portion of AFW-5 was not quantified it will not affect the emission reduction estimates in AFW-1, rather, it should be seen as a complimentary measure that would help create the market for products built with sustainably harvested Maryland wood.

Policy No.: AFW-6

Policy Title: Expanded Use of Forest and Farm Feedstocks and By-Products for Energy Production

SAIC was tasked with reviewing the AFW-6 policy analysis which was conducted by a prior MDE contractor (Original Methodology). SAIC conducted a thorough examination of the methodologies, assumptions, data sources, and results and subsequently described the methodology and results as well as provided SAIC's observations and recommendations. SAIC also quantified the air quality co-benefits of this policy. The results of SAIC's review of the Original Methodology and the quantification of related co-benefits is below:

1.0 GHG EMISSION REDUCTIONS

AFW-6 seeks to increase the utilization of biomass from urban and rural feedstocks, including processing by-products for generation of electricity, thermal energy, and transportation fuels. AFW-6 also seeks to reduce the amount of CH_4 emissions from livestock manure by installing manure digesters and implementing energy recovery projects.

AFW-6 contains several policy goals: 1) To increase use of agricultural residues and utilize 10 percent and 25 percent of available in-state agricultural residue biomass by 2015 and 2020, respectively, for electricity, steam, and heat generation; 2) To increase use of forest residues and utilize 10 percent and 25 percent of available in-state forest residue biomass by 2015 and 2020, respectively, for electricity, steam, and heat generation; 3) Increase energy crop use to utilize 50 percent of available in-state energy crop biomass for electricity, steam, and heat generation by 2020; and 4) Capture and use 50 percent of available CH_4 from livestock manure and poultry litter for renewable electricity, heat, and steam generation, by 2020.

Table AFW-6.1. Estimated GHG Emission Reductions Resulting from AFW-6[51]

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
AFW-6 Total	**0.13**	**0.24**	**0.54**
Biomass (Including Agricultural Residue, Forest Feedstocks, and Energy Crops)	0.12	0.22	0.50
Methane (CH_4) Utilization From Livestock Manure and Poultry Litter	0.01	0.022	0.04

[51] GHG Reduction numbers for 2012 and 2020 in this table come from the "Summary List of Recommended Priority Policy Options" on page 3 of Appendix D. GHG Reduction numbers for 2015 come from Table I-30 Summary of GHG Benefits and Costs for Biomass on page 58 of Appendix D and Table I-31 GHG Benefits for CH_4 Utilization from Livestock Manure on page 59 of Appendix D.

1.1. Summary of GHG Emission Methodology

Biomass GHG Benefits

To estimate the GHG benefit from this policy, the analysis first obtained the potential biomass feedstock production in 2020 from a Maryland DNR study.[52] The annual production was multiplied by the percentage increase in use needed each year from 2008 through 2020 to achieve the policy's biomass utilization goals. The yearly biomass feedstock production as determined for 2008 through 2020 was then multiplied by a factor to estimate the GHG benefits from the use of biomass instead of coal to generate electricity, heat, and steam.

CH_4 Utilization from Livestock Manure and Poultry Litter GHG Benefits

The GHG benefits of this aspect of AFW6 are two-fold – the reduction of CH_4 emissions and the emissions saved by producing electricity from the waste CH_4 instead of from conventional sources. The prior study used CH_4 emissions data from the Maryland GHG Inventory & Forecast[53] as a baseline. To obtain the quantity of CH_4 that could be captured, the estimated CH_4 emissions were first adjusted to reflect the partial efficiency of the collection process. Then, for each year of the policy period, the amount captured was uniformly increased from 2008 to 2020 to reach the goal of 50 percent capture and use by 2020. The annual amount of CH_4 captured each year was then used to determine the amount of electricity produced. The emissions normally produced for this quantity of electricity produced was then determined. The total GHG benefit was estimated as the sum of both the CH_4 captured and CO_2e offset as electricity.

1.2. Rationale for GHG Emission Methodology

To calculate the incremental GHG benefit from the use of biomass feedstocks in place of fossil fuel for the generation of electricity, steam, and heat, an emission reduction benefit factor was developed that was then multiplied by the estimated in-state biomass production potential. Then CH_4 avoided from the capture of CH_4 from livestock manure and chicken litter was calculated by multiplying an estimated collection efficiency factor to the potential CH_4 emissions generated from these agricultural sources. To calculate the incremental GHG benefit of the conversion of captured CH_4 to electricity, an energy recovery factor was applied to the mass of CH_4 captured and this value was multiplied by a Maryland-specific emission factor for electricity generation. The methodologies used appear to have been developed specifically for this measure in the absence of a standardized approach.

1.3. GHG Emission Reduction Calculations

The methodologies employed for calculating the GHG emission reductions for the biomass feedstock utilization goal and the CH_4 from livestock manure and poultry litter utilization goal are discussed separately below.

[52] Maryland DNR. 2006 (Mar.). The potential for biomass co-firing in Maryland. Prepared by Princeton Energy Resources International, LLC and Exeter Associates Inc. for the DNR Maryland Power Plant Research Program.
[53] Maryland GHG Inventory & Reference Case Projections 1990-2020, prepared by CCS.

Biomass GHG Benefits

The methodology for calculating GHG reductions associated with increasing the utilization of biomass to offset fossil fuel consumption[54] are described stepwise below.[55]

Step 1: Determine the amount of biomass available in 2020

The amount of biomass available in 2020 (in dry tons) from agricultural and forestry feedstocks were obtained from two studies,[56] and consisted of:

- 622,882 dry tons of agricultural residues[57]
- 251,019 dry tons of energy crop[58]
- 812,345 dry tons of forestry resides[59]

Step 2: Estimate the potential heat input

The amount of each residue available was multiplied by the heat content[60] of the residue to estimate the potential heat input (in MMBtu). The available heat input from biomass is estimated to be:

- 5,169,921 MMBtu from agricultural residue
- 3,689,979 MMBtu from energy crops
- 8,663,717 MMBtu from forestry residues

Step 3: Calculate the annual biomass utilization fraction

The potential heat input available from each biomass type was multiplied by the fraction necessary to satisfy the biomass utilization policy goals for each year. For agricultural and forestry residues, the yearly utilization fraction was calculated over two different time periods based on the policy goals. Each of the two utilization goals (10 percent by 2015 and 25 percent by 2020) were divided evenly between the goal years, resulting in a 1.25 percent additional

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[54] The analysis assumed biomass will replace coal. This is based on the assumption that biomass will be used to replace coal in the RCI and electricity sector (where coal represents the majority of electricity generated)
[55]The quantification method described in Appendix D only lists the available mass and heat input from biomass residues in Maryland. The methods used to quantify the GHG reductions are described based on the calculations contained in the "MD AFW Quantification" spreadsheets.
[56] With the exception of available urban wood waste, the amount of biomass available in 2020 in Maryland was obtained from Maryland DNR. 2006 (Mar.). The potential for biomass co-firing in Maryland. Prepared by Princeton Energy Resources International, LLC and Exeter Associates Inc. for the DNR Maryland Power Plant Research Program. Available urban wood waste is based on analysis by Daniel Rider, Maryland DNR Forest Service.
[57] Agricultural residues include residues generated from corn, wheat, winter wheat, and barley crops.
[58] The amount of energy crop available is estimated based on the assumption that 25% of idle cropland in Maryland is used to grow switchgrass.
[59] Forestry feedstocks include residues generated from forest, mill, and urban residues
[60] Heat content of agricultural by-products sourced from above DNR Report, which references EIA (1999) Annual Electric Generator. Heat content for switchgrass is also sourced from the DNR Report, which references the EIA Annual Energy Outlook 2005 (Feb.), Table H1.

utilization fraction for each year between 2008 and 2015 and a 3 percent additional utilization fraction for each year between 2015 and 2020.[61,62]

A similar calculation was performed for energy crop utilization (50 percent by 2020) where a slower growth rate of 2 percent additional utilization fraction each year was assumed between 2008 and 2012, which ramped up to a 5 percent additional utilization fraction for each year between 2012 and 2020.[63]

Step 4: Calculate the GHG benefit from each biomass feedstock utilized

To obtain the GHG benefit from the utilization of each biomass feedstock for each year through the goal period, the heat input calculated in Step 3 above was multiplied by an emission factor (in tCO_2e/MMBtu)[64] quantifying the GHG benefit of replacing coal with biomass fuel. This emission factor (0.094 tCO_2e/MMBtu) was calculated by subtracting the emission factor for refuse-derived biomass fuel (0.0019 tCO_2e/MMBtu) from the emission factor for subbituminous coal (0.0959 tCO_2e/MMBtu).

Step 5: Determine the total GHG benefit from the use of biomass feedstocks instead of fossil fuels

The GHG benefits resulting from the utilization of agricultural and forestry residues and energy crops through the policy goal period were summed to obtain the total GHG benefit from the use of additional biomass feedstocks instead of fossil fuels.

CH_4 *Utilization from Livestock Manure and Poultry Litter GHG Benefits*

The methodology for calculating GHG reductions from the use of CH_4 from livestock manure and poultry litter for renewable electricity, heat, and steam generation is described stepwise below:

Step 1: Estimate the GHG benefits of CH_4 capture

The business as usual (BAU) CH_4 emissions generated from dairy, swine, and poultry sources were obtained from the Maryland GHG Inventory and Forecast[65] and the sum of these emissions was used as the starting point to estimate the GHG benefits of capturing the volumes of CH_4 targeted by the policy.

Step 2: Determine the CH_4 that could be captured annually

[61] 2012 Ag Residue Biomass (MMBtu) Utilized = (5,169,921 MMBtu) × (1.25% × 5); Note, 2012 is the 5th year of the goal period. The 1.25% additional utilization fraction is the result of (10% ÷ 8 years).
[62] 2012 Forestry Residue Biomass (MMBtu) Utilized = (8,663,717 MMBtu) × (1.25% × 5); Note, 2012 is the 5th year of the goal period. The 1.25% additional utilization fraction is the result of (10% ÷ 8 years).
[63] 2012 Energy Crop Biomass (MMBtu) Utilized = (3,689,979MMBtu) × (2.0% × 5); Note, 2012 is the 5th year of the goal period. The 2.0% additional utilization fraction is the result of (10% ÷ 5 years).
[64] The emission factors utilized in these calculations were found in the "MD AFW Quantification" spreadsheets made available to MDE. The original data source of these emission factors was not noted in these spreadsheets.
[65] Maryland GHG Inventory & Reference Case Projections 1990-2020, prepared by CCS released in 2008.

An assumed collection efficiency of 75 percent was applied to the CH_4 emissions from manure and poultry litter obtained in step 1 above to obtain the potential CH_4 that could be captured each year through 2020.[66]

Step 3: Calculate annual utilization factor

The potential quantity of CH_4 captured was then multiplied by a yearly utilization factor based on the policy target of achieving 50 percent collection in 2020. This yearly utilization fraction was calculated in a manner similar to the method described above in Step 3 of the previous methodology for biomass feedstock yearly utilization rates. For CH_4 capture, the 50 percent collection goal was divided evenly between 2008 and 2020 resulting in an annual additional increase in use of approximately 3.85 percent.[67]

Step 4: Estimate the amount of electricity produced from the captured CH_4

To estimate the amount of electricity produced (kWh) from the captured CH_4, the captured CH_4 each year was converted to its heat content (in Btus), and then multiplied by an energy recovery factor (17,100 Btu/kWh[68]).

Step 5: Estimate the total CO_2e associated with utilizing the captured CH_4 for electricity generation

The estimated amount of electricity produced for each year was converted to megawatt hours (MWh) by dividing by 1,000. The prior MDE contractor multiplied this value by the Maryland specific emission factor for electricity production from the U.S. Environmental Protection Agency's (EPA) Emissions & Generation Resource Integrated Database (eGRID, 0.587 tCO_2e/MWh) to estimate the total mass of CO_2e (tons) associated with utilizing the captured CH_4 for electricity.

Step 6: Determine the total GHG benefit

The total GHG benefit was estimated as the sum of both the CH_4 captured and CO_2e offset as electricity.

1.4. GHG EmissionData and Data Sources

Sources used in the previous analysis include:

Biomass GHG Benefits

- Maryland DNR. 2006 (Mar.). The potential for biomass co-firing in Maryland. Prepared by Princeton Energy Resources International, LLC and Exeter Associates Inc. for the DNR

[66] The 75% value is an assumed value based on engineering judgment. No applicable studies were identified at the time of this analysis that provided information on CH_4 collection efficiencies achieved using manure digesters (as it relates to collection of entire farm-level emissions).
[67] 2012 CH_4 (MMt CO_2e) Captured = (0.090 MMt CO_2e) × (3.85% × 5); Note, 2012 is the 5th year of the goal period. The 3.85% additional utilization fraction is the rounded result of (50% ÷ 13 years).
[68] The energy recovery factor assumed a 25% efficiency for conversion to electricity in an engine and generator set.

Maryland Power Plant Research Program. Available at http://esm.versar.com/pprp/bibliography/PPES_06_02/PPES_06_02.pdf

- Daniel Rider, Maryland DNR Forest Service, "Available urban wood waste."
- U.S. Energy Information Administration (1999) Annual Electric Generator. Form EIA-860B Database, Available at http://www.eia.doe.gov/cneaf/electricity/page/eia860b.html
- U.S. Energy Information Administration, Annual Energy Outlook 2005 (Feb.), Table H1. Available at ftp://ftp.eia.doe.gov/forecasting/0383%282005%29.pdf

CH_4 Utilization from Livestock Manure and Poultry Litter GHG Benefits

- Maryland GHG Inventory & Reference Case Projections 1990-2020, prepared by CCS, Available at http://www.mde.state.md.us/assets/document/Air/ClimateChange/AppendixC_Inventory.pdf
- U.S. Environmental Protection Agency, Emissions & Generating Resource Integrated Database, Available at http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

1.5. GHG Emission Assumptions

Several assumptions were made in this analysis concerning the GHG benefits from displacing fossil fuels with biomass feedstocks in the generation of electricity, steam, and heat as well as the GHG benefits from utilizing CH_4 from livestock and poultry litter for renewable electricity, heat, and steam generation. Assumptions include:

Biomass GHG Benefits

- Biomass will replace only coal in the RCI and electricity sector through 2020.
- 25 percent of idle cropland (approximately 51,307 acres in Maryland) can be used to grow switchgrass (which translates to approximately 250,000 dry tons of switchgrass fuel).
- The quantity of available biomass will remain constant over the entire goal period.
- The upward bound of biomass feedstock utilization is feasible.
- Co-firing technology would be used through 2020.

CH_4 Utilization from Livestock Manure and Poultry Litter GHG Benefits

- The average collection efficiency of methane capture technology is 75 percent. This estimate was an assumed value based on an engineering judgment.
- The quantity of available methane will remain constant over the entire goal period.
- Conversion efficiency of methane to electricity is 25 percent in an engine and generator set.
- EPA's eGRID factor is an accurate representation of the electricity that the captured and converted methane will offset.
- The upward generation and collection of methane from livestock manure and poultry litter is feasible

1.6. GHG Emission Analysis and Recommendations

GHG emission reductions associated with AFW-6 are based on the utilization of biomass feedstocks instead of coal to generate electricity, steam, or heat, and the avoidance of CH_4 emissions from livestock manure and poultry litter and the utilization of that CH_4 to generate electricity, steam, or heat.

In terms of the potential biomass feedstock production estimate, several assumptions should be noted. First, the GHG benefit methodology assumes that both the utilization of biomass feedstocks will occur uniformly and that the supply of biomass feedstock will remain constant over the goal period. This may not occur as other factors, such as weather or the consumption of biomass feedstocks by other sectors, may change the amount of feedstocks available each year. The analysis notes that if shortfalls in the preferred biomass sources (agricultural resides, forestry residues, and energy crops) occur, feedstocks may be met by municipal solid waste (MSW) such as paper, cardboard, organics, and yard waste. Further analysis of the amount of MSW potentially available would be helpful, particularly in light of AFW-9 which aims to reduce MSW generated through source reduction and advanced recycling.

Another area that might benefit from further analysis would be the availability of various firing technologies through 2020. In the cost portion of this analysis, the analysis assumed that co-firing would be used through 2020. However, as technology advances, other options (such as gasification) may be more cost effective and energy efficient.

In terms of CH_4 recovery from livestock manure and poultry litter, it should be noted that as described above, the GHG benefit methodology assumes that both the use and supply of CH_4 will remain constant over the goal period. However, several factors could alter this CH_4 supply, such as a change in either the diet of dairy cows, swine, or poultry, or their overall population.

While the methodology for the CH_4 from livestock manure and poultry litter policy goal is relatively straightforward, Maryland may wish to revisit several assumptions. In particular, updated collection efficiency factors and energy recovery factors could be available. It was noted in the methodology that no applicable studies were identified that provided information on CH_4 collection efficiencies achieved using manure digesters, as it relates to collection of entire farm-level emissions. No citation was provided for the energy recovery factor used. However, offsets and renewable electricity certificates (RECs) markets have further developed since this analysis was first completed, and state and federal grant programs have helped promote the installation of digesters at farms. Updated data on system efficiencies could be available.

2.0 AIR QUALITY CO-BENEFITS

The air quality co-benefits of replacing fossil fuels or grid-based power with biomass is highly situation specific and difficult to estimate. Co-firing with some types of biomass—particularly wood chips and agricultural waste—are as likely to result in an increase as a decrease in PM, CO, or NO_X emissions. Although co-firing will tend to result in a reductionin SO_2 emissions, this reduction will be insignificant relative to the total statewide SO_2 emissions inventory. It was therefore assumed that co-firing coal-fired plants with less than 10 percent biomass will not significantly change the criteria pollutant emission factors (based not only on the above considerations, but on a figure presented by Lesley Sloss of the IEA

Clean Coal Centre at the 35th Annual EPA-A&WMA Annual Exchange in December 2010) from those for coal alone.

3.0 INTERACTION WITH OTHER POLICIES

AFW-6 aims to increase the use of biomass for generation of electricity, steam, and heat. As reported in Appendix D of the Maryland CAP,[69] AFW 6 overlaps with policy ES-8 which evaluates the GHG reduction benefits from increased biomass use at existing plants when economical. The analysis noted that the quantity of biomass needed for ES-8 may be limited by that needed for AFW-6. To avoid double counting, the 2008 Climate Action Plan allocated all emission reductions from biomass-to-energy production to ES-8. While AFW-9 seeks to reduce the quantity of MSW, and thus potentially lower the feedstock stream available for biofuel production, it is important to note that agricultural resides, forestry residues, and energy crops are the preferred feedstocks. The probability of having insufficient supplies of all these preferred sources, such that the reduction of MSW via AFW-9 would become material, is judged to be very low.

[69] Appendix D of the Maryland CAP, Greenhouse Gas & Carbon Mitigation Working Group: Policy Option Documents

Policy No.: AFW-7b

Policy Title: In-State Liquid Biofuels Production

SAIC was tasked with reviewing the AFW-7b policy analysis which was conducted by a prior MDE contractor (Original Methodology). SAIC conducted a thorough examination of the methodologies, assumptions, data sources, and results and subsequently described the methodology and results as well as provided SAIC's observations and recommendations. SAIC also quantified the air quality co-benefits of this policy. The results of SAIC's review of the Original Methodology and the quantification of related co-benefits is below:

Note: *The original analysis of AFW-7b in Appendix D-1 of the Maryland CAP included quantification of GHG benefits associated with in-state production of ethanol (referred to as AFW7a) and bio-diesel (referred to as AFW7b).*[70]

1.0 GHG EMISSION REDUCTIONS

Policy AFW-7b seeks to promote sustainable in-state production and consumption of bio-diesel from agriculture and/or agroforestry feedstocks, to displace the use of fossil fuels in the production of bio-diesel.The policy goal of AFW 7 is to increase in-state bio-diesel production from Maryland non-food feedstocks to offset diesel consumption in the State by 2 percent in 2015 and 2.2 percent in 2020. This policy is linked to TLU-4, "Low Greenhouse Gas Fuel Standard".[71] The analysis predicted the following GHG reduction potential associated with replacing imported soy based biodiesel with non-food based biodiesel produced in Maryland:

Table AFW-7b.1- Estimated GHG Emission Reductions Resulting from AFW-7b[72]

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
AFW-7 Total	**0.099**	**0.127**	**0.167**
Bio-diesel Production	0.099	0.127	0.167
Ethanol Production	Not included		

[70]The ethanol portion of the analysis has been excluded here by direction of MDE. Ethanol was excluded due to concern over potential detrimental impacts on consumer food prices resulting from the use of food-based feedstocks as transportation fuels.

[71] The GHG benefit of replacing standard diesel with bio-diesel was calculated as part of related action TLU-4, "Low Greenhouse Gas Fuel Standard". Pg. 91 of the MD Climate Action plan states that recommendation TLU-4 was withdrawn by the MD Commission on Climate Change pending further analysis and technological innovation.

[72] GHG Reduction numbers in this table vary from 2015 and 2020 numbers presented on page 68 of Appendix D but do agree with 2012 and 2020 numbers presented in the "Summary List of Recommended Priority Policy Options" on page 3 of Appendix D. The source of GHG-reduction numbers on page 68 is unclear.

1.1. Summary of GHG Emission Methodology

To estimate the GHG benefit from this policy, an upper limit potential for in-state non-food bio-diesel (in-state bio-diesel) production amounts was estimated for 2015 and 2020. The production amounts were then multiplied by the estimated "emission reduction benefit" of using in-state bio-diesel as opposed to imported soy based bio-diesel to determine emission reductions.[73] The GHG emission reduction benefit was calculated to be the difference between a lifecycle soy based bio-diesel emission factor and an estimate of GHG emissions associated with transporting in-state bio-diesel an average of 100 miles by diesel rail.[74]

The business as usual (BAU) fossil diesel consumption for Maryland for 2015 and 2020 was also used to estimate the volume of bio-diesel production necessary to displace 2 percent of fossil diesel in 2015 and 2.2 percent in 2020.[75]

1.2. Rationale for GHG Emission Methodology

To calculate the incremental GHG benefit of the use of Maryland grown non-food feedstocks over imported soy-based bio-diesel, an emission reduction benefit factor was developed that was then multiplied by the estimated in-state bio-diesel production potential. The methodology appears to have been developed specifically for this measure in the absence of a standardized approach.

1.3. GHG Emission Reduction Calculations

The methodologies employed for calculating the GHG emission reductions and for estimating the in-state bio-diesel production goals are discussed separately below.

In-State Biodiesel GHG Emission Benefits

The methodology for calculating GHG reductions associated with producing bio-diesel in Maryland from non-food feedstocks (as compared to importing soy based bio-diesel) are described stepwise below.

<u>Step 1: Estimate the upper limits of potential in-state bio-diesel produced from non-food feedstocks</u>

The upper limits of potential in-state bio-diesel that could be produced from non-food feedstocks (in 1,000 gallons) was estimated to total 17,571 in 2015 and 23,120 in 2020. Consisting of:

- 5,791,000 gallons from animal fats in both 2015 and 2020[76]
- 11,780,000 gallons from yellow grease in 2015[77]
- 12,329,000 gallons from yellow grease in 2020
- 5,000,000 gallons from algal oils in 2020

[73] That use of an "emission reduction benefit" multiplier to determine GHG reductions is not common practice in GHG accounting, a more standardized approach is discussed in 1.6.
[74] 100 miles is the distance from the center of MD to the border. In-state transportation emissions are assumed by CCS to be the only GHG emissions associated with in-state non-food feedstock bio-diesel.
[75] It is unclear if the assessment of available in-state non-food bio-diesel feedstocks was completed before or after the policy goals for 2015 and 2020 were set.
[76] Animal fats available were estimated based on the ratio of Maryland livestock and poultry slaughter and production to that of Minnesota.Calculations of these estimates are not clearly documented but are included in the excel spreadsheet "MD AFW Quantification", tab "7-Bio-diesel".
[77]Yellow grease was projected based on estimate of 14 pounds of restaurant grease per capita (using U.S. Census projections for Maryland) and 7.6 pounds of grease per gallon of bio-diesel.

Step 2: Estimate the GHG reduction benefit of in-state bio-diesel

The estimated reduction benefit of in-state bio-diesel was estimated by using a lifecycle emission factor for soy based bio-diesel of 7,261 metric tons of carbon dioxide equivalent (tCO_2e) per million gallons[78] and subtracting estimated transportation emissions associated with shipping in-state bio-diesel an average of 100 miles, to yield an "emission reduction benefit" of 7,207 tCO_2e per million gallons of in-state bio-diesel.

Emission reduction benefit formula: soybean lifecycle emission factor (EF) – (miles*fossil diesel EF)/ gallons of bio-diesel per short ton of soybeans*ton-miles per gallon of diesel = emission reduction benefit, or, 7,207 tCO_2e per million gallon = 7,261$mtCO_2e$ per million gallon – (100*(.01006 $mtCO_2e$)*10^6)/44.632 gal per ton*423 ton-miles

Step 3: Estimate 2015 emission reductions

The in-state bio-diesel emission reduction benefit, as determined in Step 2 above, was multiplied by the 2015 in-state bio-diesel production goal of 17,571,000 gallons, as determined in step 1 above, to estimate 2015 emission reductions associated with this action.

2015 GHG reductions of 126,634 tCO_2e= 17.571 MMgal * 7,207 tCO_2e/MMgal

Step 4: Estimate 2020 emission reductions

The in-state bio-diesel emission reduction benefit, as determined in Step 2 above, was multiplied by the 2020 in-state bio-diesel production goal of 23,120,000 gallons, as determined in step 1 above, to estimate 2020 emission reductions associated with this action.

2020 GHG reductions of 166,626 tCO_2e= 23.120 MMgal * 7,207 tCO_2e/MMgal

In-State Bio-diesel Production Goals

The methodology for calculating the in-state bio-diesel production goals is described stepwise below. Calculations for production goals show the amount of in-state bio-diesel production necessary to achieve the AFW-7b policy goals of increasing in-state biodiesel production to 2 percent in 2015 and 2.2 percent in 2020 as described in Section 1 above.

Step 1: Determine the BAU fossil diesel consumption in Maryland

The business as usual (BAU) fossil diesel consumption data for Maryland for 2015 (817 million gallons) and 2020 (941 million gallons) was identified.[79]

Step 2: Calculate bio-diesel production

[78] The lifecycle emission factor for biodiesel is a 41% reduction from a lifecycle fossil diesel emission factor of 12,306 $mtCO_2e$ as presented in J. Hill, E. Nelson, D. Tilman, et al. 2006. Environmental, economic, and energetic costs and benefits of bio-diesel and ethanol biofuels. *Proceedings of the National Academy of Sciences* 103:11206–11210.

[79] Page 66 of the Maryland CAP Appendix D AFW7 lists the Maryland Draft Inventory & Forecast prepared by CCS as the data source used as "the starting point for quantifying the benefits of offsetting fossil diesel and gasoline consumption with bio-diesel".

The necessary bio-diesel production was calculated by multiplying BAU fossil diesel consumption in 2015, as determined in step 1, by 2 percent, and dividing by the heat content of bio-diesel as compared to fossil diesel (91 percent), for a production target of 18 million gallons.

18 million gallons=817million gallons*.02/.91

Step 3: Determine the bio-diesel production necessary to achieve the AFW-7b policy objectives

The necessary bio-diesel production needed to achieve the 2020 policy goal was calculated by multiplying BAU fossil diesel consumption in 2020, as determined in step 1, by 2.2 percent, and dividing by the heat content of bio-diesel as compared to fossil diesel (91 percent), for a production target of 23 million gallons.

23 million gallons=941million gallons*.022/.91

1.4. GHG Emission Data and Data Sources

Sources used in the analysis include:

- California Grain & Feed Association. "Evaluate the Cost and Usage of Various Fuels." http://www.cgfa.org/news.html
- Center for Energy and Environment "Identifying Effective Biomass Strategies: Quantifying Minnesota's Resources and Evaluating Future Opportunities," http://www.mncee.org/public_policy/renewable_energy/biomass/index.php
- Oak Ridge National Laboratory, Biomass Energy Data Book, Appendix A- Conversions. http://cta.ornl.gov/bedb/appendix_a.shtml
- Cleantech.com "Chevron turning California kitchen grease into biogas", November 21, 2006 http://cleantech.com/news/node/376
- Hill, Jason, Erik Nelson, David Tilman, Stephen Polasky, and Douglas Tiffany, 2006, "Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels," *Proceedings of the National Academy of Sciences*, Vol. 103, no. 30 (July 25, 2006**)**, http://www.pnas.org/content/103/30/11206.short

1.5. GHG Emission Assumptions

Several assumptions were made concerning the potential production volume of in-state bio-diesel over the goal period and the GHG benefit from displacing soy based bio-diesel with in-state bio-diesel. Assumptions include:

- In-state biodiesel would replace imported soy based bio-diesel.
- All available feedstock that does not serve as a food source will be used for fuel production.

- Two bio-diesel facilities, MD bio-diesel and Greenlight biofuels (in production at the time the CCS analysis was conducted), would be completed and online as scheduled.
- Maryland and Minnesota have similar livestock and poultry slaughter and production rates, which is the basis of potential animal fat feedstock production.[80]
- By 2020, algal bio-diesel technology would progress enough to be available to provide approximately 20 percent of bio-diesel production.
- Bio-diesel produced from animal fats, yellow grease, and algae feedstocks contain 91 percent of the usable energy of energy of fossil based diesel.
- The upward bound of the mix of feedstocks estimated in the previous analysis is feasible.
- Animal fats, algal oils, and yellow grease have negligible additional embodied energy compared to soybean feedstocks.
- The only GHG emissions associated with in-state bio-diesel produced with non-food feedstocks are transportation related.
- Transportation emissions associated with each million gallons of in-state non-food bio-diesel are equivalent to the proportional share of emissions that would result from transporting the necessary amount of soybean feedstock it would take to produce that fuel, 100 miles by diesel powered freight.

1.6. GHG EmissionAnalysis and Recommendations

GHG reductions associated with this measure are based on reductions in lifecycle emissions that would occur outside of Maryland and should be clearly identified as such when they are referenced. The 2008 Maryland CAP states that the entire policy option, AFW 7, "should not be included in the total GHG emission reductions or costs because of concern over food- and animal feed-based feedstocks".[81] The lifecycle nature of the biodiesel GHG reduction estimate further justifies its exclusion from cumulative GHG emission reductions that contribute to the State's GHG reduction targets.

The assumptions used to estimate the incremental GHG benefit of in-state non-food bio-diesel production over imported soy based bio-diesel need further analysis. The approach to determining the GHG reductions associated with in-state biodiesel should not be to take the difference between lifecycle GHG emissions associated with imported soy bio-diesel and subtract out distribution related transportation emissions that would occur in Maryland, but rather to compare the lifecycle GHG emissions associated with production of bio-diesel from different feedstocks (soybeans, yellow grease, animal fat, and algae), in addition to distribution related transportation emissions. The analysis assumes that, of these feedstocks, soybeans are the only feedstock that would produce GHGs during the production stage, which is unlikely.

Maryland could improve the methodology by utilizing a standardized approach. Such an approach could consist of estimating GHG emissions from imported bio-diesel based on a volume of fuel * emission factor calculation as a base case, and then subtracting GHG emissions from in-state bio-diesel (also calculated using a volume of fuel* emission factor approach) as the after case, rather than using an

[80] Accessed from MN's BioPower Evaluation Tool (report listed in data sources)

[81] Pg. 52

emission reduction benefit factor as described in Section 1.3 above. Note that this would still entail using lifecycle emission factors, and those factors may need to be developed for each of the in-state feedstocks.[82]

Additional analysis of the assumptions used to estimate in-state bio-diesel production capacity, presented in 1.5, is needed to add credibility to the emission reduction potential presented for this action. For example, the estimate of potential for algal bio-diesel does not appear to have a source. Additional review of bio-fuel capacities completed by the MEA for the Comprehensive Energy Plan may be helpful.[83]

Since the larger GHG benefit of replacing fossil diesel with biofuels (analyzed in TLU-4, "Low Greenhouse Gas Fuel Standard") is directly linked to this action, further research on in-state biofuel production would benefit from being conducted in conjunction with additional analysis of TLU-4.

Future analysis of GHG emissions from bio-diesel, in AFW-7b and in the Maryland statewide GHG inventory, could also include an assessment of biogenic CO_2 emissions. Biogenic CO_2 emissions associated with bio-diesel result from the combustion of materials derived from organic matter and from agricultural practices associated with growing the feedstocks.[84] Guidance for determining biogenic emissions associated with combustion of bio-diesel is included in the General Reporting Protocol of the Climate Registry (of which MDE is a member).[85] The Climate Registry requires separate reporting of biogenic emissions from both stationary and mobile sources in GHG inventories.

2.0 AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated emissions reductions from AFW-7b are shown in the following table:

Table AFW-7b.2: Emissions Reductions in Maryland Associated with AFW-7b

	Statewide (tons/yr)	
Pollutant	**2015**	**2020**
SO_2	7.0	8.9
NO_X(Increases)	-9.0	-7.6
CO	823	952
VOC	83	85
PM10 - primary	1.9	1.5
PM2.5 - primary	1.3	1.4

[82]The May 2009 "EPA Lifecycle Analysis of Greenhouse Gas Emissions from Renewable Fuels" EPA-420-F-09-024 available at http://www.epa.gov/oms/renewablefuels/420f09024.htm contains draft lifecycle GHG emission reduction results for soy and waste grease bio-diesel that could be used, but not algae and animal fats.

[83] Pg. 10, MD Commission on Climate Change's January 2010 "Update to Governor and General Assembly"

[84] The lifecycle emission factor for soy based biodiesel used by CCS assumed that the soy was produced on land that was already in production and therefore there were no biogenic emissions associated with land conversion.

[85] http://www.theclimateregistry.org/resources/protocols/general-reporting-protocol/

These numbers were compared against the MANE-VU inventories for 2012 (compared to 2015) and 2018 (compared to 2020) in Table AFW-7b.3. Because all the values are less than one-tenth of a percent, the table indicates that the criteria pollutant emissions reductions/increases associated with this policy would be unlikely to significantly improve or degrade air quality.

Table AFW-7b.3- Percentage Reductions in State Emissions Inventory Associated with AFW-7b

	Maryland (%)	
Pollutant	**2012**	**2018**
SO_2	< .1	< .1
NO_X(Increase)	< .1	< .1
CO	< .1	< .1
VOC	< .1	< .1
PM10-primary	< .1	< .1
PM2.5-primary	< .1	< .1

2.2. Summary of Air Quality Co-Benefits Methodology

The method is based upon the estimated change in statewide Vehicle Miles Traveled (VMT). It was assumed that the percentage reduction in Maryland's VMT would result in an equivalent percentage reduction in the state's mobile source emission inventory. The potential for improved air quality was estimated by comparing reductions in the mobile source inventory to estimates for the total statewide emission inventory.

2.3. Rationale for Air Quality Co-Benefits Methodology

Given the small role of VMT reductions due to car-based passenger-mile reductions a simple comparison (i.e., percentage) of change in the statewide emission inventory was used as the parameter for net co-benefit. The uncertainty and assumptions associated with a more detailed modeling approach would not produce a better result.

2.4. Air Quality Co-Benefits Emission Calculations

Statewide VMT estimates of 55,631 and 78,989 million VMT (mVMT) were estimated for 2009 and 2030, respectively. An estimate of 59,000, 62,000 and 68,000 mVMT in 2012, 2015 and 2020, respectively were determined by linear interpolation.

As a result of AFW-7b, 90 and 115 million gallons of biodiesel (B20) will be used in the state in 2015 and 2020, respectively. Assuming an average diesel fuel use of 8 miles per gallon this would result in 720 and 920 million VMT traveled with biodiesel. This is equivalent to 1.2 and 1.4 percent of the estimate VMT for the state, 2015 and 2020, respectively.

It is estimated that a B20 (i.e., 20 percent) blend of biodiesel will reduce emissions of CO, VOC, SO_2, and PM by 11, 21, 100, and 10 percent, respectively. It will also increase NO_X emission by 2 percent. When those emission changes are applied to the fraction of the statewide mobile source inventory represented by 720 and 920 million VMT the emission reductions listed in Table 1 are derived. The potential co-benefit of those emission reductions listed in Table 2 is the absolute reductions (increase in the case of NO_X) in Table 1 compared to the statewide emission inventory.

2.5. Air Quality Co-Benefits Data and Data Sources

- **Statewide VMT estimates.** A Presentation Smart Growth & Transportation, Funding/Investment, Blue Ribbon Commission on Transportation Funding, Richard E. Hall, AICP, Secretary, Maryland Department of Planning, November 15, 2010
- **Statewide emission inventory.** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory
- **Biodiesel Emission Factors.** Air Biodiesel Fact Sheet published by the Oklahoma Department of Environmental Quality. www.deq.state.ok.us/factsheets/air/biodieselfs.pdf

2.6. Air Quality Co-Benefits Assumptions

- The emission changes when replacing diesel with biodiesel varies with the fraction of biodiesel in the fuel. The Oklahoma fact sheet from which the emission changes were derived was based on a B20 (i.e., 20 percent biodiesel) blend. We assumed that the biodiesel used in Maryland would be a B20 blend.
- It was assumed that diesel trucks average 8 miles per gallon (mpg). It was reported that semi-trailer trucks average in the range of 5 – 7 mpg (on the road). Smaller diesel vans have average mpgs in the mid-teens. These would vary with city/highway driving, load being hauled, and many other factors. The 8 mpg factor was simply selected as a starting point and was not calculated.
- Emissions from production of the fuel were not considered due to a lack of information.

3.0 INTERACTION WITH OTHER POLICIES

The GHG benefits of AFW-7b could be captured under the Maryland Low-Carbon Fuel Standard policy TLU-4), if this policy had not been removed from consideration by the Maryland Commission on Climate Change (MCCC). Moving forward, specific GHG reductions associated with AFW-7b should not be reported independent of TLU-4, as that would constitute double counting.

Policy No.: AFW-8

Policy Title: Nutrient Trading with Carbon Benefits

SAIC was tasked with reviewing the ES-8 policy analysis which was conducted by a prior MDE contractor (Original Methodology). SAIC conducted a thorough examination of the methodologies, assumptions, data sources, and results and subsequently described the methodology and results as well as provided SAIC's observations and recommendations. SAIC also quantified the air quality co-benefits of this policy. The results of SAIC's review of the Original Methodology and the quantification of related co-benefits is below:

1.0. GHG EMISSION REDUCTIONS

AFW-8 is designed to reduce nitrogen loss from agricultural soils through improved agricultural practices that increase soil carbon sequestration and reduce the use of nitrogen fertilizers that release nitrous oxide (N_2O), a GHG with 310 times the effect (or global warming potential) of one unit of carbon dioxide (CO_2). AFW-8 achieves GHG emission reductions by increasing nitrogen fertilizer efficiency by 20 percent by implementing a nutrient trading scheme. The projected GHG emission reductions from AFW-8 are summarized below:

Table AFW-8.1- Estimated GHG Emission Reductions Resulting from AFW-8

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
Increased fertilizer efficiency by 20 per cent through nutrient trading	0.054	0.087	0.141

1.1. Summary of GHG Emission Methodology

Estimates of N_2O emission rates for fertilizer production and application to agricultural soils were used to determine how N_2O emissions could be reduced through AFW-8. Nitrogen additions to soil, such as fertilizer, drive underlying soil nitrification and de-nitrification cycles, which produce N_2O as a by-product. The emissions estimation accounts for the direct and indirect sources of N_2O emissions from agricultural soils due to fertilizer application. Direct N_2O emissions occur at the site of application and indirect N_2O emissions occur when the nitrogen applied at the site leaches to groundwater or moves in surface runoff and is transported off-site before entering the nitrification/de-nitrification cycle. These direct and indirect N_2O emissions were converted to a CO_2 equivalent emission factor on a per unit of nitrogen basis. The impact on lifecycle emissions of CO_2 that occur during the manufacture and transport of the fertilizer to the agricultural fields was also included in the analysis based on a known emission factor. The improved agricultural practices applied through AFW-8 would reduce the GHG emissions that occur when farmers apply fertilizer to their crops. This reduction was calculated by applying a 20 per cent decrease to the current fertilizer use value (expressed in tons of nitrogen) incrementally in a linear fashion over the policy period. The yearly avoided GHG emissions were calculated by multiplying the reduction in fertilizer use by the related GHG emission factors. The calculation was repeated for each year of the policy (2008-2020) and then summed as appropriate to obtain the GHG reductions in years 2012, 2015, and 2020.

1.2. Rationale for GHG Emission Methodology

N_2O emissions from nitrogen fertilizer use applied to land were calculated using the US Environmental Protection Agency's State Greenhouse Gas Inventory Tool (SIT) software and the methods provided in the Emission Inventory Improvement Program (EIIP) guidance document for the sector. The SIT methodology applies emission factors developed for the United States to activity data for the agricultural sector. SIT data on fertilizer usage came from *Commercial Fertilizers*, a report from the Fertilizer Institute. The activity data for fertilizer includes all potential uses in addition to agriculture, such as residential and commercial (e.g., golf courses).

In line with international GHG emission accounting practices, N_2O emissions from nitrogen fertilizer use applied to land were converted to carbon dioxide equivalents per unit element of fertilizer product (i.e., CO_{2e}/ kg nitrogen (N)) using the GWP. The GWP determines the relative contribution of a gas to the greenhouse effect. The GWP (with a time span of 100 years) of CO_2, CH_4 and N_2O is 1, 21, and 310, respectively (IPCC 1996).

The lifecycle GHG emissions factor from nitrogen fertilizer production and transport was not calculated, rather, a value was obtained from the scientific literature (an article by Wood and Cowie (2004)). The emissions factor value is the weighted mean for CO_2 emissions from commercial nitrogen fertilizer production (mineral extraction and fertilizer manufacture) and transport from the production facility to the farm. The CO_2 emission values are reported based on type of energy input (natural gas, electricity, distillate fuel, steam, coal, and gasoline) and summed to determine the total CO_2 emissions per ton of nitrogen. This value is believed to be low, as discussed in the analysis and recommendations section.

1.3. GHG Emission Reduction Calculations

The methodology employed for calculating the GHG emission reductions is described stepwise below.

Step 1: Determine annual nitrogen use

Citing Maryland Department of Agriculture (MDA) financial year data, the average annual nitrogen use was determined to be 108,019 tons.[86]

Step 2: Determine Global Warming Potential (GWP) of N_2O

Citing the IPCC Second Assessment Report, the global warming potential of N_2O as compared to CO_2 was determined to be 310.

[86] The total fertilizer use (expressed in tons of nitrogen) for years 2004 through 2006 was averaged to obtain the average annual nitrogen use value. Appendix D states that it was obtained from the MDA 1999-2000 to 2005-2006 data.

Step 3: Determine annual N_2O emissions from fertilizer applied to agricultural land in Maryland

Citing Appendix C (Maryland Inventory & Forecast data), the annual N_2O emissions from nitrogen fertilizer use that was applied to land was determined.[87]

Step 4: Determine GHG impact from fertilizer use

Using Step 2 and Step 3, the GHG impact from nitrogen fertilizer use applied to land was determined. The yearly N_2O emissions from nitrogen fertilizer use applied to land (Step 3) were multiplied by the global warming potential for N_2O (310) to determine the CO_2 equivalent emissions (Step 2).

Step 5: Determine average CO_2e emission factor for fertilizer use

Using Step 1 and Step 4, an average CO_2e emission factor for fertilizer use applied to land was determined. The yearly CO_2e emissions for nitrogen fertilizer applied to land (Step 4) were divided by the yearly total fertilizer use (Step 1). The 2000 through 2006 yearly values were averaged to obtain an average CO_2e emission factor of 5.75E-6 million metric tons CO_2equivalent per ton of nitrogen ($MMTCO_2e$/ton N).

Step 6: Determine a lifecycle CO_2 emission factor for the production and transport of fertilizer

Citing data from Wood and Cowie (2004), a lifecycle CO_2 emissions factor from the production and transport of nitrogen fertilizer was determined to be 0.778 tons CO_2 per ton of nitrogen.[88][89]

Step 7: Forecast fertilizer efficiency over time

Assumed the 20 per cent fertilizer efficiency improvements brought about by the nutrient trading program would increase linearly during the policy period (i.e., from 2 per cent in 2008 to 20 per cent in 2020).

[87]The values ofN_2Oemissions for three line items (direct fertilizer, indirect fertilizer, and leaching/runoff) in the AFW Quantification spreadsheet were added for each year between 1990 and 2006 to obtain the annual N_2Oemissions for nitrogen fertilizer use that was applied to land. The emissions were estimated using the US EPA's State Greenhouse Gas Inventory Tool (SIT) software and the methods provided in the Emission Inventory Improvement Program (EIIP) guidance document.

[88]This factor was taken from Table 5 of the Wood and Cowie publication entitled "Greenhouse gas emission factors for Ammonium Nitrate (AN), Calcium Ammonium Nitrate (CAN) and Mean N Fertilisers". The estimate provided for the United States (taken from West And Marland (2001)) was 857.5 grams of CO_2e per kilogram of nitrogen (gCO_2e /kgN)69 or 0.778 tCO_2e per ton of nitrogen (tCO_2e /tN).

[89]This factor is the weighted mean value for CO_2 emissions from energy use in commercial nitrogen fertilizer production and transport only. Carbon emissions from fossil fuels used in the production of the nitrogen fertilizers include emissions from mineral extraction and fertilizer manufacture (Bhat et al., 1994). Energy used in packaging was not included in the calculations because fertilizers used on farms are commonly sold and transported in bulk form.

Step 8: Determine the annual fertilizer reductions

From Step 1 and Step 7, the quantity of fertilizer reduction that would occur each year was determined. The total fertilizer use value of 108,019 tons nitrogen (Step 1) was multiplied by the per cent efficiency improvement for each year of the policy (Step 7).

Step 9: Determine the avoided GHG emissions from reduced fertilizer use

From Step 5 and Step 8, the avoided GHG emissions for nitrogen fertilizer use applied to the land was determined for each year of the policy period. The yearly nitrogen fertilizer reduction value (Step 8) was multiplied by the average CO_2e emission factor of 5.75E-6 $MMTCO_2e$/ton N (Step 5).

Step 10: Determine the avoided GHG emissions from the manufacture and transport of the fertilizer

From Step 6 and Step 8, the avoided GHG emissions for the manufacture and transport of nitrogen fertilizer was determined for each year of the policy period. The yearly fertilizer reduction value (Step 8) was multiplied by the carbon equivalent emissions factor of 0.778 tCO_2 per ton N (Step 6).

Step 11: Calculate the total annual GHG reductions

From Step 9 and Step 10, the total reduction in GHG emissions for each year of the policy period was determined. The avoided GHG emissions value for nitrogen fertilizer use applied to land (Step 9) was added to the avoided GHG emissions value for the manufacture and transport of nitrogen fertilizer (Step 10) for each year of the policy period. The yearly GHG reduction values were added as appropriate to determine the total reductions for years 2012, 2015, and 2020 as shown in Table AFW-8.1.

1.4. GHG Emission Data and Data Sources

The analysis used the following data sources:

- Bhat, M.G., English, B.C., Turhollow, A.F., Nyangito, H.O., 1994. *Energy in Synthetic Fertilizers and Pesticides: Revisited*. ORNL/Sub/90-99732/2. Oak Ridge National Laboratory, Oak Ridge, Tennessee.
- Borjesson, P.I.I., 1996. *Energy Analysis of Biomass Production and Transportation.* Biomass Bioenergy, 11, pg. 305-318.
- Ruth, M., Selman, M., Marshall, L., Gasper, R. and Bagley, G., 2010, *Multiple Ecosystem Markets in Maryland: Quantifying the carbon benefits associated with nutrient trading*, Center for Integrative Environmental Research and World Resources Institute, August 2010.
- *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, IPCC Second Assessment Report, May 2000.
- Maryland Climate Action Plan, Appendix C, Inventory & Forecast data
- Maryland Department of Agriculture financial year data
- Mudahar, M.S., Hignett, T.P., 1982. *Energy and Fertilizer- Policy Implications and Options for Developing Countries.* International Fertilizer Development Center, Muscle Shoals, Alabama.
- West, T.O. and Marland, G., 2001. *A Synthesis of Carbon Sequestration, Carbon Emissions and Net Carbon Flux in Agriculture: Comparing Tillage Practices in the United States.*Agriculture, Ecosystems and Environment. Volume 1812, pages 1-16.

- Wood, S. and Cowie A., 2004. *A review of greenhouse gas emission factors for fertiliser production.* Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting. Available at http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer Production_July2004.pdf

1.5. GHG Emission Assumptions

The following assumptions were made:

- The GHG emission reduction is achieved through a decrease in commercial nitrogen fertilizer use only.
- The efficiency improvements will increase linearly during the policy period.
- Business As Usual (BAU) fertilizer use will remain constant at 108,000 t/year during the policy period.
- Activity data for fertilizer includes all potential uses in addition to agriculture, such as residential and commercial (e.g., golf courses).[90]
- In the lifecycle CO_2 emissions factor, electricity is assumed to be the primary energy input required for power generation in the production of nitrogen fertilizer with a use rate of 10.5 MJ k $Wh(e)^{-1}$ (0.0105 GJ $kWh(e)^{-1}$).[91]
- In the lifecycle CO_2 emissions factor, demands for steam are assumed to be met by combustion of natural gas.[6]
- In the lifecycle CO_2 emissions factor, transportation of the nitrogen fertilizer from the production facility to the farms assumes an energy use of 0.7 and 1.4 MJ Mg^{-1} km^{-1} by railroad and truck, respectively.[92]
- In the lifecycle CO_2 emissions factor, transportation of the nitrogen fertilizer from the production facility to the farms assumes the distance of transportation is 800 and 160 km by railroad and truck, respectively.[93]

1.6. GHG Emission Analysis and Recommendations

The analysis is restricted to the reduction in N_2O emissions from commercial nitrogen fertilizer production, transport, and application. The analysis omits several other sources of GHG emissions from fertilizer and does not account for GHG reductions created from other types of agricultural improvement

[90] The activity data was used in the calculation of annual N_2O emissions from nitrogen fertilizer that was applied to land.
[91] Bhat et al., 1994
[92] Borjesson, 1996
[93] Mudahar and Hignett, 1982

projects. Farmers often use multi-nutrient fertilizers that contain various amounts of phosphorus and potassium in addition to nitrogen. Lime is also a common soil amendment used in the agricultural industry and Concentrated Animal Feeding Operations (CAFOs) typically apply manure to fertilize their crops with minor additions of commercial fertilizer. The emissions from the production and application of these other compounds are not included in the analysis.

In addition, the analysis does not include the emission reductions from agricultural Best Management Practices (BMPs) that reduce nutrient runoff and sequester carbon in the soil. These BMPs include a variety of practices such as conservation tilling, cover crop use, forest buffers, grass buffers, nutrient management planning, manure management, and wetland restoration.[94] These omissions underestimate the GHG emissions and the avoided GHG emissions attributed to land application practices, which in turn underestimates the total reduction in GHG emissions for years 2012, 2015, and 2020, as reported in Table AFW-8.1. To some degree, this underestimate is counterbalanced by an over estimate of the calculated N_2O emissions from the SIT model, which used activity data for fertilizer that includes all potential uses in addition to agriculture, such as residential and commercial (e.g., golf courses). To what degree these estimates balance out is unknown.

The analysis used a value for the lifecycle CO_2e emissions factor from nitrogen fertilizer production and transport that was obtained from the scientific literature (an article by Wood and Cowie (2004)). It should be noted here that the value reported in the article is believed to be low. According to the authors, the reported value excluded N_2O emissions, which are significant in total GHG emissions. In other words, the value only accounts for the CO_2 emissions from the production and transport of nitrogen fertilizer. Regardless of the omission of N_2O emissions, the estimate is still considered to be relatively low according to the authors because it is significantly lower than the estimates for European fertilizers (ranging from 5,339.9 to 7,615.9 gCO_2e/kgN). The use of this low value in the analysis of the CO_2e emissions factor underestimates the yearly fertilizer reduction value, which in turn underestimates the total reduction in GHG emissions for years 2012, 2015, and 2020, as reported in Table AFW-8.1.

2. AIR QUALITY CO-BENEFITS

This policy has no NAAQS co-benefits.

3. INTERACTION WITH OTHER POLICIES

This policy does not appear to have significant overlap with other policies.

[94] Carbon benefits associated with seven agricultural BMPs were evaluated after Appendix D was produced. The study is entitled "Multiple Ecosystem Markets in Maryland: Quantifying the carbon benefits associated with nutrient trading", Center for Integrative Environmental Research and World Resources Institute, (August 2010).

Policy No.: AFW-9

Policy Title: Waste Management through Source Reduction and Advanced Recycling

SAIC was tasked with reviewing the AFW-9 policy analysis which was conducted by a prior MDE contractor (Original Methodology) and revising the methodology to include Maryland-specific data and/or other enhancements. SAIC subsequently recalculated the GHG emission reductions associated with AFW-9 based upon its recommended methodology (Revised Methodology). SAIC's revised policy findings along with its air quality co-benefits analysis are described below:

1. GHG EMISSION REDUCTIONS

AFW-9 encompasses the GHG reductions realized from increasing diversion of materials from landfill. There are several components to this policy:

- Source reduction, or preventing waste before it occurs, through process changes, transition to durables, extended producer responsibility, etc.;
- Increasing recycling and composting of various materials; and
- The end of life profile of the remaining discards: landfill or incineration.

SAIC analyzed the impacts in the year 2020 associated with reducing the combined amount to landfill and incineration for each material above the 2006 diversion rate by 10 percent, 20 percent, 30 percent, 40 percent and 50 percent respectively. The total GHG reductions from increased diversions from landfills and incineration over the 2006 baseline[95] is summarized in the table below. Green indicates a GHG reduction.

Table AFW-9.1- GHG Emission Reductions Resulting from AFW-9

Year 2020	GHG Reductions (Million Metric Tons CO_2e)				
Increased Diversion for each material over the 2006 baseline	10%	20%	30%	40%	50%
Total	(0.84)	(2.32)	(3.80)	(5.12)	(5.97)

[95] Data provided by MDE in "WARM CY 2006 v 2007.xls"

1.1. Summary of GHG Emission Methodology

GHG emissions reductions were estimated using the solid waste industry standard EPA Waste Reduction Model (WARM)[96]. EPA developed WARM to model the GHG impacts of solid waste and diversion practices of communities or organizations. The WARM Model compares GHG and energy baselines with alternate scenarios for landfilling, recycling, composting, incineration and source reduction of various materials.

1.2. Rationale for GHG Emission Methodology

The industry standard methodology to estimate greenhouse gas impacts from solid waste decisions remains the EPA WARM Model. The adoption of this methodology benefits from the detailed documentation and easy comparison to other efforts and scenarios modeled with the same software.

Version 10 of the WARM model was utilized for consistency with previously conducted modeling by MDE with the same software. The WARM model itself has been updated since, ostensibly making it a more accurate tool. Some revisions in WARM, version 11 include:

- Revised assumptions regarding capture of landfill gas based on system installation;
- Incorporated decay rate for organic materials;
- Detailed choices regarding moisture and landfill gas recovery; and
- Updated options for energy grid customized by State and landfill options.

However, at this time the benefits of resulting from updates were outweighed by the ability to limit the number of changing variables by staying with Version 10.

1.3. Detailed Explanation of GHG Emission Methodology

EPA's WARM Model is the result of an in-depth Life Cycle Analysis that looks to document the process of material discards and the impacts of that process. The process includes:

1) Extraction of minerals; ores; other raw materials and their initial processing;
2) Production of goods;
3) Hauling of the goods to markets
4) Consumer use; and
5) Their end of life or discard fate (reuse, recycling, compost, landfill, or incineration).

GHG emission impacts related to material discards stem from:

1) Energy consumption or combustion of fuels used to extract, process, transport, use or dispose of a material;
2) Greenhouse gas emissions from processing or manufacture of goods;
3) Landfill Emissions – Methane;
4) Incineration Emissions – Carbon Dioxide and Nitrous Oxide; and

[96] http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

5) Carbon Sequestration.

WARM is a comparative tool, showing GHG reductions for a scenario with respect to a baseline. While Source Reduction is an option in the WARM model any year 2020 waste prevention that occurs with respect to the standard 2020 generation case also needs to account for the *increase* in materials generation as compared to 2006 as projected due to factors such as population growth.

The materials analyzed were the total quantity of waste generated in the state of Maryland. Therefore this includes tons of Municipal Solid Waste (MSW) exported in the analysis, but not those imported.

1.4. GHG Emission Reduction Calculations

Waste Projections

The waste generated figures were based on the Solid Waste Tonnage Reports from permitted solid waste acceptance facilities and the Maryland Recycling Act (MRA) Tonnage Report[97]. Discards and population statistics for the years 2005 to 2008 were used to calculate a per capita waste discard value in ton/year. This was used in conjunction with population projections from the Maryland Department of Planning to forecast the actual discards for each future year.

$$\text{Population}_{2020} \times \text{Ton/Person/Year} = \text{Tons/Year}$$

Source Reductions

Maryland creates incentives for preventing waste before it is created by offering Source Reduction Credits for specific initiatives such as grasscycling[98]. Based on the Source Reduction credits for 2005 and 2008 of 3.43 percent and 3.64 percent, respectively, it was projected that the same increase would occur annually until 2020. A compounded Source Reduction Credit of 4.56 percent for the year 2020 was calculated.

$$SR_{\text{Annual Increase}} = \{(SR_{2008}/SR_{2005}) - 1\} / 3 \text{ years}$$

$$= \{(3.64\%/3.43\%) - 1\} / 3 \text{ years}$$

$$= 2.04\% \text{ increase in Source Reduction per Year}$$

$$SR_{2020} = \{(SR_{\text{Annual Increase}} \times 14 \text{ years}) + 1\} \times SR_{\text{Baseline (2006)}}$$

$$= \{(2.04\% \times 14) + 1\} \times 3.55\%$$

$$= 4.56\% \text{ Source Reduction in the Year 2020}$$

Waste Characterization

Available data on amount of materials discarded, recycled, landfilled and incinerated were tracked and obtained, but the specific materials and their fate impact the greenhouse gases generated or reduced. In

[97] Data provided by MDE: 2009 MRA Totals.xls

[98] Grasscycling is the practice of leaving grass cuttings on the lawn to decompose when mowing, In contrast to collecting the clippings to compost or landfill them.

order to estimate quantities of each of the materials for input into the WARM model figures from EPA's Municipal Solid Waste Generation, Recycling, and Disposal in the United States 2008[99] were used to estimate the quantities of each waste generated that were both generated and source reduced in Maryland in the year 2020.

Recycling

Baseline recycling for the year 2006 was determined from actual tonnage data[100] (see GHG Emission Data and Data Sources Section 1.5 below).

1.5. GHG Emission Data and Data Sources

The analysis benefitted from data that was tracked since the 2008 Climate Action Plan. Updated waste statistics compiled from the Annual Maryland Recycling Act (MRA) Tonnage Reporting Surveys informed the waste projections. Data from the Source Reduction Credit Reporting System was utilized to more conservatively estimate future Source Reduction Credits and their impact.

Key Input data for the policy:

Waste Projection

Population $_{2020}$ = 6,326,975 People as obtained from Maryland Department of Planning

Discard waste generation with Source Reduction $_{\text{(Ave 2005 – 2008)}}$ = 1.36 Ton/Person/Year

The quantities of waste generated were obtained from the annual Solid Waste Tonnage Report (filed by Maryland permitted solid waste acceptance facilities) and the annual MRA Tonnage Reporting Survey for the years 2005 to 2008. It is the actual amount of waste generated in Maryland as can be ascertained from required reporting. This does not include non-MRA waste, as much of that waste is from industrial and commercial entities, which are not required to report. As a result Non-MRA waste reported fluctuates from year to year, ostensibly not due to large variations in materials discarded, but rather due to reporting choices of reporting entities.

The MSW generation includes all discards *generated* in the State of Maryland. It should be noted that landfilling and incineration includes exports, but not imports.

Source Reductions

The Source Reduction Credit Reporting System provides an incentive for counties to implement and track waste prevention initiatives and report them to MDE. Through this system, Source Reduction Credits were tracked for the years 2005 to 2008 and the trend over that period was used to estimate the conservative, but steady increase of source reduction activities that will be undertaken from 2006 to 2020.

[99] http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2008data.pdf

[100] Provided by MDE: WARM 2006 v 2007.xls

Waste Characterization

The data provided in EPA's Municipal Solid Waste Generation, Recycling, and Disposal in the United States 2008 was used to estimate the percentage of the waste stream for each of a number of applicable materials that can be inputted into WARM. The following table shows the estimated percentage of the total MSW discards for each material:

Recycling

Information used to develop the quantities recycled in 2006 includes:

- Beverage Container Data by County from MRA Report[101] – Use of data from counties where containers are sorted (Aluminum, Tin/Steel, Polyethylene Terephtalate (PET), High-Density Polyethylene (HDPE), #3, 4, 5 & 7)

- Annual Report Solid Waste Management in Maryland Report 2006

- The 2006 Maryland Recycling Act (MRA) Tonnage Reporting Survey:
  (1) The total amount, by weight, of solid waste collected;
  (2) The total amount, by weight, of solid waste disposed of at solid waste acceptance facilities;
  (3) The amount and types of materials recycled;
  (4) The methods of disposal of solid waste used, other than recycling; and
  (5) The percentage reduction in the amount of solid waste needing disposal that has been achieved.

End of Life Profile

The 2009 profile for the waste generated remaining after recycling and composting was obtained from the 2009 Annual Report Solid Waste Management in Maryland Report. This determined the allocation of the 2020 non-recycled, non-composted waste generation to landfill or incineration.

1.5. GHG Emission Assumptions

The following assumptions were made:

- Source Reduction: With no framework for targeting specific materials it is assumed these programs reduce the overall amount of waste that must be managed. The amount of each material that was prevented from being generated in 2020 was determined using the EPA 2008 Waste Characterization.

- Export and Import MSW rate change – it was assumed that exports and imports increased at the same rate as the MSW. As well, it was assumed that the ratio of exports to imports to discards generated remains constant.

[101] Provided by MDE: "2006 MRA totals no edit.xls"

- Of the materials remaining after recycling and composting, the percent split between landfill and incineration remained static at the percentages they were in 2009, at 61 percent and 39 percent, respectively.

- The 2006 discards (actual tonnages discarded, so this incorporates the Source Reduction into the Baseline) was allocated to the material types using the EPA 2008 MSW Waste Characterization.

The following table shows the input values calculated and input into the WARM model for the 2006 baseline.

Table AFW-9.3- Input Values for the WARM Model

	2006 Diversion	Tons Landfilled	Tons Combusted	Tons Recycled or Composted
Aluminum Cans	17%	22,478	14,311	7,678
Steel Cans	8%	43,536	27,718	6,410
Glass	16%	190,051	120,998	58,994
HDPE	57%	5,994	3,816	13,032
PET	20%	39,750	25,307	16,566
Corrugated Cardboard	42%	330,177	210,211	395,582
Magazines/Third-class Mail	0%	145,086	92,371	710
Newspaper	22%	131,948	84,006	61,277
Office Paper	58%	49,352	31,420	109,825
Phonebooks	0%	16,161	10,289	12
Food Scraps	6%	687,264	437,555	72,041
Yard Trimmings	50%	378,692	241,099	618,860
Mixed Paper (general)	62%	143,007	91,047	387,825
Mixed Metals	57%	136,221	86,727	289,934
Mixed Plastics	11%	440,582	280,502	89,660
Mixed Recyclables	66%	130,579	83,135	422,212
Mixed Organics	79%	22,647	14,419	140,261
Tires	5%	82,493	52,520	7,827
Total		**2,996,016**	**1,907,450**	**2,698,706**

1.6. GHG Emission Analysis and Recommendations

Based on the approach outlined above, the waste generation projected for 2012, 2015 and 2020 are shown in Table 4 below. Based on the trend of source reduction, the anticipated overall tons of MSW prevented is also shown.

Table AFW-9.4- Waste Generation Projections

Tons	2012	2015	2020
Waste Generated	8,486,946	8,693,182	9,010,656
MSW Source Reduced	338,179	365,291	411,272
Materials Composted	NA	NA	Varies see table below
Material Recycled	NA	NA	Varies see table below
Material Landfilled	NA	NA	Varies see table below

Rather than setting benchmark diversion goals for each material, the GHG emission reductions were analyzed based on increasing the diversion by material in 10 percent increments. This analysis provides a guideline regarding which materials to target to maximize GHG reductions, instead of summarizing the reductions for specific target reductions. While a number of the resulting diversion percentages may be extremely optimistic, as several materials reach and maintain 100 percent diversion, this more clearly highlights the materials that make an impact on the Maryland's carbon footprint. This information will be considered in conjunction with the existing diversion rates, infrastructure analysis and technological options for reducing, reusing or recycling any of these materials.

The table below shows the GHG reductions from 2006 baseline diversion per material (GHG emission reductions are shown in green font):

Table AFW-9.5-GHG Reductions from 2006 Baseline Diversion per Material

	GHG Reductions (Million Metric Tons CO_2e)									
Increment	**10%**		**20%**		**30%**		**40%**		**50%**	
Year 2020	**Diversion**	**$MMTCO_2E$**	**Diversion**	**$MMTCO_2E$**	**Diversion**	**$MMTCO_2E$**	**Diversion**	**$MMTCO_2E$**	**Diversion**	**$MMTCO_2E$**
Aluminum Cans	27%	(0.03)	37%	(0.10)	47%	(0.17)	57%	(0.24)	67%	(0.31)
Steel Cans	18%	0.01	28%	0.00	38%	(0.01)	48%	(0.02)	58%	(0.03)
Glass	26%	0.01	36%	(0.00)	46%	(0.02)	56%	(0.03)	66%	(0.04)
HDPE	67%	(0.00)	77%	(0.01)	87%	(0.01)	97%	(0.02)	100%	(0.02)
PET	30%	0.00	40%	(0.01)	50%	(0.03)	60%	(0.05)	70%	(0.07)
Corrugated Cardboard	52%	0.22	62%	(0.06)	72%	(0.33)	82%	(0.61)	92%	(0.88)
Magazines/Third-class Mail	10%	0.19	20%	0.12	30%	0.05	40%	(0.02)	50%	(0.08)
Newspaper	32%	0.07	42%	0.01	52%	(0.04)	62%	(0.10)	72%	(0.16)
Office Paper	68%	0.10	78%	0.03	88%	(0.03)	98%	(0.09)	100%	(0.10)
Phonebooks	10%	0.01	20%	0.01	30%	0.00	40%	(0.00)	50%	(0.01)
Food Scraps	16%	(0.03)	26%	(0.06)	36%	(0.09)	46%	(0.13)	56%	(0.16)
Yard Trimmings	60%	(0.02)	70%	0.00	80%	0.03	90%	0.05	100%	0.07
Mixed Paper (general)	72%	(0.40)	82%	(0.61)	92%	(0.82)	100%	(0.99)	100%	(0.99)
Mixed Metals	67%	(0.51)	77%	(0.80)	87%	(1.09)	97%	(1.38)	100%	(1.48)
Mixed Plastics	21%	(0.16)	31%	(0.34)	41%	(0.52)	51%	(0.70)	61%	(0.88)
Mixed Recyclables	76%	(0.34)	86%	(0.52)	96%	(0.69)	100%	(0.75)	100%	(0.75)
Mixed Organics	89%	(0.00)	99%	(0.00)	100%	(0.00)	100%	(0.00)	100%	(0.00)
Tires	15%	0.04	25%	0.01	35%	(0.02)	45%	(0.05)	55%	(0.08)
Total		(0.84)		(2.32)		(3.80)		(5.12)		(5.97)

In terms of the potential for refining the analysis moving forward, version 10 of the WARM model does not allow for source reduction of a number of material categories, such as mixed paper, mixed metals, mixed plastics etc. The subsequent version of the model does allow for source reduction inputs for these materials.

If adequate data is obtained regarding source reduction activities that are awarded credits, it would be more accurate to be able to allocate the source reduction to the specific materials that are prevented from being created. For example, grasscycling programs would be credited to grass (or yard trimmings as the broader category), junk mail and catalog reduction initiatives would target magazines and third class mail, and re-manufacturing programs would impact materials such as metals or plastics.

Overall, the more specific data regarding materials and categories that can be procured, the more accurate the model will be. With Maryland's E-Waste Law, tonnages of applicable electronics may be easily tallied, and split out as certified recycling efforts in WARM. As well, many of the categories requested by the MRA survey could be incorporated to further refine the data set.

2.0 AIR QUALITY CO-BENEFITS

The estimated emissions reductions from AFW-9 are shown in the following table:

Table AFW-9.6- Emissions Reductions in Maryland Associated with AFW-9 (tons/year)

	% Reductions in Combined Amount Sent to Landfill and Incineration in 2020				
Pollutant	**10%**	**20%**	**30%**	**40%**	**50%**
SO_2 (1)	24 to 61	110 to 280	190 to 500	270 to 710	350 to 890
NO_X	150	710	1300	1800	2200
CO	20	92	160	230	290
PM (2)	2.5 to 9.0	12 to 42	21 to 73	29 to 100	37 to 131

(1) The ranges of emissions for SO_2 and PM represent the different air pollution control technologies/emission levels that could be applied to those emissions. It was assumed that the emissions were controlled but not by a specific technology.

The 2020 bounding emission reductions in Table AFW-9.6 are presented as a percentage of 2018 MANE-VU inventories in Table AFW-9.7. Because all the increased values are less than two-tenths of a percent it indicates that the criteria pollutant emission increases when reductions in the amount sent to the landfill is only 10 percent would not significantly degrade air quality. Because the decreased values for CO and PM are less than one-tenth of a percent, it indicates that the criteria pollutant emissions decreases when reductions in the amount sent to the landfill is 50 percent would not significantly improve air quality. The higher impacts for SO_2 and NO_X of 1.0 percent and 2.1 percent, respectively, might result in a small improvement in air quality.

Table AFW-9.7: Percentage Reductions in State Emissions Inventory Associated with AFW-9

	Maryland (%)	
Pollutant	**Minimum Reductions (10% Reductions in Landfill Amount)**	**Maximum Reductions (50% Reductions in Landfill Amount)**
SO_2	< 0.2	1.1
NO_X	< 0.2	2.2
CO	< 0.2	< 0.1
PM	< 0.2	< 0.1

2.1. Summary of Air Quality Co-Benefits Methodology

The only significant emissions from landfills are methane and carbon dioxide. Neither of these are criteria (i.e., NAAQS) pollutants. The only affect this policy will have on air quality is if it affects the tonnage of waste that will be incinerated. The AP-42 emission factors for incineration were applied to the annual change in waste tonnage that was projected to be incinerated. The waste tonnage incinerated varied with increased recycling and composting. Calculations were made for reducing the amount of material to the landfill and incineration by 10 percent, 20 percent, 30 percent, 40 percent and 50 percent over the 2006 diversion baseline. The ratio of the amount landfilled and incinerated remained constant, at 61 percent and 39 percent respectively. Incineration tonnage decreased by 85,743 tons/year; 396,407 tons/year; 695,841tons/year; 988,105 tons/year; and 1,250,019 tons/year for increased diversion percentages 10, 20, 30, 40, and 50 percent, respectively.

2.2. Rationale for Air Quality Co-Benefits Methodology

This methodology is the only approach for estimating the change in criteria pollutant emissions. Better estimates would require site specific emission data and a determination of how the change in waste tonnage would impact specific incinerators.

2.3. Air Quality Co-Benefits Calculations

Emission factors (EF) for refuse combustion were taken from AP-42. For pollutants that are controlled, AP-42 provided emission factors for the different control techniques. It was assumed that the incinerators in Maryland were controlled. However, there was no way to determine which specific incinerators might be affected by the change in waste tonnage due to this policy. So we used the least affective and most affective air pollution controls to bind a range for the change in emissions.

The annual emissions were calculated as follows:

EF(lb/ton) x change in tonnage incinerators(ton/yr)/2000 lb/ton = emissions (tons/yr)

The changes in annual emissions are summarized in Table 1. The percentage of the statewide emission inventory represented by the emission changes in Table 1 is the potential co-benefit and is presented in Table 2.

2.4. Air Quality Co-Benefits Data and Data Sources

- **Statewide emission inventory.** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory
- **Incinerator Emission Factors. AP-42,** 2.1 Refuse Combustion, Table 2.1-2 Particulate Matter, Metals, And Acid Gas Emission Factors For Mass Burn And Modular Excess Air Combustors And Table 2.1-4 Organic, Nitrogen Oxides, Carbon Monoxide, And Carbon Dioxide Emission Factors For Mass Burn Waterwall Combustors.

2.5. Air Quality Co-Benefits Assumptions

It was assumed that any of the benefits from reducing the NAAQS pollutants emitted by landfills are insignificant compared to the benefits from reducing the incineration.

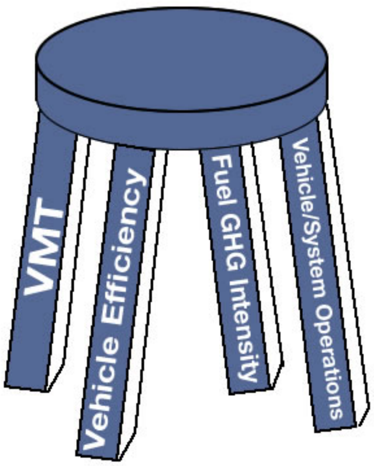
3.0 INTERACTION WITH OTHER POLICIES

The discussion of policy interactions is provided in Chapter 5.

Chapter 4: Transportation and Land Use (TLU) Policies

Transportation sector emissions are a function of many complex, often interrelated factors that include the efficiency of the overall vehicle, the carbon intensity of the fuel, the activity level of the vehicle, and the transportation system-wide operational efficiency, as illustrated in Figure 4.1. The TLU policies address each of these factors except the fuel GHG intensity factor.

Figure 4.1. Transportation GHG Emissions Mitigation Options



The following TLU Policies were analyzed:

- TLU 2: Land Use and Location Efficiency
- TLU 3: Transit
- TLU 5: Intercity Travel
- TLU 6: Pay-As-You-Drive Insurance
- TLU 8: Bike and Pedestrian Infrastructure
- TLU 9: Incentives, Pricing and Resource Measures
- TLU 10: Transportation Technologies

TLU Policy Findings

Table 4.1 presents the 2020 GHG emission reduction estimates for the above-listed seven policies. SAIC developed the reduction estimates for TLU-6 (Pay-As-You-Drive Insurance); the estimated reductions for the other six policies are from the CAP. As the table indicates, Policy TLU-9 accounts for 50 percent of the sum of the reductions across the TLU sector, while TLU-2 (Land Use and Location Efficiency) and

TLU-3 (Transit) contribute 26 percent and 12 percent, respectively, to the TLU sum. The remaining four policies combined account for 11 percent of the TLU emission reduction sum.

Table 4.1. Summary of GHG Emission Reductions from the TLU Sector in 2020

Sector/Policy	2020 GHG Emission Reductions ($MMTCO_2e$)
Transportation & Land Use (TLU)	
TLU-2: Land Use & Location Efficiency	0.96
TLU-3: Transit	0.45
TLU-5: Intercity Travel	0.02
TLU-6: Pay-As-You-Drive Insurance	0.03
TLU-8: Bike & Pedestrian Infrastructure	0.15
TLU-9: Incentives, Pricing & Resource Measures	1.84
TLU-10: Transportation Technologies	0.20
TLU Total (Unadjusted for Overlap)	**3.65**

Table 4.2 presents the projected 2020 reductions in criteria pollutant emissions for the nine AFW policies. As this table indicates, Policy TLU-9 (Incentives, Pricing and Resource Measures) accounts for the majority of the reductions for the various criteria pollutants.

Table 4.2. Summary of Criteria Pollutant Emission Reductions from the TLU Policies in 2020

		SO_2 (Tons)	NO_x (Tons)	CO (Tons)	VOC (Tons)	PM10 (Tons)	PM2.5 (Tons)
	Transportation & Land Use (TLU)						
TLU-2	TLU 2 - Land Use & Location Efficiency	15.00	620.00	14,000.00	660.00	25.00	23.00
TLU-3	TLU 3 – Transit	8.70	370.00	8,500.00	397.00	15.00	14.00
TLU-5	TLU 5 - Intercity Travel	0.60	26.00	600.00	28.00	1.00	1.00
TLU-6	TLU 6 - Pay-As-You-Drive Insurance	1.00	44.00	1,000.00	47.00	1.70	1.60
TLU-8	TLU 8 - Bike & Pedestrian Infrastructure	4.60	200.00	4,500.00	210.00	7.80	7.30
TLU-9	TLU 9 - Incentives, Pricing & Resource Measures	37.00	3,300.00	43,000.00	2,500.00	140.00	74.00
TLU-10	TLU 10 - Transportation Technologies						
	TLU Total	**66.90**	**4,560.00**	**71,600.00**	**3,842.00**	**190.50**	**120.90**

As is discussed in the individual policy sections that follow, the various TLU policies interact closely with each other, both synergistically and competitively. Due to the complexity of these interactions, a transportation and land use planning modeling effort would need to be undertaken to quantify the impact of these interactions on the GHG and criteria pollutant emission reductions projected for the different policies. Such a modeling effort was outside the scope of our analysis.

Policy No.: TLU-2

Policy Title: Land Use and Location Efficiency

SAIC was tasked with reviewingthree versions of the TLU-2 policy analysis: 1) the original TLU-2 policy analysis, which was conducted by a prior MDE contractor (henceforth referred to as CAP 2008), 2) a subsequent re-analysis of the same policy, which was conducted by Maryland Department of Transportation (MDOT) contractors,[102] and the current policy analysis conducted by the Maryland Department of Planning (MDP).[103] SAIC conducted a thorough examination of the methodologies, assumptions, source materials, and results, and documented the methodology and results, as well as provided SAIC's observations and recommendations. In addition SAIC quantified the air quality co-benefits associated with TLU-2. SAIC's findings are described below:

1. GHG EMISSION REDUCTIONS

TLU-2 is designed to implement land-use planning and development strategies that reduce the number of VMT and corresponding GHG emissions. Table TLU-2.1 presents the estimated reductions.

[102] Maryland Department of Transportation, Maryland CAP – Draft Implementation Status Report. November 4, 2009, and Appendix B of the same report.

[103] Maryland Department of Planning, 2020 CO2 Reduction Attributable to Smart Growth in Maryland, January 2011.

Table TLU-2.1- Estimated Reduction in GHG Emissions and Vehicle Miles Traveled Resulting from TLU-2

Emissions Category	Estimated Reductions		
	2012	2015	2020
Total TLU-2 GHG Reductions from Urban Transportation and Building Energy ($MMTCO_2e$)	0.16	0.43	0.96
Urban Transportation VMT-Related Reductions ($MMTCO_2e$)	0.1	0.28	0.65
Building Energy Savings from Compact Development ($MMTCO_2e$)	0.06	0.15	0.31
Statewide Transportation VMT Reductions (Million Miles)	233	645	1,502

Notes: Not all digits displayed are significant figures.

Source: Maryland Department of Planning, February 2011.

1.1. Summary of GHG Emission Methodology

MDP, for the purposes of estimating the potential climate change mitigation benefits of widespread implementation of the TLU-2 policy, includes the following four components in its desired outcomes of smart growth strategies:[104]

- Geographic and spatial relationships between origins and destinations,
- Governance of transportation, land use and development,
- Functional and social integration of transportation modes, and
- Mass transit efficiency and affordability.

MDP estimated GHG emissions from smart growth strategies using a methodology thaton the two metrics of density and relative amount of growth. MDP's methodology originated in the Urban Land Institute book *Growing Cooler*[105] and was subsequently refined and applied on behalf of the California Air Resources Board (CARB) to validate a GHG estimate for inclusion in the Draft AB 32

[104] Maryland Department of Planning, "Maryland Commission on Climate Change Report Update," TLU-2, November 2010.
[105] Reid Ewing, et al. *Growing Cooler: The Evidence on Urban Development and Climate*, Urban Land Institute, April 11, 2008.

Scoping Plan.[106] University of Maryland Professor Reid Ewing of the National Center for Smart Growth was a co-author of *Growing Cooler* and the subsequent study for CARB. MDP considers this methodology to be an interim approach, sufficiently robust to support analyses pursuant to Maryland's Greenhouse Gas Emissions Reduction Act of 2009, until Maryland transportation models are revised and updated with the capability of quantifying TLU-2 impacts.

The proposed interim methodology relates VMT and GHG reduction to smart growth based on the assumption that compact development has the potential to reduce VMT per capita by 30 percent relative to sprawl. This assumption is used in a formula that incorporates two key metrics:

- Density of Maryland's built environment – MDP plans to increase the share of Maryland's built environment that is "compact" (defined as having a minimum of 4 units per acre) to 75 percent, using strategies that influence the density of new and re-development; and

- Relative amount of growth – MDP projects that the amount of new development within the next decade will represent 10 percent of Maryland's total built environment.

In addition to VMT reductions, MDP estimates GHG reductions from building energy as a result of high-density development.

1.2. Rationale for GHG Emission Methodology

MDP chose the interim methodology for the GHG estimate based on the precedent of its application on behalf of CARB for validating GHG emission reductions attributable to smart growth in California. The methodology was applied for CARB by two of the leaders in the field of smart growth and climate change mitigation.[107] The methodology originated in the Urban Land Institute book *Growing Cooler*.[108]MDP considers the interim approach sufficiently robust to support analyses pursuant to Maryland's Greenhouse Gas Emissions Reduction Act of 2009, until Maryland transportation models are revised and updated with the capability of quantifying smart growth impacts.

1.3. Detailed Explanation of Methodology

Each of the three TLU-2 GHG reduction estimates, presented below, was based on a different methodology. MDP concluded that the reductions originally calculated in the 2008 CAP may have been overestimated. The subsequent MDOT approach considers some of the same literature as the interim MDP methodology, but adopts a different formula to compute the results.

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[106] Reid Ewing and Arthur C. Nelson, "CO_2 Reductions Attributable to Smart Growth in California," National Center for Smart Growth, University of Maryland, and Metropolitan Research, University of Utah, January 7, 2010, http://metroresearch.utah.edu/products/11-CO_2-Reductions-Attributable-to-Smart-Growth-in-California.
[107] Reid Ewing and Arthur C. Nelson, "CO_2 Reductions Attributable to Smart Growth in California," National Center for Smart Growth, University of Maryland, and Metropolitan Research, University of Utah, January 7, 2010, http://metroresearch.utah.edu/products/11-CO_2-Reductions-Attributable-to-Smart-Growth-in-California.
[108] Reid Ewing, et al. *Growing Cooler: The Evidence on Urban Development and Climate*, Urban Land Institute, April 11, 2008.

Table TLU-2.2- Comparison with Other Studies

TLU-2 Reduction Estimates Based on Different Methodologies	Reduction in 2020 (MMTCO_2E)
MDP 2011[109]	0.65
MDOT 2009[110]	0.18 – 0.24
CAP 2008[111]	4.6

1.4. GHG Emission Reduction Calculations

The MDP methodology is based on the following formula, which was developed for *Growing Cooler* and subsequently applied for CARB to validate its forecast of GHG reductions with compact development:

$$TER_i = MS_i * TD_{ji} * VMT * RR * BP_i$$

Where

TER_i = Total GHG emission reduction with compact development in year i for Policy

TLU-2 (million metric tons CO_2e)

MS_i = Market Share of Compact Development in year i (percent)

TD = Percent of total development built between years j and i (percent)

VMT = % VMT reduction per capita achievable by compact development relative to sprawl (percent)

RR = Ratio CO_2/VMT reduction with compact development

BP_i = Baseline projection of transportation CO_2 in year i (million metric tons CO_2e)

i = 2020

j = estimate base year of 2010[112]

MDP provided the statewide VMT reduction estimate.

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[109] Maryland Department of Planning, 2020 CO2 Reduction Attributable to Smart Growth in Maryland, January 2011.

[110] Maryland Department of Transportation, Maryland CAP – Draft Implementation Status Report. November 4, 2009, Appendix B.

[111] Maryland CAP Appendix D-4, 2008.

[112] Different from CAP base year of 2006.

In addition to the transportation sector savings, compact development in Maryland is estimated to reduce building energy use and associated GHG emissions by 0.31 $MMTCO_2E$ in 2020, based on the following formula:

$$TBER_i = MS_j * TD_{ji} * BECR * RCI$$

Where

$TBER_i$ = Total building energy emissions reductions in year i

BECR = building energy consumption reduction (%)

RCI = Baseline estimate from Residential/Commercial/Industrial (RCI) fuel use in the CAP

1.5. GHG Emission Data and Data Sources

MDP input the following data into its estimate of emission reductions associated with compact development:

- MSi = Market Share of Compact Development – The MDP forecast of 75% compact development market share by 2020 is based on the following historic data and factors:
  - MDP reviewed 1997 to 2010 data and trend of market share of compact development in Maryland, which was obtained from the source MDPropertyView, a MDP geographic information systems (GIS) database tool that includes property map and parcel information. For 2006, the market share of compact development in Maryland was 68.5 percent. Figure TLU-2.1 presents historical data to characterize the level of compact development in the residential sector in Maryland. As the figure illustrates, high-density development generally has been increasing in Maryland since 2002.
  - MDP defined compact development as having a minimum density of 0.25 acre per housing unit, based on the transit bus service minimum density requirement of 4 housing units per acre, as established by research by the Victoria Transport Policy Institute.
- TD = Percent of total development built between years 2010 and 2020 – MDP's estimate of 10 percent, which represents the increment of new development or redevelopment in Maryland relative to the stock that will exist in the base year 2020, is based on two data sources:
  - Maryland State Data Center - housing units growth projection for 2010 to 2020 is 8.5 percent of the 2020 built environment
  - 2009 American Community Survey and the Census Bureaus' demolition rates were used to determine the housing stock replacement percentage

- VMT = Ewing and Nelson[113] and *Growing Cooler* establish the factor of 30 percent per capita VMT reduction achievable by compact development relative to sprawl. This factor applies to each increment of development or redevelopment but does not affect base development.

- RR = MDP uses a ratio CO_2e to VMT reduction of 90 percent, consistent with the conservative assumption adopted by Reid and Nelson for CARB.

- BP = Baseline projection of CO_2 in year i (million metric tons CO_2e)

- VMT = Total statewide VMT in given year. Data, in billion miles, are provided here:
    - VMT 2012 = 61.5
    - VMT 2015 = 64.8
    - VMT 2020 = 69.9

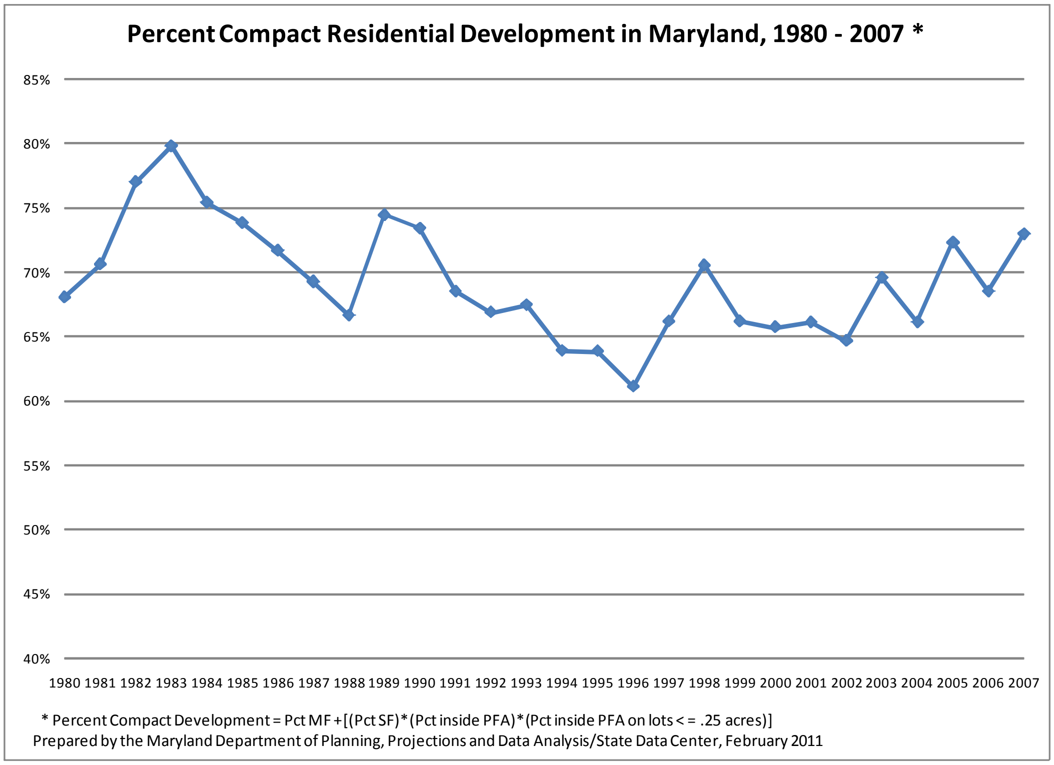
GHG emission reductions associated with building energy savings are estimated using the following data:

BECR = 20 percent

RCI = Baseline RCI = 20.7 $MMTCO_2e$

[113] Reid Ewing and Arthur C. Nelson, "CO_2 Reductions Attributable to Smart Growth in California," National Center for Smart Growth, University of Maryland, and Metropolitan Research, University of Utah, January 7, 2010, http://metroresearch.utah.edu/products/11-CO2-Reductions-Attributable-to-Smart-Growth-in-California.

Figure TLU-2.1. Percent Compact Residential Development in Maryland (1980 – 2007)



1.6. GHG Emission Assumptions

MDP relied on several assumptions to quantify smart growth impacts on GHG emissions, including the following associated with compact development market share:

- MDP assumes the compact development market share in Maryland will increase to 75 percent by 2020, from 68 percent in 2010. MDP based this assumption on discussions with a demographer and reviews of historic data and trends (described in the *Data and Data Sources* section), and feels it is achievable through the implementation of aggressive but realistic policy actions. MDP provides the following background:

> *Land use patterns that support the TLU-2 strategy include redevelopment and infill, smaller lot sizes, designated growth areas, rural conservation zoning, transit-oriented development (and other development that can make use of existing alternative transportation networks), development patterns that can support extensions of and future alternative transportation networks, mixed-use development, and building new homes (origins) near jobs and other destinations.*[114]

[114] Maryland Department of Planning, TLU-2, Maryland CAP Update Project, January 2011.

- MDP assumes that the share of new attached units to all units constructed in Maryland will continue to increase, not only in response to recent nation-wide financial sector events, but also changing demographics and housing market trends, consistent with assumptions adopted by Ewing and Nelson in the study "CO_2 Reductions Attributable to Smart Growth in California," on which the overall MDE methodology is based.

- MDP validated the feasibility of the 75 percent target by calculating possible compact development market share values from a range of potential scenarios reflecting changes in shares of single family and multi-family units within and outside Maryland's Priority Funding Areas, relative to the respective historic levels for each housing type.

Assumptions regarding the estimated increment of new development or redevelopment include:

- MDP assumes that roughly 10 percent of the total development will be built between years 2010 and 2020, which compares to Dr. Ewing's estimate for CARB of 25 percent of California's built environment in 2020 will be built between 2010 and 2020.

- MDP estimated a 10-year loss rate of approximately 1.6 percent.

- There is no demolition of homes less than ten years old; i.e., no loss rate is applied to houses built this decade.

The key assumption in the analysis is that VMT per capita will be reduced by 30 percent with compact development relative to sprawling development. This assumption is based on four different empirical literatures reviewed in *Growing Cooler*, whichindicate compact development has the potential to reduce VMT per capita by 20 to 40 percent relative to sprawl. MDP's assumed reduction percent of 30 is consistent with Ewing and Nelson for CARB.

MDP assumes a ratio CO_2e to VMT reduction of 90 percent, consistent with the conservative assumption adopted by Reid and Nelson for CARB. Reid and Nelson refer to Growing Cooler and explain that a reduction in VMT emissions would produce a slightly smaller reduction in CO_2 emissions, as a result of CO_2 penalties associated with cold starts and reduced vehicle operating speeds.

MDP estimates relevant VMT based on the share of statewide VMT that occur in urban areas, which was 74 percent as of 2009. MDP projected that the urban share will continue to increase at a rate of 6 percent through 2020, based on regression analysis of historical data from 1996 to 2009.

2.0 AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

TLU-2 is estimated to reduce emissions to the atmosphere due to reduced VMT and reduced production at EGUs. The reductions in emissions from EGUs were estimated to be less than 2 thousandths of a ton for relevant NAAQS pollutants making them insignificant. The emissions and percent reductions in the following tables represent changes due to reductions in VMT.

The estimated emissions reductions from TLU-2 are shown in the following table:

Table TLU-2.3- Emissions Reductions in Maryland Associated with TLU-2

	Statewide (tons/year)		
Pollutant	**2012**	**2015**	**2020**
SO_2	2.2	6.3	15
NO_X	200	410	620
CO	2,600	6,700	14,000
VOC	150	350	660
PM10 - primary	8.6	17	25
PM2.5 - primary	4.5	11	23

These numbers were compared against the MANE-VU inventories for 2012 and 2018 in Table TLUE-2.4. Because all the values are less than eight-tenths of a percent, the table indicates that the criteria pollutant emissions reductions associated with this policy would be unlikely to significantly improve air quality.

Table TLU-2.4- Percentage Reduction in State Emissions Inventory Associated with TLU-2

Reductions	Maryland (%)	
Pollutant	**2012**	**2018**
SO_2	< .80	< .80
NO_X	< .80	< .80
CO	< .80	< .80
VOC	< .80	< .80
PM10-primary	< .80	< .80
PM2.5-primary	< .80	< .80

2.2. Rationale for Air Quality Co-Benefits Methodology

Given the small role of VMT reductions due to car-based passenger-mile reductions, a simple comparison (i.e., percentage) of change in the statewide emission inventory was used as the parameter for net co-benefit. The contribution to the mobile source emission inventory of non-LDVs was not readily available and would involve significant resources for modeling that are not really justified for the minimal impact this approach estimates for those VMT reductions.

2.3. Summary of Air Quality Co-Benefits Methodology

The method used to calculate the change in emissions to the atmosphere due to reduced VMT is based upon the estimated change in statewide VMT. It was assumed that the percentage reduction in Maryland's VMT would result in an equivalent percentage reduction in the state's mobile source emission inventory.

The potential for improved air quality was estimated by comparing reductions in the mobile source inventory to estimates for the total statewide emission inventory.

The method used to calculate the change in emissions to the atmosphere due to reduced production at EGUs is based on the PROMOD model. The PROMOD model results estimate the decreased fuel consumption at various plants based on marginal reductions in electricity consumption. The marginal plant emissions reductions are calculated by multiplying each power plant's decreased fuel consumption by the plant-specific emission factors (lb pollutant/mmBtu), and domain-wide emission factors are computed from the marginal calculations. Then emissions reductions are computed by multiplying the policy's decrease in fuel consumption by the domain-wide emission factors.

2.4. Air Quality Emission Reduction Calculations

Statewide VMT estimates of 55,631 and 78,989 million VMT (mVMT) were estimated for 2009 and 2030, respectively. An estimate of 59,000, 62,000 and 68,000 mVMT in 2012, 2015 and 2020, respectively were determined by linear interpolation.

As a result of Policy TLU-2, vehicle miles traveled will be reduced by 233, 645, and 1,502 mVMT in 2012, 2015 and 2020, respectively. The reductions represent 0.4, 1.0 and 2.2 percent reductions to the total statewide VMT in 2012, 2015 and 2020, respectively. When those percent reductions are applied to the total state mobile source inventory the emission reductions listed in Table TLU-2.3 are derived. The potential co-benefit of those emission reductions listed in Table TLU-2.4 is the absolute reductions in Table TLU-2.3 compared to the statewide emission inventory.

The emission reductions associated with electricity consumption reductions were calculated as follows:

- Use the marginal electricity emissions factors.
- Divide the CO_2 saved (tons CO_2) by the average CO_2 rate of change (tons CO_2/MWh) to find the energy saved (MWh).
- Multiply the calculated energy saved (MWh) by the emission factors (lb/MWh) to calculate the emission reductions.

2.5. Air Quality Emission Reduction Data and Data Sources

- **Statewide VMT estimates.** A Presentation Smart Growth & Transportation, Funding/Investment, Blue Ribbon Commission on Transportation Funding, Richard E. Hall, AICP, Secretary, Maryland Department of Planning, November 15, 2010

- **Statewide emission inventory.** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

2.6. Air Quality Emission Reduction Assumptions

- It was assumed that the reduction in VMT would result in a proportional reduction in the mobile source inventory and that emissions from light duty vehicles (LDV) are such a large fraction of the total mobile source emissions, that these calculations can be based on the total emissions of mobile sources.

- It was assumed that TLU 2 would impact all mobile sources equally. In actuality it would mostly impact the light duty vehicle (LDV) portion of mobile sources. LDVs emit less per VMT than other portions of the source category. So the impacts are probably lower than what has been estimated by this method.

3. INTERACTION WITH OTHER POLICIES

The interactions of land uses and development and transportation infrastructure and policy decisions are many in number and complex in character. Local and regional governments and organizations nationwide have begun to recognize the importance of system-wide transportation and land-use modeling and analysis. Such modeling is outside the scope of this project, but key interactions can be summarized qualitatively for TLU-2. TLU-2 strategies have significant interactions with each other, primarily synergistic, however there is the possibility of conflicting and overlapping effects.

Some TLU policies may achieve little reductions on their own, but with the implementation of TLU-2 and others, they have large impacts. For example, transit service is not feasible in low-density areas where parking is plentiful, as high density development is a prerequisite for cost-effective transit system deployment. Therefore, certain transit strategies alone would not achieve reductions without compact development in place. However, transit enhancements (TLU-3) in combination with smart growth strategies (TLU-2) and pricing incentives (TLU-9) will provide significant VMT and GHG reductions. Such interactions are the subject of an anticipated 2011 Transit Cooperative Research Program project, titled: Determining the Land Use Effect of Transit's Role in Reducing Regional Greenhouse Gas Emissions. The following is an excerpt from the project background:

Evidence also suggests that there are additional synergies for reducing GHG among transit ridership, land use, and pricing strategies for transportation, including parking. Detailed information on the character and magnitude of these synergies is not currently available. Research in this area would further help local and state governments, metropolitan planning organizations, transit agencies, and others to estimate potential GHG reduction that would result from pursuing combined strategies regarding increased transit capacity, related land use planning and development, and associated pricing policies affecting related services.

In addition to TLU-2 interactions with TLU-3 and TLU-9, TLU-2 also interacts with TLU-8, the Bike and Pedestrian strategies, and may support TLU-6 and TLU-10 as well. Further research is needed to better describe these TLU interactions. Beyond interactions among the TLU strategies, there will be interactions between select TLU policies and other sectors. Specifically, the Land Use & Location Efficiency TLU-2 policy will interact with the AFW-4 policy (Protection & Conservation of Agricultural Land, Coastal Wetlands & Forested Land). This TLU-2 policy encourages high density development and discourages urban sprawl, which will protect vegetation, and land protection measures just as AFW-4 will promote high density development over sprawl. Therefore, the joint TLU-2 and AFW-4 policy implementation will have a synergistic effect, as noted in Chapter 5. However, since the emissions reductions from these two policies are calculated based on two different metrics (reduced VMT for TLU-2 and avoided carbon emissions from the clearing of forests AFW-4), the emission reductions for the two policies may be summed.

Finally, TLU2 will impact the energy sector in ways that are not captured by other policies. For example, compact and mixed use developments will reduce residential and commercial energy, since high density developments associated with TLU-2 increase multi-family housing and mixed-use buildings, and multi-family buildings have been shown to use approximately half the electricity of single family dwellings. In addition, more compact developments may be expected to decrease inefficiencies of local electricity distribution systems.

Policy No.: TLU-3

Policy Title: Transit

SAIC was tasked with reviewing 1) the original TLU-3 policy analysis, which was conducted by a prior MDE contractor (henceforth referred to as CAP 2008), and 2) the subsequent re-analysis of the same policy, which was conducted by MDOT contractors[115] (henceforth referred to as MDOT). SAIC conducted a thorough examination of the methodologies, assumptions, source materials, and results, and documented the methodology and results, as well as provided SAIC's observations and recommendations. In addition, SAIC estimated reductions for the intermediate years that MDOT did not analyze. Finally, SAIC quantified the air quality co-benefits associated with TLU-3. SAIC's findings are described below:

1. GHG EMISSION REDUCTIONS

TLU-3 is designed toshift passenger transportation mode choice to increase transit ridership and carpooling. This strategy will reduce GHG emissions by reducing VMT (fewer vehicle trips)[116]. The TLU-3 target is based on the Maryland Transit Administration (MTA) 2001 Maryland Comprehensive Transit Plan (MCTP) goal of doubling transit ridership by 2020 from a 2000 baseline.

Table TLU-3.1- Estimated GHG Emission Reductions Resulting from TLU-3

Emissions Category	GHG Emission Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
TLU-3	0.05	0.11	0.45

Note: The GHG emission reduction estimate reflects the sum of VMT-related reductions (0.31 MMTCO_2e) and delay-related reductions (0.14 MMT). The VMT avoided were estimated to be 414.3 million, which isattributed solely to the addition of 105.8 million unlinked transit trips in 2020. The VMT underlying the 0.31 MMT reductions includes a land use adjustment calculation, which MDOT converted to a total VMT reduction of 900 million.

1.1. Summary of GHG Emission Methodology

MDOT first quantified the baseline, and then forecasted the 2020 transit trip ridership values in the absence of TLU-3 strategies (i.e., business-as-usual). Next, MDOT subtracted the BAU 2020 ridership estimate from the 2001 MCTP 2020 goal. The resulting difference in transit trip ridership values was the basis for converting to avoided VMT and then calculating GHG reductions. Specifically, MDOTconverted these transit passenger trips to VMT using average vehicle occupancy and average trip length data. Finally, MDOT converted VMTs to GHG reductions using emission factors from EPA's MOBILE 6 model. In addition, MDOT estimated reductions associated with reduced delay, following the American Public Transportation Association (APTA) recommended guidelines for transit, which include a land-use adjustment calculation.

[115] Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report. November 4, 2009, and Appendix B of the same report.
[116] 2008 Maryland CAP

1.2. Rationale for GHG Emission Methodology

The interpolation method used by SAIC for the intermediate years of 2012 and 2015 was chosen based on expert judgment in absence of data, and to maximize transparency and flexibility to facilitate future updates or revisions.

The methodology for the 2020 GHG estimate developed by MDOT was chosen based on data availability and expert judgment to improve upon the original 2008 estimate by providing a more accurate representation of emission reductions associated with existing and planned projects and funding levels.

1.3. Detailed Explanation of GHG Emission Methodology

MDOT quantified the MCTP ridership goal as 459.0 millionunlinked passenger trips per year in 2020, equal to a doubling of 2000 ridership. To quantify the incremental increase required to meet the goal, MDOT developed an estimate of the 2020 ridership forecast based on assumed business-as-usual (BAU) transit-related programs and expansions (i.e., 353.2 million unlinked trips). MDOT defined BAU as already planned and funded. To estimate the BAU growth through 2020, MDOT uses a combination of data sources (defined below), starting from a 2007 ridership value.

MDOT subtracted the BAU unlinked passenger trips ridership forecast (i.e., passenger-trips) from the 2020 target of doubling the 2000 ridership. The difference represents 105.8 million unlinked transit trips.[117] MDOT translated these transit passenger trips to VMT by using average vehicle occupancy and average trip length data.Specifically MDOT calculated VMTs by multiplying unlinked transit passenger trips by average trip length (i.e., miles per trip), and dividing the result by average vehicle occupancy (i.e., passengers per vehicle). Finally, MDOT converted the resulting VMTs to GHG reductions using emission factors from EPA's MOBILE 6 model.

MDOT explains that the 414.3 million VMT reductions is attributed solely to the addition of 105.8 million unlinked transit trips in 2020. The VMT underlying the 0.31 $MMTCO_2e$ reductions includes a land use adjustment calculation, consistent with a 2008 report from APTA, which brings the total VMT reduction in a range from 770 to 900 million. MDOT elected to report the higher value in order to reflect the maximum benefit possible by 2020.

1.4. Difference between Original Methodology and Revised Methodology

The CAP 2008[118]projected GHG reductions of 1.1 and 2.2 $MMTCO_2e$ in 2012 and 2020, respectively,[119] which is an order of magnitude greater than the 2009 MDOT estimate.

Several factors contribute to the difference, including:

1) The CAP 2008 estimate for TLU-3 included reductions associated with TLU-3 and TLU-8 (Bike and Pedestrian Infrastructure).

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[117] Maryland Department of Transportation, Maryland CAP – Draft Implementation Status Report, Appendix B. November 4, 2009.
[118] Maryland CAP Appendix D-4, 2008.
[119] Maryland Commission on Climate Change CAP documents report conflicting estimates of TLU-3 GHG reductions in 2020: 2.8 and 2.2 $MMTCO_2e$ in Chapter 4 and Appendix D-4, respectively.

2) The CAP 2008 methodology reportedly reflects the synergistic emission reductions effects of bundling TLU-3 and TLU-9 (Incentives, Pricing, and Resource Measures), although those synergies, with regard to GHGs, are not documented in the CAP. The MDOT estimate reflects each measure individually.

3) The most significant reason for the difference in estimates is the difference in methodology. The key differences are two-fold:

1) The original 2008 CAP methodology was based on the assumption that the proposed funding increase was equal to 84 percent (based on the predicted revenue from a TLU-9 strategy, rather than the 42 percent increase defined by the policy goal). The original method assumed that each percent increase in funding would result in an equal percent (84 percent) increase in transit mode share, and the resulting transit increase shifted entirely from single occupancy vehicle trips. The MDOT methodology disregarded the 2008 CAP approach as unrealistic and therefore did not attempt to directly relate transit funding levels to mode shift. The revised MDOT methodology represents a more pragmatic approach with a tangible 2020 policy goal and required costs to achieve the goal. MDOT commented that the mode share approach is arbitrary and does not reflect the realities of the current and proposed funding and operation of the transit system in Maryland.

2) The CAP 2008 methodology attributed all changes in transit and single-occupancy-vehicle mode shares after 2005 to the TLU-3 policy. In contrast, the MDOT method documented includes in the baseline any existing projects or programs planned or underway as of 2009, and excludes the resulting BAU projected growth rate in transit ridership from the TLU-3 policy.[120]

1.5. GHG Emission Reduction Calculations

MDOT did not calculate emission reductions associated with TLU policies for any baseline or intermediate years. Therefore, the TLU-3 emission reduction estimates for 2012 and 2015 are interpolated from 2010 using the following equation based on an exponential trendline that reflects 10 percent and 25 percent, respectively, of the 2020 total annual GHG reduction.

$TER_i = TER_{2020} * RUF_i$

Where

TER_i = Total GHG emission reductions in year i for Policy TLU-3 ($MMTCO_2e$)

TER_{2020} = Total GHG emission reductions in year 2020 for Policy TLU-3 ($MMTCO_2e$)

[120] MDOT comments dated January 2011 acknowledged that its goal was to measure the benefit of Maryland's existing transportation program through 2020, before estimating the potential benefits of additional funding across the TLU categories. MDOT noted that it is difficult, and ultimately not instructive to this process to extract the benefit of a single strategy (transit expansion and operations) from forecast VMT reductions from plans and programs through 2020 due to the multimodal nature of the transportation system and it's interaction with population and employment growth.

RUF_i = Ramp-Up Factor for year i, which reflects how much of the annual GHG reduction in 2020 can be expected to be achieved in year i

RUF_{2012} = 10%

RUF_{2015} = 25%

1.6. GHG Emission Data and Data Sources

MDOT used several data sources to estimate the existing ridership trend through 2020 and the more aggressive ridership rates associated with the TLU-3 policy goal, as documented in the 2009 MDOT Climate Action Plan Draft Implementation Status Report, Appendix B.[121]

Table TLU-3.2 presents historical statewide transit trip data.

Table TLU-3.2. Historical Statewide Transit Trip Data

Ridership	Unlinked Transit Trips (million)		
	2000	2006	2020 (goal)
Maryland total	229.515	252.8	459.0

Sources: The source of the 2020 value is Maryland Department of Transportation, Maryland CAP – Draft Implementation Status Report, 2009. MDOT determined the 2000 value based on interpolating annual statewide ridership values as reported in the Maryland Annual Attainment Report. The 2020 value is double the 2000 ridership value. The source of 2006 value is the Comprehensive Greenhouse Gas and Carbon Footprint Reduction Strategy, Report of the Maryland Commission on Climate Change Greenhouse Gas and Carbon Mitigation Working Group, Maryland CAP Appendix D-4, August 2008.

MDOT used the following data sources to develop the BAU ridership forecast:

- National Transit Database (NTD)
- Maryland Annual Attainment Report (AAR)
- Baltimore Regional Transportation Board (BRTB) and Metropolitan Washington COG Long Range Plans
- American Public Transportation Association (APTA) 2008 and 2009 ridership reports

These sources were used to come up with the following Maryland Transit Ridership Trends, which reflect all transit modes.

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[121] For more details on the technical approach, assumptions, GHG emission reduction and costs analysis for each TLU policy option, refer to Maryland Department of Transportation, Maryland CAP – Draft Implementation Status Report, Appendix B. November 4, 2009.

Table TLU-3.3- Maryland Transit Ridership Trends

Scenario	Annual Growth Rate	2020 Ridership Forecast (million unlinked trips)	MCTP 2020 Goal Differential (million unlinked trips)	Equivalent mVMT Reduction
NTD (1998-2007)	1.5%	322.8	136.2	533.3
AAR (2001-2007)	1.5%	315.9	143.1	560.5
MPO Plans	1.3%	305.6	153.5	601.0
Plans & Programs (2010 – 2020)	2.4%	353.2	105.8	414.3
CAP 2020 Goal	5.3%	459.0	--	--

Source: 2009 MDOT Climate Action Plan Draft Implementation Status Report, Table B2.
Note: Red text in Plans & Programs row highlights the numbers that were used to estimate the 2020 CAP goal, which is highlighted in red in subsequent row.

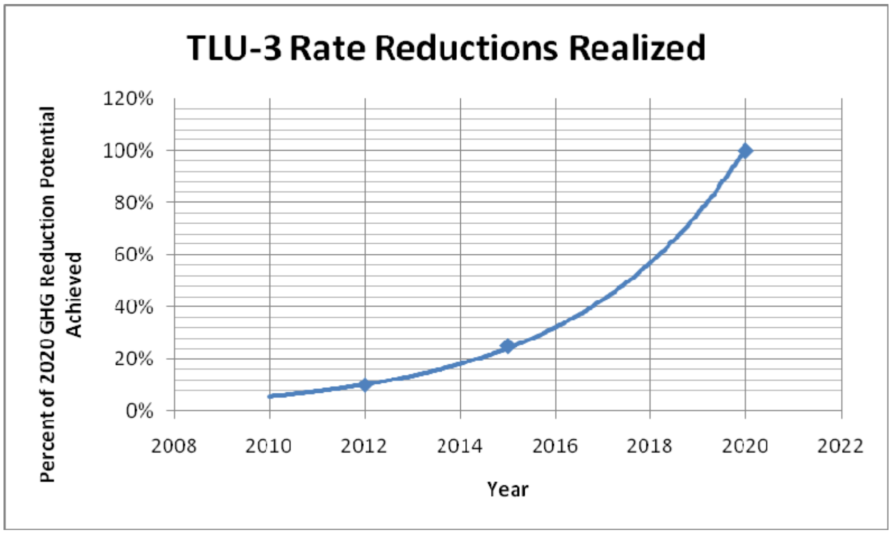
MDOT used the following data sources to relate the increase in transit trips to a reduction VMT:

- Average vehicle occupancy: 1.43 persons per vehicle from the 2001 National Household Travel Survey
    - assumes that 60 percent of new transit trips were home based work vehicle trips with an average occupancy of 1.14, and
    - 40 percent of the new transit trips were non-work vehicle trips with an average occupancy of 1.84
- Average transit trip length: 5.6 miles per trip based on the weighted average of Maryland 2007 NTD data.

1.7. GHG Emission Assumptions

The GHG reductions for intermediate years 2012 and 2015 were estimated based on an exponential trendline from zero in 2010. This pace at which we assume the reductions will be achieved is illustrated here:

Figure TLU-3.1- TLU-3 Rate Reductions Realized



For the 2020 GHG estimate, MDOT documented the assumptions it developed in a separate detailed report.[122] Among MDOTs assumptions, the most influential in the resulting GHG reduction estimate are the Maryland transit ridership rates that were selected to best represent the existing ridership trend through 2020. The existing ridership trend, which is included in the BAU baseline, assumes the implementation of all 2009-2014 Consolidated Transportation Program (CTP) transit projects and Transportation Emission Reduction Measures (TERMs), and Metropolitan Planning Organization (MPO) long range transit projects included in modeling assumptions by 2020 (e.g., Purple Line, Corridor Cities Transitway, Red Line). The benefits for CTP projects were captured in MDOTs Existing Plans and Programs Analysis.

1.8. GHG Emission Analysis and Recommendations

A recommended approach to track progress toward the defined goal of doubling ridership is to monitor annual statewide ridership levels and compare them to projected values illustrated by the trend line in Figure 1. To achieve the emission goal without drastic actions in the last five years, ridership in 2012 and 2020 should reach at least roughly 320 million and 360 million, respectively. In addition, sources of and any assumptions about ridership data should be transparent.

There are four areas that could be considered for further analysis or refinement of the MDOT methodology:

1) The methodology does not attempt to quantify the emissions effects of changes in transit operations resulting from increased ridership, such as emissions from fuel use for additional bus service, electricity for rail service, or impacts of inefficient vehicle retirements and more efficient

[122]Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report, Appendix B. November 4, 2009.

and advanced technology vehicle procurements. Future analyses should consider such impacts in addition to reduced VMT. [123]

2) A baseline-related issue for clarification is whether and how the strategy is quantified separately from BAU. For its TLU-3 analysis, MDOT assumed that the ridership trend associated with BAU funding and activities is not credited toward the TLU-3 policy. Future revisions to this and other policies could include a review of this assumption and whether it has been or should be consistently applied across policies. It is a useful approach for identifying the likely gap between the goal and what is likely to be achieved by implementing strategies already planned or underway, and in such it is one technique for measuring the challenge of meeting the policy goal. Further, MDOT acknowledged that it is a challenge to estimate the benefit of plans and programs by individual TLU policies, therefore a single BAU for the transportation sector was estimated representing all activities through 2020.

3) Although, for all TLU strategies, the Original Methodology documents that GHG estimates were quantified for CO_2, methane (CH_4), and black carbon, which differs from widely accepted guidance, MDOT quantified reductions for CO_2, CH_4 and N_2O, which have been recognized as more common metrics. The MDOT approach is recommended.

2. AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated emissions reductions from TLU-3 are shown in the following table:

Table TLU-3.4- Emissions Reductions in Maryland Associated with TLU-3

	Statewide (tons/year)		
Pollutant	**2012**	**2015**	**2020**
SO_2	0.86	2.2	8.7
NO_X	76	140	370
CO	1,000	2,300	8,500
VOC	59	123	397
PM10 - primary	3.3	5.9	15.0
PM2.5 - primary	1.8	3.9	14.0

These numbers were compared against the MANE-VU inventories for 2012 and 2018 in Table TLU-3.5. Because all the values are less than one-half of a percent, the table indicates that the criteria pollutant emissions reductions associated with this policy would be unlikely to significantly improve air quality.

[123] MDOT commented in January 2011 that for TLU-3, annual transit revenue miles are estimated to increase 43.4-46.1 million in 2020 to reach the ridership goal. Additional emissions from these miles could be calculated.

Table TLU-3.5- Percentage Reduction in State Emissions Inventory Associated with TLU-3

Reductions	Maryland (%)	
Pollutant	**2012**	**2018**
SO_2	< .5	< .5
NO_X	< .5	< .5
CO	< .5	< .5
VOC	< .5	< .5
PM10-primary	< .5	< .5
PM2.5-primary	< .5	< .5

2.2. Summary of Air Quality Co-Benefits Methodology

The method is based upon the estimated change in statewide VMT. It was assumed that the percentage reduction in Maryland's VMT would result in an equivalent percentage reduction in the state's mobile source emission inventory. The potential for improved air quality was estimated by comparing reductions in the mobile source inventory to estimates for the total statewide emission inventory.

2.3. Rationale for Air Quality Co-Benefits Methodology

Given the small role of VMT reductions due to car-based passenger-mile reductions, a simple comparison (i.e., percentage) of change in the statewide emission inventory was used as the parameter for net co-benefit. The contribution to the mobile source emission inventory of non-LDVs was not readily available and would involve significant resources for modeling that are not really justified for the minimal impact this approach estimates for the associated VMT reductions.

2.4. Air Quality Co-Benefits Calculations

Statewide VMT estimates of 55,631 and 78,989 million VMT (mVMT) were estimated for 2009 and 2030, respectively. An estimate of 59,000, 62,000 and 68,000 mVMT in 2012, 2015 and 2020, respectively were determined by linear interpolation.

As a result of Policy TLU-3, VMT will be reduced by 90, 225 and 900 mVMT in 2012, 2015 and 2020, respectively. The reductions represent 0.15, 0.36 and 1.3 percent reductions to the total statewide VMT in 2012, 2015 and 2020, respectively. When those percent reductions are applied to the total state mobile source inventory the emission reductions listed in Table TLU-3.4 are derived. The potential co-benefit of those emission reductions listed in Table TLU-3.5 is the absolute reductions in Table TLU-3.4 compared to the statewide emission inventory.

2.5. Air Quality Co-Benefits Data and Data Sources

- **Statewide VMT estimates.** A Presentation Smart Growth & Transportation, Funding/Investment, Blue Ribbon Commission on Transportation Funding, Richard E. Hall, AICP, Secretary, Maryland Department of Planning, November 15, 2010

- **Statewide emission inventory.** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

2.6. Air Quality Co-Benefits Assumptions

- It was assumed that the reduction in VMT would result in a proportional reduction in the mobile source inventory and that emissions from LDV are such a large fraction of the total mobile source emissions, that these calculations can be based on the total emissions of mobile sources.

- It was assumed that TLU 3 would impact all mobile sources equally. In actuality it would mostly impact the LDV portion of mobile sources. LDVs emit less per VMT than other portions of the source category. So the impacts are probably lower than what has been estimated by this method.

3. INTERACTIONS WITH OTHER POLICIES

The interactions of land uses and development and transportation infrastructure and policy decisions are many in number and complex in character. Local and regional governments and organizations nationwide have begun to recognize the importance of system-wide transportation and land-use modeling and analysis. Such modeling is outside the scope of this project, but key interactions can be summarized qualitatively for TLU-3. TLU-3 strategies have significant interactions with other TLU policies, primarily synergistic, however there may be conflicting and overlapping effects as well.

Some TLU policies may achieve little reductions on their own, but with the implementation of TLU-3 with others, they have large impacts. For example, as described in the TLU-2 Interaction Section and the TLU-9 Interaction Section, transit service is not feasible in low-density areas where parking is plentiful, as high density development is a prerequisite for cost-effective transit system deployment. Therefore, certain transit strategies alone would not achieve reductions without compact development in place. However, transit enhancements (TLU-3) in combination with smart growth strategies (TLU-2) and pricing incentives (TLU-9) will provide significant VMT and GHG reductions. Such interactions is the subject of an anticipated 2011 Transit Cooperative Research Program project, titled: Determining the Land Use Effect of Transit's Role in Reducing Regional Greenhouse Gas Emissions. The following is an excerpt from the project background:

Evidence also suggests that there are additional synergies for reducing GHG among transit ridership, land use, and pricing strategies for transportation, including parking. Detailed information on the character and magnitude of these synergies is not currently available. Research in this area would further help local and state governments, metropolitan planning organizations, transit agencies, and others to estimate potential GHG reduction that would result from pursuing combined strategies regarding increased transit capacity, related land use planning and development, and associated pricing policies affecting related services.

In another example of a TLU-3 interaction, improvements to sidewalk connectivity from TLU-8 may allow a commuter to walk to a transit stop and transfer to a bus to complete a daily commute. However, in the absence of the TLU-8 policy, the transit station is inconvenient or inaccessible and therefore the entire trip is completed by car. By providing or improving alternatives to low-occupancy vehicle trips TLU-3 potentially enhances and enables all other TLU policies, including not only TLU-8 but also TLU-5 (intercity travel), TLU-6 (pay-as-you-drive insurance), TLU-9 (pricing), and TLU-10 (transportation technologies). However, it is assumed that the TLU-6 measure will have negligible interactions with other policies.

The combination of measures, in some cases, may be in conflict or produce overlapping effects. An example of competition would be if TLU-9 pricing measures effectively reduce traffic congestion enough to induce transit riders with long commutes back into their vehicle to save time, which is known as the rebound effect. In other cases, reduced congestion may draw out the latent demand from suppressed vehicular trips. In general, however, it is expected that the combination of TLU-3 and TLU-9 would have a synergistic effect, because the TLU-9 strategy is designed with pricing high enough to achieve only a freeway level of service (LOS) improvement from LOS F to LOS D, which is defined as less than free-flow levels of traffic, approaching operational capacity of the highway.

This TLU policy is not expected to significantly interact with policies in other sectors.

Policy No.: TLU-5

Policy Title: Intercity Travel

SAIC was tasked with reviewing 1) the original TLU-5 policy analysis, which was conducted by a prior MDE contractor (henceforth referred to as CAP 2008), and 2) the subsequent re-analysis of the same policy, which was conducted by MDOT contractors[124] (henceforth referred to as MDOT). SAIC conducted a thorough examination of the methodologies, assumptions, source materials, and results, and documented the methodology and results, as well as provided SAIC's observations and recommendations. In addition, SAIC estimated reductions for the intermediate years that MDOT did not analyze. Finally, SAIC quantified the air quality co-benefits associated with TLU-5. SAIC's findings are described below:

1. GHG EMISSION REDUCTIONS

TLU-5 is designed to provide transportation infrastructure between cities to create connectivity of non-auto, non-truck transportation modes. The goal of TLU-5 is to reduce transportation sector GHG emissions from intercity travel by making passenger and freight rail more accessible, efficient, and available.[125]

Table TLU-5.1- Estimated Reductions of GHG Emissions and Vehicle Miles Traveled Resulting from TLU-5

Emissions Category	Estimated Reductions		
	2012	2015	2020
GHG Reductions (Million Metric Tons CO_2e)	0	0.003	0.02
Light Duty VMT Reductions (Million Miles)	0	10	64

Note: Not all digits displayed are significant figures.

1.1. Summary of GHG Emission Methodology

The MDOT methodology for analyzing the TLU-5 strategy has two components, both associated with car-based passenger-mile reductions to be achieved by 2020. The analysis of GHG reductions is based on a total VMT reduction of 64 million, based on:

1) increasing the transit mode share for trips to/from BWI Marshall from the current public access share of 11.4 percent to a goal of 20 percent, which results in a VMT reduction of 30 million; and

[124]Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report. November 4, 2009, and Appendix B of the same report.

[125] 2008 Maryland CAP

2) increasing long-distance Amtrak ridership in Maryland in the range of 5 to 10 percent, which results in a total reduction of 33 million VMT in the year 2020.[126]

1.2. Rationale for GHG Emission Methodology

The interpolation method for the intermediate years of 2012 and 2015 was chosen based on data availability, expert judgment, and to maximize transparency and flexibility to facilitate future updates or revisions.

The MDOT methodology for the 2020 GHG estimate developed by MDOT apparently was chosen based on data and resource availability and expert judgment. MDOT focused on two aspects of TLU-5 related to reducing intercity passenger car trips, for which a sound analytical method could be developed. MDOT did not attempt to quantify the other strategies identified in the 2008 CAP associated with freight transport by truck or rail, or changes in aviation.

1.3. Differences Between Original and Revised Methodologies

The CAP 2008 methodology resulted in estimated reductions of 0.2 and 0.3 $MMTCO_2e$ in 2012 and 2020, respectively, which are greater than the MDOT methodology estimates which are reported in Table.1. The MDOT methodology is unrelated to the CAP 2008, and appears to have at least partially different assumptions about the policy objectives. The MDOT methodology is based on reductions in gasoline use by passenger car-based VMTs. The CAP 2008 methodology was based on improvements only in the freight rail system that would reduce heavy-duty diesel truck VMTs.

The CAP 2008 methodology acknowledges that the "emissions reductions are for implementing only the Mid-Atlantic Rail Operations Study recommendations, and recommends broader improvement of freight and passenger infrastructure and operations in Maryland. The CAP 2008 methodology reported a low-end estimation of the possible VMT reductions that are available from improving intercity rail."[127]

The TLU-5 working group considered the freight strategies and assumed that transportation funding identified in the CTP and MPO long range plans would help improve freight movement, especially access to intermodal facilities. However, at the time of the analysis, many of the freight strategies were still unfunded and/or were unlikely to be completed before 2020. However, MDOT acknowledges that with new initiatives, there will be additional TLU-5 benefits related to freight activity that should be accounted for outside of the funded plans and programs by 2020, and will be considered in a future MDOT analysis.

1.4. GHG Reduction Calculations

For the Increased Transit Access to BWI-Marshall component of the TLU-5 strategy, the MDOT GHG estimate was developed from 2007 passenger access trip data, which was converted to passenger miles based on an average airport access trip distance. Next, the total number of passenger miles traveled to BWI Marshall in 2020 was extrapolated from the 2007 value, by applying a growth rate based on an analysis of annual enplanements[128] between 2002 and 2007. The current (11.4 percent) and target

[126] Difference between total VMT estimate and sum of estimate components due to rounding.
[127] Maryland CAP, Greenhouse Gas & Carbon Mitigation Working Group Policy Option Documents, Appendix D-4, page 34.
[128] An enplanement is defined as a revenue passenger boarding an aircraft.

(20percent) mode splits[129] for transit were applied to the 2020 passenger miles value, and the balance of miles traveled were assumed to be by passenger cars. The reduction in passenger miles by car associated with the increased transit mode share was converted to VMT reductions by dividing by the average vehicle occupancy rate. Lastly, the VMT reduction value was converted to GHG reductions by applying an aggregate emissions factor of 321 grams CO_2 per mile.

For the Increased Ridership on Amtrak component of the TLU-5 strategy, the MDOT methodology was based on multiplying the number of rail trips (221,500), which are assumed to shift to Amtrak from single occupancy vehicles, by an average trip length of 150 miles.

MDOT did not calculate emission reductions associated with TLU policies for any baseline or intermediate years. Therefore, the emission reduction estimate for 2012 and 2015 are estimated from zero in the 2006 base year using the following equation based on 0 percent and 15 percent, respectively, of the 2020 total annual GHG reduction.

$TER_i = TER_{2020} * RUF_i$

Where

TER_i = Total GHG emission reductions in year i for Policy TLU-5 (million metric tons CO_2e)

TER_{2020} = Total GHG emission reductions in year 2020 for Policy TLU-5 (million metric tons CO_2e)

RUF_i = Ramp-Up Factor for year i, which reflects how much of the annual GHG reduction in 2020 can be expected to be achieved in year i

$RUF_{2012} = 0\%$

$RUF_{2015} = 15\%$

1.5. GHG Emission Data and Data Sources

The MDOT methodology relies on the following data and sources:

- Historic data on total annual enplanements for 2002 and 2007, and mode split percentages for access trips, were used to project total passenger miles to 2020, based on data taken from Table 4 of the 2007 Washington-Baltimore Regional Air Passenger Survey by National Capital Region Transportation Planning Board, *et al*. In 2007, passenger miles totaled 377,970,000, and transit mode share was 11.4 percent.

[129] The mode split, or modal split, is defined as the percentage of trips on each of the available modes.

- An average vehicle occupancy rate of 1.4 passengers per vehicle[130] is based on the 2001 National Household Travel Survey (NHTS), which assumes that:

    - 60 percent of new transit trips were home based work vehicle trips with an average occupancy of 1.14, and
    - 40 percent of the new transit trips were non-work vehicle trips with an average occupancy of 1.84

- For the BWI Marshall analysis, the average trip distance of 21.5 passenger miles per trip was taken from data on the number of passengers arriving by ground transportation, and multiplying by 2 (based on a round trip).

- For the Amtrak analysis, MDOT considered data from the 2001 NHTS indicating the average length of a long distance rail trip is 192 miles.

- MDOT used a composite statewide average light duty GHG emission factor for the year 2020 weighted by VMT and speed of 321 grams CO_2e per mile based on Maryland data and the U.S. EPA MOBILE 6 Adjusted model. The CO_2e rate is based on the CO_2 emissions rate from the MOBILE model multiplied by 1.05 to account for the minor role of other gases in mobile source GHG emissions including CH_4, N_2O, and hydro fluorocarbons (HFCs).

1.6. GHG Emission Assumptions

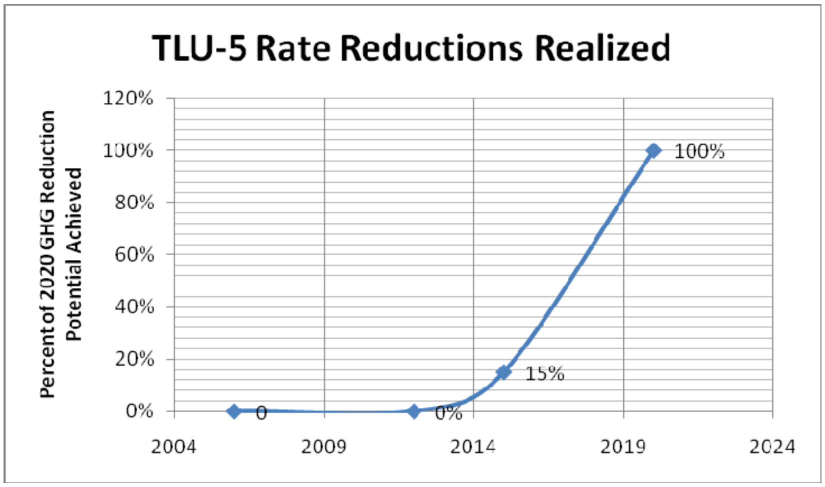
The MDOT methodology used the following assumptions in its GHG estimate for 2020.

- Growth rate in BWI Marshall Access Trips from 2007 to 2020 is assumed to be 2.09 percent, based on historic growth trends in enplanements.
- All non-transit travel is assumed to be by passenger vehicle.
- Vehicle occupancy rate is assumed to be 1.4 passengers per vehicle.
- The average trip distance for airport access trips is assumed to be equal to the average of the distance from BWI Marshall to downtown Baltimore (11 miles) and to downtown Washington DC (32 miles).
- For the Amtrak analysis, MDOT assumes that the implementation of improvements to Amtrak's connectedness, accessibility, and availability of information, would "increase ridership by 5 percent to 10 percent. This translates into an increase in 2020 of 221,500 intercity rail trips."[131]
- For the Amtrak analysis, MDOT assumed the average Maryland Amtrak trip distance to be 150 miles.

[130] MDOT does not document the source of the vehicle occupancy rate within the Draft Implementation Status Report Appendix B – Strategy Assumptions and Methodology discussion of TLU-5. However, MDOT documented its vehicle occupancy rate data source and assumptions in its explanation of TLU-3 to relate the increase in transit trips to a reduction VMT. SAIC assumes that the same NHTS data and assumptions were applied for TLU-5.
[131] Maryland Department of Transportation, Maryland CAP – Draft Implementation Status Report, Appendix B. November 4, 2009, p. B-19.

The GHG reductions for intermediate years 2012 and 2015 were estimated based on MDOT's assumption that the pace of implementation would increase over time starting from zero in 2012. This pace at which we assume the reductions will be achieved is illustrated here:

Figure TLU-5.1- TLU-5 Rate Reductions Realized



1.7. GHG Emission Analysis and Recommendations

SAIC's observations are detailed below:

- The CAP 2008 methodology included the intention of reducing air travel: "an expansion of rail is especially encouraged to shift passenger trips away from short-range air travel and to increase rail freight transportation."[132] However, the MDOT methodology does not consider changes in freight or air travel in its approach, but rather passenger VMT only. The working group, which included the Maryland Aviation Administration (MAA),did not include the reduction of air passenger travelor passenger travel growth at BWI as a recommended TLU-5 goal.[133] Therefore the focus was placed on decreasing the single occupancy vehicle (SOV) mode share of landside access to BWI.

- TLU-5 strategy results in VMT reductions, which would theoretically improve traffic flow and reduce delay, resulting in additional GHG reductions. Although reduced delay associated with VMT reductions is estimated for TLU-3 and TLU-9 and included in the overall GHG reduction estimates, reduced delay is not included in TLU-5. MDOT considered the congestion reduction impact for TLU-

[132] Comprehensive Greenhouse Gas and Carbon Footprint Reduction Strategy, August 2008, Report of the Maryland Commission on Climate Change Greenhouse Gas and Carbon Mitigation Working Group, Maryland CAP, Chapter 4, p.96.
[133] MDOT comments on SAIC draft report, January 2011.

5; however the VMT reductions are significantly lower and not necessarily tied to a peak period or time of day, and therefore assumed to have an insignificant effect on congestion.

- The MDOT methodology does not attempt to quantify the emissions effects of increases in transit or Amtrak operations resulting from increased ridership, such as emissions from fuel use for additional bus and train service, and electricity for rail service. MDOT acknowledges that future analyses should consider such net impacts in addition to reduced VMT, for both TLU-5 and TLU-3.

2. AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated emissions reductions from TLU-5 are shown in the following table:

Table TLU-5.2- Emissions Reductions in Maryland Associated with TLU-5

	Statewide (tons/year)		
Pollutant	**2012**	**2015**	**2020**
SO_2	0.0	0.1	0.6
NO_X	0.0	6.3	26
CO	0.0	100	600
VOC	0.0	5.5	28
PM10 - primary	0.0	0.26	1.0
PM2.5 - primary	0.0	0.17	1.0

These numbers were compared against the MANE-VU inventories for 2012 and 2018 in Table TLU-5.3. Because all the values are less than three-hundredths of a percent, the table indicates that the criteria pollutant emissions reductions associated with this policy would be unlikely to significantly improve air quality.

Table TLU-5.3- Percentage Reduction in State Emissions Inventory Associated with TLU-5

Reductions	Maryland (%)	
Pollutant	**2012**	**2018**
SO_2	0.0	< .03
NO_X	0.0	< .03
CO	0.0	< .03
VOC	0.0	< .03
PM10-primary	0.0	< .03
PM2.5-primary	0.0	< .03

2.2. Summary of Air Quality Co-Benefits Methodology

The method is based upon the estimated change in statewide VMT. It was assumed that the percentage reduction in Maryland's VMT would result in an equivalent percentage reduction in the state's mobile source emission inventory. The potential for improved air quality was estimated by comparing reductions in the mobile source inventory to estimates for the total statewide emission inventory.

2.3. Rationale for Air Quality Co-Benefits Methodology

Given the small role of VMT reductions due to car-based passenger-mile reductions, a simple comparison (i.e., percentage) of change in the statewide emission inventory was used as the parameter for net co-benefits. The contribution to the mobile source emission inventory of non-LDVs was not readily available and would involve significant resources for modeling that are not really justified for the minimal impact this approach estimates for those VMT reductions.

2.4. Air Quality Co-Benefits Calculations

Statewide VMT estimates of 55,631 and 78,989 million VMT (mVMT) were estimated for 2009 and 2030, respectively. An estimate of 59,000, 62,000 and 68,000 mVMT in 2012, 2015 and 2020, respectively were determined by linear interpolation.

As a result of Policy TLU-5, vehicle miles traveled will be reduced by 0.0, 10 and 64 mVMT in 2012, 2015 and 2020, respectively. The reductions represent 0.0, 0.02 and 0.09 percent reductions to the total statewide VMT in 2012, 2015 and 2020, respectively. When those percent reductions are applied to the total state mobile source inventory, the emission reductions listed in Table TLU-5.2 are derived. The potential co-benefit of those emission reductions listed in Table TLU-5.3 is the absolute reductions in Table TLU-5.2 compared to the statewide emission inventory.

2.5. Air Quality Co-Benefits Data and Data Sources

- **Statewide VMT estimates.** A Presentation Smart Growth & Transportation, Funding/Investment, Blue Ribbon Commission on Transportation Funding, Richard E. Hall, AICP, Secretary, Maryland Department of Planning, November 15, 2010

- **Statewide emission inventory.** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

2.6. Air Quality Co-Benefits Assumptions

- It was assumed that the reduction in VMT would result in a proportional reduction in the mobile source inventory.
- For the co-benefits analysis, it was assumed that Policy TLU 5 would impact all mobile sources equally. In actuality it would mostly impact the LDV portion of mobile sources. LDVs emit less per VMT than other portions of the source category, and hence the air quality impacts are probably less than what has been estimated. However, given that emissions from LDVs are such a

large fraction of total mobile source emissions, the latter emissions can be used as a reasonable proxy of the former.

3. INTERACTION WITH OTHER POLICIES

The interactions of land uses and development and transportation infrastructure and policy decisions are many in number and complex in character. Local and regional governments and organizations nationwide have begun to recognize the importance of system-wide transportation and land-use modeling and analysis. Such modeling is outside the scope of this project, but examples of key interactions can be summarized qualitatively for TLU-5.

The TLU-5 strategies will interact with both TLU-3 (Transit) and TLU-8 (Bike and Pedestrian) strategies. Specifically, the maximum GHG reduction potential of TLU-5 is dependent upon the timely implementation of TLU-3 and TLU-8. TLU-3 will provide greater transit service, enabling a reduction in intercity travel by single occupancy vehicles (SOV). TLU-8 will provide enhanced connectivity and accessibility for increased bike and pedestrian travel, which would enable a reduction in intercity SOV trips. However, TLU-5 is not wholly dependent on TLU-3 and TLU-8, and a significant share of the reduction potential of TLU-5 could be achieved even if the others are not implemented. In addition, TLU-2 may provide synergistic effects for TLU-5.

This TLU policy is not expected to significantly interact with policies in other sectors.

Policy No.: TLU-6

Policy Title: Pay-As-You-Drive Insurance

SAIC was tasked with reviewing: 1) the TLU-6 policy analysis, which was conducted by a prior MDE contractor (henceforth referred to as CAP 2008), and 2) the subsequent re-analysis of the same policy, which was conducted by MDOT contractors[134] (henceforth referred to as MDOT). After conducting a thorough examination of thesemethodologies, assumptions, source materials, and results, SAIC improved the existing methodologies to create new results (SAIC Methodology) that better reflect how the policy will likely impact Maryland. SAIC documented the current methodology and provided observations and recommendations. In addition, SAIC quantified the air quality co-benefits associated with the GHG emission reductions. SAIC's findings are described in detail below:

1. GHG EMISSION REDUCTIONS

Pay-As-You-Drive (PAYD) auto insurance ties a substantial portion of consumer insurance costs to a variable cost with respect to actual motor-vehicle travel use, so premiums are more directly related to hours or miles driven, with adjustment for other rating factors, such as driving record, age, and the vehicle driven[135]. TLU-6 is designed to make PAYD insurance coverage available to all Maryland drivers by 2010, with 10 percent of Maryland drivers adopting such policies by 2012, and 100 percent adopting by 2020. The expected result of PAYD insurance is a reduction in VMT, which can then be translated to GHG emission reductions.

Table TLU-6.1. Estimated Reductions of GHG Emissions and Vehicle Miles Traveled Resulting from TLU-6

Emissions Category	Estimated Reductions		
	2012	2015	2020
TLU-6 Emission Reductions (MMTCO_2e)	0.01	0.02	0.03
VMT Reductions (Million Miles)	19	50	107

Notes: Not all digits displayed are significant figures.

1.1. Summary of GHG Emission Methodology

TLU-6 (PAYD Insurance), also known as use-based or mileage-based insurance, directly incorporates mileage as a rate factor when calculating insurance premiums. PAYD pricing would provide a financial incentive to motorists to reduce their mileage. Although there are too few actual products currently available to consumers to predict with certainty how they will be structured in the future, it is expected that the insurance premium paid will be based on the distance driven, and possibly also time spent

134 Maryland Department of Transportation, Maryland CAP – Draft Implementation Status Report. November 4, 2009, and Appendix B of the same report.

135 Maryland CAP, Greenhouse Gas & Carbon Mitigation Working Group Policy Option Documents, Appendix D-4

driving, time-of-day, and driving style, which would characterize safe or risky driving behavior.[136] PAYD technology that analyzes factors in addition to mileage has been successfully deployed in the commercial sector. However, the SAIC estimation methodology for TLU-6 does not consider driving style, but rather assumes that the economic price signal associated with insurance premiums would affect demand. Specifically, the opportunity to pay less for insurance would encourage consumers to drive fewer miles.

1.2. Rationale for GHG Emission Methodology

The SAIC methodology maintains a consistent approach to analyzing TLU-6 as was applied in previous analyses by the 2008 CAP and MDOT, but adjusts the assumptions as documented above, specifically:

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- Relevant VMT – by excluding heavy duty VMT and uninsured motorist travel;
- Effectiveness rate – by assuming a slightly lower effectiveness than prior analyses; and
- Participation rate – by assuming only 5 percent of motorists participate by 2020.

1.3. Difference Between Original & Revised Methodologies and Results

The CAP 2008 methodology[137] considered total statewide VMT, a 100 percent statewide participation rate, and a 15 percent effectiveness rate.[138] The MDOT methodology[139] tested a range of participation from 5 to 20 percent, and analyzed a range of effectiveness rates from 5 to 10 percent.

The SAIC methodology made several changes to the data and assumptions used in the two former analyses. First, the VMT forecast to which the analysis would apply was revised. Whereas previous estimates included all statewide VMT in the analysis, the Current Methodology considered only light-duty VMT, and reduced this subtotal by 12 percent to exclude non-insured motorists. SAIC applied a 4 percent effectiveness rate and assumed a cautiously increasing participation rate that reaches only 5 percent by 2020 based on input from the Maryland Insurance Administration (MIA).

[136] Currently in Maryland, Progressive offers a PAYD product that offers savings "for driving fewer miles, in safer ways and during safer times of the day." http://www.progressiveagent.com/auto/myrate.aspx

[137] Maryland CAP, Greenhouse Gas & Carbon Mitigation Working Group Policy Option Documents, Appendix D-4.

[138] The original MDE estimate was based on the assumption that 100% of Maryland motorists would adopt a PAYD insurance product, and it would apply not only to miles driven but also driving behavior, which would improve vehicle operational efficiency. The analysis assumed an aggressive level of implementation, and the report acknowledged that with less aggressive deployment, "expected GHG reductions would tend toward one half of the reductions shown."

[139] Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report, Appendix B. November 4, 2009.

Table TLU-6.2. Comparison with Other Studies

TLU-6 Reduction Estimates Based on Different Methodologies and Data	Reduction in 2020 ($MMTCO_2E$)
SAIC	0.03
MDOT 2009	0.26
CAP 2008[140]	3.4

1.4. GHG Emission Reduction Calculations

The Current Methodology is based on the following formula:

$TER_i = VMT_i * PR_i * EF *EF$

Where

TER_i = Total GHG emission reduction from TLU-6 in year i (million metric tons CO_2e)

VMT = Relevant VMT (million)

PR_i = Participation Rate in year i

ER = Effectiveness Rate

EF = Composite CO_2e emission factor

i = given year

1.5. GHG Emission Data and Data Sources

The following data and sources were used:

- The reductions are based on light duty VMT projections from the 2006 base year to 2020, considering existing Plans and Programs.[141] MDOT [142] is the source of the following data:
  - Table 2.2 reports the 2006 baseline for statewide light duty annual VMT of 51,212 million.
  - Table 3.3 reports the 2020 statewide light duty annual VMT base forecast less Plans & Programs of 60,884 million.

[140]Comprehensive Greenhouse Gas and Carbon Footprint Reduction Strategy, Report of the Maryland Commission on Climate Change Greenhouse Gas and Carbon Mitigation Working Group, Maryland CAP Appendix D-4, August 2008.

[141] MDOT 2009 Appendix B defines Plans and Programs projections as reflective of MPO plans and HPMS data

[142] Maryland Department of Transportation, Maryland CAP – Draft Implementation Status Report. November 4, 2009.

- The difference between these values reflects an annual growth rate of 1.24 percent. Intermediate year estimates based on these data are documented in the Assumptions section.

- Maryland has an uninsured motorist rate of 12 percent according to 2007 data reported by the Insurance Research Council, "Estimated Percentage of Uninsured Motorists by State in 2007," News Release, January 21, 2009.[143]

- This analysis adopts MDOT's composite statewide average light duty GHG emission factor for the year 2020 weighted by VMT and speed of 321 grams CO_2e per mile based on Maryland data and the U.S. EPA MOBILE 6 Adjusted model. The CO_2e rate is based on the CO_2 emissions rate from the MOBILE model multiplied by 1.05 to account for the minor role of other gases in mobile source GHG emissions including CH_4, N_2O, and HFCs. This assumption is consistent with other TLU policies quantified by MDOT.

1.6. GHG Emission Assumptions

This estimate relies on several assumptions to quantify TLU-6 impacts, including the following assumptions that were used to narrow the applicable VMT from the statewide total:

- Non-insured motorists are excluded from the relevant VMT considered in the analysis. It is assumed that the rate of non-insured motorists in Maryland would remain at 12 percent for all years.

- Heavy duty vehicles are excluded because it is assumed that a PAYD product will be offered for passenger and commercial vehicles only. Transit buses, garbage trucks, and other heavy duty truck operators typically follow assigned routes with fixed distances, so the PAYD strategy doesnot apply.

- The interim year statewide light duty annual VMT values were estimated from the MDOT 2006 and 2020 data,[144] and adjusted to exclude uninsured motorists. The resulting statewide light duty annual VMT projections used in this analysis are as follows:

Table TLU-6.3- VMT Projections

Year	2006	2012	2015	2020
Light duty, excluding uninsured (million VMT)	45,067	48,535	50,368	53,578

The participation rate was based on the following considerations and assumptions:

- The assumed rate of increase is approximately 0.5 percent per year from 2011 to 2020, resulting in 1 percent by 2012, three percent by 2015, and an adoption rate of 5 percent of policies by 2020, which is the low-end rate of participation considered in the previous MDOT analysis.

[143] http://www.ircweb.org/News/IRC_UM_012109.pdf
[144] Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report. November 4, 2009, Tables 2.2 and 3.3.

- MIA has conducted research on existing programs and surveyed all in-state insurance carriers on the subject of potential PAYD products. During personal communication on February 17, 2011, MIA representatives reported that they expect a low participation rate, possibly lower than other states, which they attribute to unique circumstances in Maryland.

- Currently, only two insurer groups offer a use-based product for private passenger automobiles in Maryland[145]. Progressive Insurance Group is one group offering this product. Progressive maintains a market share of roughly six percent, based on premium volume. The other group is GMAC, which has a market share of 10%. MIA indicated that unless insurers with greater market share as measured by both premium volume and number of vehicles insured begin offering a usage-based option, the participation rate for this type of policy will remain low.[147]

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- A significant change in public opinion and acceptance of new products and approaches to insurance is possible over a decade, if products and information are available. Similarly, perception of privacy issues are likely to change, and technology for tracking mileage will evolve. Therefore, even though a low participation rate may occur initially, this estimate assumes that with the marketing that is described for this policy, participation will increase each year through 2020.

The effectiveness rate was based on the following considerations and assumptions:

SAIC assumed that PAYD will have an effectiveness rate in reducing VMT of four percent per insurance participant. For a comparison, the original CAP estimate used a rate of 15 percent, and the subsequent MDOT analysis considered a range of effectiveness rates from five to ten percent.

- For perspective, gasoline prices are relatively inelastic, that is the change in price causes a relatively small change in consumption, especially in the short term, as repeatedly demonstrated by empirical data. For the TLU-5 Pricing policy analysis, the applied elasticity of travel demand relative to trip cost was -0.45 (i.e., a 10 percent increase in cost to drive will result in a 4.5 percent decrease in VMT).[148]

- Few data sets are publicly available that demonstrate PAYD effectiveness, as a result of the newness of the product and proprietary nature of competitive insurance product offerings and participation. For example, some pilot programs and studies of survey responses suggest drivers' willingness to reduce driving if offered a reduced premium and further indicate PAYD could produce up to 15 percent fewer VMT per driver. For this analysis, we assume that 10 percent or 15 percent reduction is unrealistically high for the general public's implementation, given U.S. drivers' consistently low responsiveness to changes in personal vehicle travel cost. Further, it is assumed that insurance savings aggregated for a consumer in month-or-greater installments would be less effective than daily or

[145] Two additional companies offer a commercial product (Montgomery Mutual and Ohio Casualty); however, it is unlikely that the usage will be reduced since this is a commercial product.
[147] MIA, E-mail communication to MDE, March 11, 2011.
[148] Price elasticity of demand is a metric used in economics to describe the responsiveness of the quantity demanded of a good or service to a change in its price. This metric is almost always negative, to indicate decrease in demand of the good (e.g., use of highway lanes) in response to increase in price (e.g., highway user fees).

weekly out-of-pocket expenses, such as tolls or gasoline expenditures,[149] on reducing travel demand. Recent research prepared for the Pew Center on Global Climate Change did not even include PAYD insurance in its analysis of mitigation options, stating "Another pricing idea for reducing VMT is pay-as-you-drive (PAYD) insurance, in which insurance costs rise with miles driven. A better alternative from the perspective of GHG mitigation would be Pay-At-The-Pump insurance levied via an additional surcharge on all forms of energy purchased for vehicle use."[150]

1.7. GHG Emission Analysis and Recommendations

The following items were identified during the research and analysis of TLU-6:

- The term Pay-As-You-Drive® is reportedly trademarked in several countries. Alternative terms for this policy, such as use-base, usage-based, or pay-per-mile, could be considered to avoid using the trademarked term.

- At a 2009 National Association of Insurance Commissioners Meeting, Ceres and a group of transportation and environmental organizations proposed a performance standard[151] analogous to the *LEED* standard for buildings and the *Energy Star* standards for appliances to rate PAYD insurance programs to reduce consumer confusion and maximize the VMT-reduction benefit. The PAYD insurance product performance standard was initially developed by the Victoria Transport Policy Institute,[152] and offers Gold, Silver, and Bronze ratings that reflect how the following four factors are incorporated into the product:

  - Mileage band size (smaller is better).
  - Minimum number of miles motorists must purchase (smaller is better).
  - Percentage reduction in total premiums provided by a 50 percent reduction in annual mileage (larger is better).
  - If unit prices vary between mileage bands, maximum difference between highest and lowest prices in a policy (smaller is better).

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[149] Victoria Transport Policy Institute, Elasticities, TDM Encyclopedia, Updated 18 February 2011,http://www.vtpi.org/tdm/tdm11.htm

[150] David Greene and Steven Plotkin, "Reducing Greenhouse Gas Emissions from U.S. Transportation," Prepared for the Pew Center on Global Climate Change, January 2011. http://www.pewclimate.org/docUploads/Reducing_GHG_from_transportation.pdf

[151] CERES, Press Release, "Drive Less, Pay Less: Environmental and Transportation Groups Unveil Performance Standard for Pay-As-You-Drive Auto Insurance," December 9, 2009, http://www.ceres.org/Page.aspx?pid=1157

[152] Todd Litman, "Pay-As-You-Drive Insurance Product Rating System," Technical Report, Victoria Transport Policy Institute, December 9, 2009,

2. AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated emissions reductions from TLU-6 are shown in the following table:

Table TLU-6.4- Emissions Reductions in Maryland Associated with TLU-6

	Statewide (tons/year)		
Pollutant	**2012**	**2015**	**2020**
SO_2	0.18	0.50	1.0
NO_X	16	31	44
CO	210	520	1,000
VOC	12	27	47
PM10 - primary	0.7	1.3	1.7
PM2.5 - primary	0.37	0.9	1.6

These numbers were compared against the MANE-VU inventories for 2012 and 2018 in Table TLU-6.5. Because all the values are less than six-hundredths of a percent, the table indicates that the criteria pollutant emissions reductions associated with this policy would be unlikely to significantly improve air quality.

Table TLU-6.5- Percentage Reduction in State Emissions Inventory Associated with TLU-6

Reductions	Maryland (%)	
Pollutant	**2012**	**2018**
SO_2	< .06	< .06
NO_X	< .06	< .06
CO	< .06	< .06
VOC	< .06	< .06
PM10-primary	< .06	< .06
PM2.5-primary	< .06	< .06

2.2. Summary of Air Quality Co-Benefit Methodology

The co-benefits methodology is based upon the estimated change in statewide VMT. It was assumed that the percentage reduction in Maryland's VMT would result in an equivalent percentage reduction in the state's mobile source emission inventory. The potential for improved air quality was estimated by comparing reductions in the mobile source inventory to estimates for the total statewide emission inventory.

2.3. Rationale for Air Quality Co-Benefit Methodology

Given the small role of VMT reductions due to car-based passenger-mile reductions a simple comparison (i.e., percentage) of change in the statewide emission inventory was used as the parameter for net co-benefit. The contribution to the mobile source emission inventory of non-LDVs was not readily available and would involve significant resources for modeling that are not really justified for the minimal impact this approach estimates for those VMT reductions.

2.4. Air Quality Co-Benefit Calculations

Statewide VMT estimates of 55,631 and 78,989 million VMT (mVMT) were estimated for 2009 and 2030, respectively. An estimate of 59,000, 62,000 and 68,000 mVMT in 2012, 2015 and 2020, respectively were determined by linear interpolation.

As a result of TLU-6, vehicle miles traveled will be reduced by 19, 50 and 107 mVMT in 2012, 2015 and 2020, respectively. The reductions represent 0.03, 0.08 and 0.16 percent reductions to the total statewide VMT in 2012, 2015 and 2020, respectively. When those percent reductions are applied to the total state mobile source inventory, the emission reductions listed in Table TLU-6.4 are derived. The potential co-benefit of those emission reductions listed in Table TLUE-6.5 is the absolute reductions in Table TLU-6.4 compared to the statewide emission inventory.

2.5. Air Quality Co-Benefit Data and Data Sources

- **Statewide VMT estimates.** A Presentation Smart Growth & Transportation, Funding/Investment, Blue Ribbon Commission on Transportation Funding, Richard E. Hall, AICP, Secretary, Maryland Department of Planning, November 15, 2010

- **Statewide emission inventory.** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

2.6. Air Quality Co-Benefit Assumptions

- It was assumed that the reduction in VMT would result in a proportional reduction in the mobile source inventory and that emissions from light duty vehicles (LDV) are such a large fraction of the total mobile source emissions, that these calculations can be based on the total emissions of mobile sources.

- For the co-benefits analysis, it was assumed that Policy TLU 6 would impact all mobile sources equally. In actuality it would mostly impact the light duty vehicle (LDV) portion of mobile sources. LDVs emit less per VMT than other portions of the source category. So the impacts are probably lower than what has been estimated by this method.

3.1 INTERACTION WITH OTHER POLICIES

The discussion of policy interactions is provided in Chapter 5.

Policy No.: TLU-8

Policy Title: Bicycle and Pedestrian

SAIC was tasked with reviewing 1) the TLU-8 policy analysis, which was conducted by a prior MDE contractor (henceforth referred to as CAP 2008), and 2) the subsequent re-analysis of the same policy, which was conducted by MDOT contractors[153] (henceforth referred to as MDOT). SAIC conducted a thorough examination of the methodologies, assumptions, source materials, and results, and documented the methodology and results, as well as provided SAIC's observations and recommendations. In addition, SAIC estimated reductions for the intermediate years that MDOT did not analyze. Finally, SAIC quantified the air quality co-benefits associated with TLU-8. SAIC's findings are described below:

1.0 GHG EMISSION REDUCTIONS

TLU-8 is designed to increase the bicycle- and walking-mode share of all trips in Maryland urbanized areas to 15percent by 2020 by removing obstacles to increased biking and walking, as well as improving and adding additional biking and pedestrian infrastructure. Compact communities with robust walking and biking infrastructure usually reduce VMT in those communities, which translate to GHG emission reduction benefits.

Table TLU-8.1. Estimated GHG Emission Reductions Resulting from TLU-8

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
TLU-8	0.01	0.025	0.10 – 0.15

1.1. Summary of GHG Emission Methodology

To evaluate the GHG reductions potential of TLU-8 in 2020, the MDOT methodology used two unique quantification approaches, one for biking based on the Maryland Trails Plan, the other for walking based on changes in pedestrian infrastructure improvements as measured by the pedestrian environmental factor (PEF) at different population densities. MDOT estimated the amount of modal shift likely to occur as a result of the implementation of the Maryland Trails plan and the comprehensive pedestrian infrastructure improvements in targeted high-density areas. The reduction in VMTs associated with the resulting mode shift to biking and walking was quantified using GIS software. The difference in VMTs associated with the mode shift was converted to GHG reductions using emission factors from EPA's MOBILE 6 model.

1.2. Rationale for GHG Emission Methodology

The interpolation method for the intermediate years of 2012 and 2015 was chosen based on data availability, expert judgment, and to maximize transparency and flexibility to facilitate future updates or revisions.

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[153] Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report. November 4, 2009, and Appendix B of the same report.

To quantify 2020 GHG benefits, MDOT developed two unique approaches focused on one of the strategies for which a reasonable analytical method could be developed.

1.3. Difference Between Original & Revised Methodologies and Results

The CAP 2008 methodology did not quantify TLU-8 independently, but rather assumed that TLU-8-related reductions were included together with its TLU-3 estimate; therefore there was no original method or results to compare to the MDOT methodology.

1.4. GHG Emission Reduction Calculations

TLU-8 includes a variety of strategies such as education and marketing measures, updating land use policy guidance, and placement of bike facilities in strategic locations. MDOT's TLU-8 benefit calculations implicitly assume that the supportive programs are in place to maximize use of the bike and pedestrian facilities.[154] Mode share percentages are influenced by the presence or absence and relative "friendliness" of a transportation trail (e.g., bike trail, sidewalk), the distance between travel origins and destinations (i.e. population density and the mix of land uses), access to transit, and other factors.

To evaluate the GHG reductions potential of TLU-8 in 2020, MDOT developed two unique approaches: one for biking based on the Maryland Trails Plan, the other for walking based on changes in the PEF at different population densities. The bike approach is somewhat singularly focused on the benefit of filling in gaps in the state trails/bike network. The walking approach use of the PEF and density helps account for the benefit of multiple strategies in different urban settings.

MDOT estimated the amount of modal shift likely to occur as a result of the implementation of the Maryland Trails plan and the comprehensive pedestrian infrastructure improvements in targeted high-density areas. The reduction in VMTs associated with the resulting mode shift to biking and walking was quantified using GIS software. The difference in VMTs associated with the mode shift was converted to GHG reductions using emission factors from MDOT contractors' application of EPA's MOBILE 6 model.[155]

MDOT did not calculate emission reductions associated with TLU policies for any baseline or intermediate years. Therefore, the emission reduction estimate for 2012 and 2015 are calculated using the following equation based on 10percent and 25 percent, respectively, of the 2020 total annual GHG reduction. The lower bound of the range presented for the 2020 reductions was used where applicable for all subsequent calculations.

$TER_i = TER_{2020} * RUF_i$

Where

TER_i = Total GHG emission reductions in year i for Policy TLU-8 (million metric tons CO_2e)

[154] MDOT comments, January 2011.
[155] For more details on the technical approach, assumptions, GHG emission reduction and costs analysis for each TLU policy option, refer to Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report, Appendix B. November 4, 2009.

TER_{2020} = Total GHG emission reductions in year 2020 for Policy TLU-8 (million metric tons CO_2e)

RUF_i = Ramp-Up Factor for year i, which reflects how much of the annual GHG reduction in 2020 can be expected to be achieved in year i

RUF_{2012} = 10%

RUF_{2015} = 25%

1.5. GHG Emission Data and Data Sources.

Many sets of data from a variety of data sources were consulted to develop the method and factors for the TLU-8 analysis by MDOT, as documented in the MDOT Climate Action Plan Draft Implementation Status Report, Appendix B.[156] Key data sets and sources include:

- The 2001 Baltimore Metropolitan Commission (BMC) Household Travel Survey (HHT) was analyzed to ascertain the potential impact of trail availability on travel modes in the study area. For example, the mode shift factors, which were based on density and proximity to trails were developed in part from information from the HHT.
- A Pedestrian Environment Factor (PEF), an index reflecting qualities and deficiencies of pedestrian infrastructure, was obtained to reflect pedestrian conditions and applied to elasticities of VMT. The data source is Ewing, R. and R. Cervero (2001) Travel and the Built Environment. *Transportation Research Record 1780*, 87-114.
- Data on K-12 schools in Maryland were obtained from the National Center for Educational Statistics, 2005-06.
- Data on population and business districts were obtained from the 2000 Census.
- Factors to estimate potential increase in miles traveled by bicycle as a result of buildout of the trail plan were developed from data in Dill, J., and T. Carr (2003). "Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Them, Commuters Will Use Them – Another Look." *Transportation Research Record* No. 1828, National Academy of Sciences, Washington, D.C.

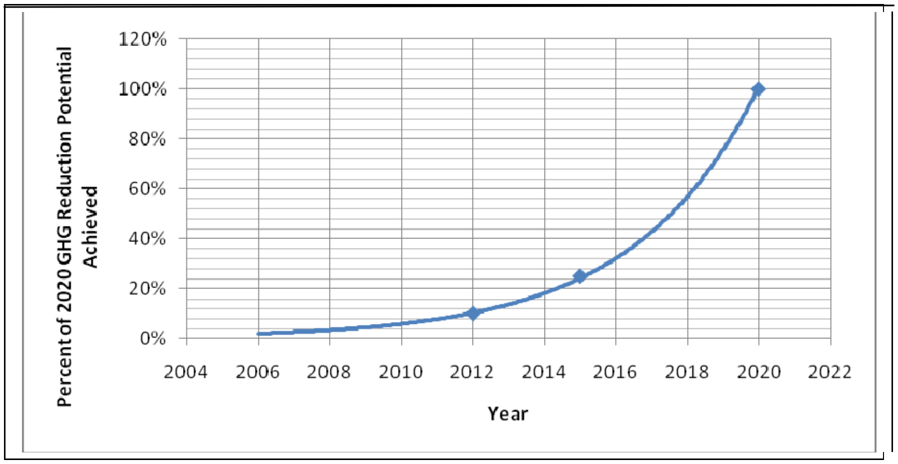
1.6. GHG Emission Assumptions

The emission reduction calculation method for 2012 and 2015 reflect the assumption that the implementation of activities on which the reductions are dependent, i.e., the completion of the Maryland Trails plan and the pedestrian infrastructure improvements, will not be completed on a linear timescale. Rather, we assume that the multiple bike and pedestrian infrastructure projects may be in various phases of planning and construction between 2010 and 2020, and the majority will not be completed very long

[156] For more details on the technical approach, assumptions, GHG emission reduction and costs analysis for each TLU policy option, refer to Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report, Appendix B. November 4, 2009.

before 2020. VMT reductions from mode switching to biking or walking on those trails will not begin until the completion of the trails. Further, we assume that there will be a ramp-up in use of the completed trails. As a result, the GHG reductions that are dependent upon the VMT reductions will be slow to be realized within the 2010 to 2020 timeframe. This pace at which the reductions are projected to be achieved is illustrated in Figure TLU-8.1.

Figure TLU-8.1- TLU-8 Rate Reductions Realized



MDOT documented the assumptions it developed for the 2020 GHG estimate in a separate detailed report.[157]

1.7. GHG Emission Analysis and Recommendations

Two items were identified during the analysis as potential next steps for monitoring progress or future enhancements to improve accuracy.

An additional way to monitor progress toward the TLU-8 goal is to revisit the GIS analysis of population in close proximity to the 160 trail segments of Maryland's transportation trails that are considered priority missing links, and update the analysis to reflect conditions in 2012 and 2015 based on those segments that have been connected or improved. Similarly, for the Comprehensive Pedestrian Strategy component of the methodology, progress could be monitored by updating the Pedestrian Environment Factor scores developed by MDOT. The review would be based on a review of conditions, such as changes in sidewalk availability, ease of street crossing, relative to the baseline for each interim year, 2012 and 2020.[158]

Future refinement of the TLU-8 analysis should utilize the updated Household Travel Survey Data for the Metropolitan Washington Council of Governments (MWCOG) region, which was not available at the

[157] For more details on the technical approach, assumptions, GHG emission reduction and costs analysis for each TLU policy option, refer to Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report, Appendix B. November 4, 2009.
[158] Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report, Appendix B, Table B-12, November 4, 2009.

time of the original MDOT analysis in 2009, in addition to the Baltimore Metropolitan Commission data that was used.

2.0 AIR QUALITY CO-BENEFITS

2.1 Criteria Pollutant Emission Reductions

The estimated emissions reductions from TLU-8 are shown in the following table:

Table TLU-8.2: Emissions Reductions in Maryland Associated with TLU-8

	Statewide (tons/year)		
Pollutant	**2012**	**2015**	**2020**
SO_2	0.45	1.2	4.6
NO_X	40	75	200
CO	530	1200	4500
VOC	31	65	210
PM10 - primary	1.8	3.1	7.8
PM2.5 - primary	0.92	2.1	7.3

These numbers were compared against the MANE-VU inventories for 2012 and 2018 in Table TLU-8.3. Because all the values are less than three-tenths of a percent, the table indicates that the criteria pollutant emissions reductions associated with this policy would be unlikely to significantly improve air quality.

Table TLU-8.3- Percentage Reduction in State Emissions Inventory Associated with TLU-8

Reductions	Maryland (%)	
Pollutant	**2012**	**2018**
SO_2	< .3	< .3
NO_X	< .3	< .3
CO	< .3	< .3
VOC	< .3	< .3
PM10-primary	< .3	< .3
PM2.5-primary	< .3	< .3

2.2. Summary of the Air Quality Co-Benefits Methodology

The method is based upon the estimated change in statewide VMT. It was assumed that the percentage reduction in Maryland's VMT would result in an equivalent percentage reduction in the state's mobile source emission inventory. The potential for improved air quality was estimated by comparing reductions in the mobile source inventory to estimates for the total statewide emission inventory.

2.3. Rationale for Air Quality Co-Benefits Methodology

Given the small role of VMT reductions due to car-based passenger-mile reductions a simple comparison (i.e., percentage) of change in the statewide emission inventory was used as the parameter for net co-benefit. The uncertainty and assumptions associated with a more detailed modeling approach would not produce a better result.

2.4. Air Quality Co-Benefit Emission Calculations

Statewide VMT estimates of 55,631 and 78,989 million VMT (mVMT) were estimated for 2009 and 2030, respectively. An estimate of 59,000, 62,000 and 68,000 mVMT in 2012, 2015 and 2020, respectively were determined by linear interpolation.

As a result of Policy TLU-8, vehicle miles traveled will be reduced by 47.6, 119.1 and 476.3 mVMT in 2012, 2015 and 2020, respectively. The reductions represent 0.08, 0.19 and 0.70 percent reductions to the total statewide VMT in 2012, 2015 and 2020, respectively. When those percent reductions are applied to the total state mobile source inventory, the emission reductions listed in Table TLU-8.2 are derived. The potential co-benefit of those emission reductions listed in Table TLU-8.3 is the absolute reductions in Table TLU-8.2 compared to the statewide emission inventory.

2.5. Air Quality Co-Benefit Data and Data Sources

- **Statewide VMT estimates.** A Presentation Smart Growth & Transportation, Funding/Investment, Blue Ribbon Commission on Transportation Funding, Richard E. Hall, AICP, Secretary, Maryland Department of Planning, November 15, 2010

- **Statewide emission inventory.** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

2.6. Air Quality Co-Benefit Assumptions

- It was assumed that the reduction in VMT would result in a proportional reduction in the mobile source inventory.

- It was assumed that Policy TLU-8 would impact all mobile sources equally. In actuality it would mostly impact the light duty vehicle (LDV) portion of mobile sources. LDVs emit less per VMT than other portions of the source category. So the impacts are probably lower than what has been estimated by this method. Since the conclusion was “no significant impact” a refined method would not change the results.

- Percentage changes in VMT in metro areas where transit ridership reductions are most likely to occur will be a higher percentage changes than the statewide values but they will still be insignificant.

3.0 INTERACTION WITH OTHER POLICIES

The interactions of land uses and development and transportation infrastructure and policy decisions are many in number and complex in character. Local and regional governments and organizations nationwide have begun to recognize the importance of system-wide transportation and land-use modeling and analysis. Such modeling is outside the scope of this project, but examples of key interactions can be summarized qualitatively for TLU-8.

TLU-8 interacts slightly with all other policies, in that it improves and increases alternatives to driving, so it enhances the effectiveness of other strategies, such as TLU-2, TLU-3, and TLU-5. Additionally, the success of most other strategies will increase the effects of TLU-8. For example, the employer-based travel demand management (TDM) strategies included in TLU-9 are considered highly supportive of bike and pedestrian trips, even though the VMT reduction estimates from that strategy are assigned to TLU-9.

Using an example provided under the TLU-3 Interactions section, improvements to sidewalk connectivity from TLU-8 may allow a commuter to walk to a transit stop and transfer to a bus to complete a daily commute. However, in the absence of the TLU-8 policy, the transit station is inconvenient or inaccessible and therefore the entire trip is completed by car. By providing or improving alternatives to low-occupancy vehicle trips TLU-8 potentially enhances and enables all other TLU policies, including not only TLU-8 but also TLU-5 (intercity travel), TLU-6 (pay-as-you-drive insurance), TLU-9 (pricing), and TLU-10 (transportation technologies). However, it is assumed that the TLU-6 measure will have negligible interactions with other policies.

This TLU policy is not expected to significantly interact with policies in other sectors.

Policy No.: TLU-9

Policy Title: Pricing and Travel Demand Management

SAIC was tasked with reviewing 1) the TLU-9 policy analysis, which was conducted by a prior MDE contractor (henceforth referred to as CAP 2008), and 2) the subsequent re-analysis of the same policy, which was conducted by MDOT contractors[159] (henceforth referred to as MDOT). SAIC conducted a thorough examination of the methodologies, assumptions, source materials, and results, and documented the methodology and results, as well as provided SAIC's observations and recommendations. In addition, SAIC estimated reductions for the intermediate years that MDOT did not analyze. Finally, SAIC quantified the air quality co-benefits associated with TLU-9. SAIC's findings are described below:

1. GHG EMISSION REDUCTIONS

TLU-9 involves implementing a variety of transportation pricing and education strategies, such as VMT fees, congestion pricing and managed lanes, parking impact fees, and employer commute incentives, which will result in reduced VMT and therefore reduced GHG emissions.

Table TLU-9.1. Estimated Reductions of GHG Emissions and Vehicle Miles Traveled Resulting from TLU-9

Emissions Category	Estimated Reductions		
	2012	2015	2020
GHG Reductions (Million Metric Tons CO_2e)			
TLU-9 Total	0.02	0.04	0.41 - 1.84
*VMT Fees**	0	0	0.18 - 0.91
*Congestion Pricing and Managed Lanes**	0	0	0.13 - 0.68
Employer Commute Incentives	0.02	0.04	0.10 - 0.25
Light Duty VMT Reductions (Million Miles)			
TLU-9 Total	50	124	997 – 4,407
*VMT Fees**	0	0	439 - 2196
*Congestion Pricing and Managed Lanes**	0	0	279 - 1499
Employer Commute Incentives	50	124	279 - 712

Notes: Not all digits displayed are significant figures.

2012 and 2015 reflects a ramp-up rate applied to the average of the 2020 range.

[159] Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report. November 4, 2009, and Appendix B of the same report.

*GHG reductions estimated for VMT Fees and Congestion Pricing and Managed Lanes strategies reflect not only the VMT reductions, but also GHG reductions associated with a reduction in delay as a result of reduced congestion. Reduced delay represents roughly 25 percent of the total GHG reductions for these two components of TLU-9. Overall, VMT represents approximately 77 percent and delay the remaining 23 percent of the GHG reductions attributable to TLU-9.

1.1. Summary of GHG Emission Methodology

TLU-9 focuses on the following four strategy components, in addition to an education component for state and local officials:

1. VMT fees,
2. Congestion pricing and managed lanes,
3. Parking impact fees, and
4. Employer commute incentives.

A unique method was developed to analyze strategies (1) and (2). The EPA's COMMUTER model was applied to analyze (4). MDOT did not quantify the GHG impact of component (3) or the educational component.

To analyze GHG reductions for components (1) and (2), MDOT first quantified the vehicle miles traveled (VMT) associated with all relevant private vehicle activity in Maryland in 2020 for each strategy component. Next, MDOT applied a travel demand elasticity factor to the quantified VMTs. For both components (1) and (2), the applied elasticity of travel demand relative to trip cost was -0.45 (i.e., a 10 percent increase in cost to drive will result in a 4.5 percent decrease in VMT).

For component (1), the analysis used a range of VMT fee rates from $0.01 to $0.05 per mile.

For TLU-9 component (2), a range of deployment levels were considered (e.g., from one lane in each direction to all lanes in both directions). The analysis assumes a congestion pricing fee ranging from $0.25 to $0.30, based on the Level of Service (LOS) D target[160].

For both (1) and (2), GHG reductions reflect not only the VMT reductions, but also the emissions benefits associated with the fuel reduction achieved by reducing congestion to LOS D conditions. MDOT estimated the change in hours of delay per 1,000 VMT. Reduced delay represents roughly 25 percent of the total GHG reductions for these two components of TLU-9. Overall, VMT represents approximately 77 percent, and delay accounts for the remaining 23 percent, of the GHG reductions attributable to TLU-9.

Lastly, the VMT reduction values estimated for (a) and (b) were converted to GHG reductions by applying an aggregate emissions factor of 321 grams CO_2 per mile.

1.2. Rationale for GHG Emission Methodology

[160] LOS ratings, typically A (best) through F (worst) are widely used in transportation planning as indicators of speed, convenience, comfort and security of transportation facilities and services as experienced by users.

The methodology for the 2020 GHG estimate developed by MDOT apparently was chosen based on expert judgment, data and resource availability, and to improve upon certain unrealistic assumptions applied in the 2008 CAP. MDOT did not attempt to quantify the parking impact fees strategy. Rather, the TLU-9 working group recommended that the state should encourage the local governments to test this potential policy, as its implementation would largely fall under the domain of local government.

The interpolation method for the intermediate years of 2012 and 2015 was chosen based on the status of current policy, expert judgment, and to maximize transparency and flexibility to facilitate future updates or revisions. While the method for estimating reductions in intermediate years for Employer Commute Incentives was relatively straight forward, for the VMT Fees and Congestion Pricing and Managed Lanes components of the TLU-9 strategies, the implementation dates are highly uncertain. The following issues informed the choice of methodology for estimating interim year reductions:

- Federal restrictions on tolling/pricing existing lanes on Federal facilities or facilities that were constructed with Federal funds – Federal restrictions must be eased or eliminated prior to broad implementation of congestion pricing/tolling. While it is assumed that this will occur prior to 2020, it is unlikely prior to the 2012 or 2015 intermediate years.

- Timeframe of building the required infrastructure for each potential facility is uncertain, not near-term –MTA is building, extending, planning, or considering projects on several facilities that could be included in the Congestion Pricing and Managed Lanes strategy, assuming Federal restrictions are reduced. Aside from the easing of Federal restrictions, the timeframe of completion of each facility will vary, and is uncertain, given necessary lead time for planning, environmental approvals, and establishing funding sources.

- Although a few states have begun considering a VMT tax, thus far, the addition of VMT fees, or the replacement of state motor fuel taxes collected on a per gallon basis, is an issue that has been discussed mostly at the Federal level. Prior to 2020 there will be increasing pressure on Federal and state governments to develop an alternative to the current per gallon fuel tax to counter the current decline in revenues from fuel tax receipts and decreasing balances in the highway trust fund and MD transportation trust fund. Even more so in the longer term, higher fuel economy standards and greater adoption of plug-in electric vehicles will accelerate the decline in revenue for transportation funds. Nonetheless, significant policy debate will occur prior to any change in this policy. Therefore, we assume that it will not occur prior to the 2012 or 2015 interim years, and consequently no GHG reductions will occur in 2012 or 2015.

1.3. Difference Between Original & Revised Methodologies and Results

The CAP 2008 methodology documents are inconsistent in their reporting of TLU-9 GHG reduction potential. The results from the CAP 2008 and the MDOT methodology are presented below, in $MMTCO_2e$, for 2012 and 2020, respectively:

- 2.7 and 4.7 (2008 CAP[161])
- 2.6 and 3.7 (CAP Appendix D-4[162])
- 0.02 (SAIC[163]) and a range of 0.41 - 1.84 (MDOT [164])

The CAP 2008 methodology estimates of GHG reductions are significantly greater than the MDOT methodology's results. For example, for 2020, the CAP estimate of 4.7 $MMTCO_2e$ is an order of magnitude greater than MDOT's lower bound of 0.41 $MMTCO_2e$. The CAP 2008 methodology is not fully understood, other than the assumption that a carbon fuel tax would be applied starting in 2011 at $0.15 per gallon, and would increase smoothly to the equivalent of $1.00 per gallon (real dollars) in 2020.[165]

1.4. GHG Emission Reduction Calculations

Section 1.1 describes how the 2020 GHG reduction estimates were calculated or modeled.

MDOT did not calculate emission reductions associated with TLU policies for any baseline or intermediate years. Therefore, the emission reductions for 2012 and 2015 are estimated individually for each component of TLU-9 that was quantified (i.e., a, b, and d), using the following equation:

$TER_{ij} = TER_{2020} * RUF_{ij}$

Where

TER_{ij} = Total GHG emission reductions in year i for component j of Policy TLU-9 (million metric tons CO_2e)

TER_{2020} = Total GHG emission reductions in year 2020 for each component of Policy TLU-9, which is assumed to be the average of the estimated range (million metric tons CO_2e)

RUF_{ij} = Ramp-Up Factor for year i, which reflects how much of the annual GHG reduction in 2020 can be expected to be achieved by component j in year i

$RUF_{2012,\ VMT\ fees} = 0\%$

$RUF_{2015,\ VMT\ fees} = 0\%$

$RUF_{2012,\ congestion\ pricing} = 0\%$

[161] Comprehensive Greenhouse Gas and Carbon Footprint Reduction Strategy, Report of the Maryland Commission on Climate Change Greenhouse Gas and Carbon Mitigation Working Group, August 2008, downloaded from: http://www.mdclimatechange.us/.
[162] Maryland CAP Appendix D-4.
[163] SAIC developed the 2012 estimate; MDOT did not quantify reductions for interim years
[164] Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report, Appendix B. November 4, 2009.
[165] Maryland CAP Appendix D-4.

$RUF_{2015,\ congestion\ pricing} = 0\%$

$RUF_{2012,\ employer\ commute\ incentives} = 10\%$

$RUF_{2015,\ employer\ commute\ incentives} = 25\%$

To estimate VMT reductions in intermediate years, the same percentages are applied for each given year and strategy component.

1.5. GHG Emission Data and Data Sources

VMT Fees

- To develop the VMT fee assumption, MDOT reviewed current State and Federal motor fuel taxes.
- MDOT referenced the travel demand elasticity values documented in the Federal Highway Administration (FHWA) 2006 Conditions and Performance Report to Congress. The FHWA Report documented that a short-run travel demand elasticity value of 0.4 and a long-run elasticity value of 0.8 was applied in analyses.[166] The analyses for the FHWA Conditions and Performance Reports are conducted using the Highway Economic Requirements System (HERS) model, which estimates the future investments to maintain and improve U.S. highways. The 2006 source was the basis for the travel demand elasticity value that MDOT applied in both the VMT and Congestion Pricing and Managed Lanes analysis. We reviewed the 2008 Conditions and Performance Report and confirmed that FHWA continued to apply the same short- and long-run elasticity values in HERS.[167]
- To estimate delay, MDOT used Highway Performance Monitoring System (HPMS) data from the FHWA's HERS model to develop baseline statistics for Maryland interstates.
- For the VMT Fee strategy, as well as Congestion Pricing, MDOT used a composite statewide average light duty GHG emission factor for the year 2020 weighted by VMT and speed of 321 grams CO_2e per mile based on Maryland data and the U.S. EPA MOBILE 6 Adjusted model. The CO_2e rate is based on the CO_2 emissions rate from the MOBILE model multiplied by 1.05 to account for the minor role of other gases in mobile source GHG emissions including CH_4, N_2O, and HFCs.

Congestion Pricing and Managed Lanes

- There are a total of 3,140 interstate and expressway (i.e., freeway) lane miles in Maryland.
- To quantify the total potential relevant VMT to which this strategy applies, MDOT reviewed the 2008 Annual Attainment Report, which reported the share of those freeway lane miles in Marylandthat are congested daily in 2006 to be 30.4 percent.

[166] Although it is common practice for analysts to ignore the negative sign, as FHWA in this case, elasticities are almost always negative.
[167] FHWA, 2008 Conditions and Performance: Chapter 10 Sensitivity Analysis, http://www.fhwa.dot.gov/policy/2008cpr/chap10.htm

- To estimate the miles of freeway that will be congested in 2020, MDOT used BMC and MWCOG travel demand model forecasts of 40 percent of freeway miles.

- Delay was estimated using the same data and approach as applied in the VMT fees analysis.

Employer Commute Incentives

- Data from national studies were reviewed to develop estimates for future participation in all employer based commute strategies.

- We approximate the composite emission factor used by the EPA COMMUTER model for this TLU-9 component to be roughly 355 grams CO_2e per mile, by dividing the model results for GHG reductions by model results for VMT reductions.

1.6. GHG Emission Assumptions

MDOT documented the following assumptions in the Climate Action Plan Draft Implementation Status Report, Appendix B:

VMT Fees

- MDOT assumed Maryland would apply alternative VMT fees ranging from $0.01 per mile to a high of $0.05 per mile for the year 2020, which equates to equivalent gas tax increase of $0.27 to $1.37 per gallon.

- MDOT assumed an average on-road fuel economy in 2020 of 27 mpg.

- For both the VMT Fee and Congestion Pricing analysis, the applied travel demand elasticity value was a combined short- and long-run elasticity estimate of -0.45.

Congestion Pricing and Managed Lanes

- The analysis considers two scenarios: a moderate and a high projection of growth in congested lane miles by 2020.

- This table presents the assumed range of deployment of congestion pricing in 2020.

Table TLU-9.2: Assumed Range of Deployment of Congestion Pricing in 2020

Lane Miles to Apply Congestion Pricing, Assumed Target in 2020	Share of Total Freeway Miles In Maryland
1. Half of congested areas, 1 lane each direction	7.5%
2. All congested areas, 1 lane each direction	15.0%
3. Half of congested areas, all lanes in both directions	20.0%
4. All congested areas, all lanes in both directions	40.0%

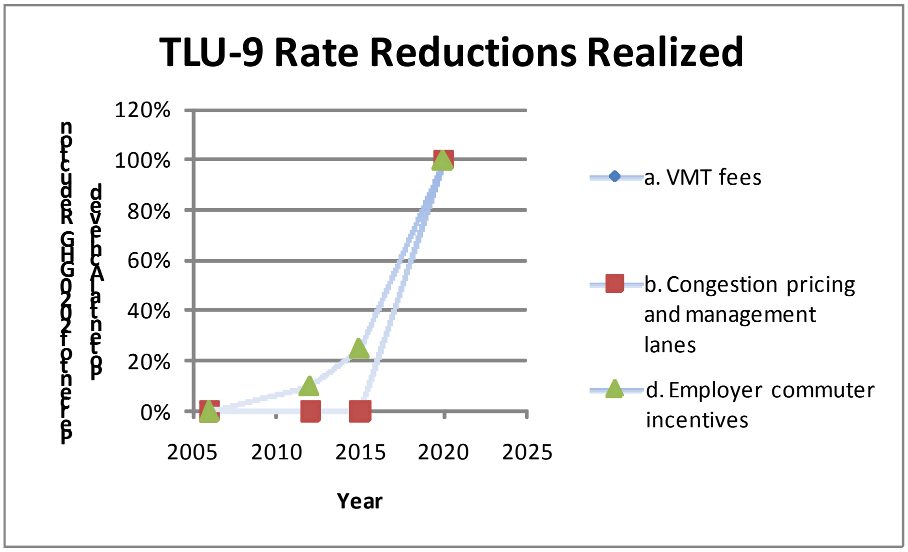
Employee Commute Incentives

- Based on national data, the analysis assumes that approximately 25 percent of Maryland's workforce would take advantage of some type of a commute program, if offered.
- The assumed medium and high participation rates in 2020 represent a program participation increase of 50 and 100 percent respectively.
- Specific inputs to the EPA COMMUTER model regarding the assumed baseline, medium, and high participation rates for 2020 are documented in the MDOT Climate Action Plan Draft Implementation Status Report Appendix B.
- The EPA COMMUTER model estimated reductions are in addition to benefits associated with the TERM strategy analysis in 2020.

Intermediate Year Reduction Estimates

The GHG reductions for intermediate years 2012 and 2015 were estimated individually for each of the three components that MDOT quantified for the TLU-9 policy. For the VMT Fees and Congestion Pricing and Managed Lane components, we assume that the strategies are not implemented prior to 2015, and therefore we assume no GHG benefits are realized in 2012 or 2015. For the Employer Commute Incentives component, we assume that the subcomponents of the strategy are implemented over time, as will the accrual of GHG benefits. For example, all state agencies may offer transit benefits and cash-in-lieu parking benefits to their employees sooner than lessors are encouraged to restructure lease contracts to unbundle residential parking costs, which may occur sooner than on-street parking spots are reduced and sidewalks expanded. Therefore, we applied an exponential growth rate from the base year until 2020. This pace at which we assume the reductions will be achieved is illustrated here:

Figure TLU-9.1- TLU-9 Rate Reductions Realized



1.7. GHG Emission Analysis and Recommendations

SAIC's observations include:

- Reductions associated with reduced delay – We recommend that MDOT describe the estimation method in more detail for readers not familiar with the LOS metrics and the peak traffic volumes and capacity data that may have been applied.

- VMT fees – the original CAP estimate was based in part on the assumption that a new fuel tax could be applied beginning in 2011. We anticipate that the implementation of any new VMT fee is unlikely to occur sooner than 2016, which is reflected in the Rate Reductions Realized chart.

- The combined short- and long-run elasticity estimate of -0.45 applied in both the VMT fee and Congestion Pricing analyses is conservative. The referenced FHWA 2006 Report that MDOT used to develop its combined elasticity estimate discusses its choice of lower elasticities than comparable parameter values used in the preceding 2004 Conditions and Performance Report. We agree that the conservative weighting toward the less elastic short-term elasticity is appropriate given the short timeframe of implementation assumed in the analyses. As noted, we assume the two relevant TLU-9 components will begin to demonstrate emissions reductions in 2016. Travel demand has been shown to be more inelastic in the short-term. Many drivers have no reasonably available alternatives to the status quo in the short term, and it often takes time to identify new travel options, and develop new patterns that reduce VMT. In the longer-term, drivers may make more drastic lifestyle choices, such as relocating to new homes and work locations, to reduce VMT and avoid costs.

2.0 AIR QUALITY CO-BENEFITS

2.1. Criteria Pollutant Emission Reductions

The estimated emissions reductions from TLU-9 are shown in the following table:

Table TLU-9.3: Emissions Reductions in Maryland Associated with TLU-9

	Statewide (tons/year)		
Pollutant	**2012**	**2015**	**2020**
SO_2	0.48	1.2	9.6 – 37
NO_X	42	78	410 – 3,300
CO	560	1300	9,400 -43,000
VOC	33	68	440 – 2,500
PM10 – primary	1.9	3.3	16 – 140
PM2.5 - primary	0.97	2.2	15 – 74

These numbers were compared against the MANE-VU inventories for 2012 and 2018 in Table TLU-9.4. Because the values for NO_X, CO, and VOC are 3.3, 2.9 and 1.4 percent, respectively, the criteria pollutant emissions reductions associated with this policy may result in a measurable improvement in air quality.

Table TLU-9.4: Percentage Reduction in State Emissions Inventory Associated with TLU-9

Reductions	**Maryland (%)**	
Pollutant	**2012**	**2018**
SO_2	< .001	< .2
NO_X	< .001	3.3
CO	< .001	2.9
VOC	< .001	1.4
PM10-primary	< .001	< .2
PM2.5-primary	< .001	< .2

2.2. Summary of Air Quality Co-Benefits Methodology

The method is based upon the estimated change in statewide VMT. It was assumed that the percentage reduction in Maryland's VMT would result in an equivalent percentage reduction in the state's mobile source emission inventory. The potential for improved air quality was estimated by comparing reductions in the mobile source inventory to estimates for the total statewide emission inventory.

2.3. Rationale for Air Quality Co-Benefits Methodology

This policy may result in significant reductions in the range of 1 to 3 percent for NO_X, CO, and VOC compounds. This method assumes that the emissions per VMT are the same for all categories of mobile sources. This policy is most likely going to reduce VMTs for the LDV mobile sources, which have lower emissions per VMT than most of the other mobile source categories. Therefore the actual co-benefit is likely lower than the 1 to 3 percent that is estimated. The data needed to refine this estimate was not readily available. Creating it would involve modeling well beyond the resources available for this portion of the analysis. This method produces a reasonable result with the information that was readily available.

2.4. Air Quality Co-Benefits Calculations

Statewide VMT estimates of 55,631 and 78,989 million VMT (mVMT) were estimated for 2009 and 2030, respectively. An estimate of 59,000, 62,000 and 68,000 mVMT in 2012, 2015 and 2020, respectively were determined by linear interpolation.

As a result of Policy TLU-9, vehicle miles traveled will be reduced by 50,124 and a range 997 – 4,407 mVMT in 2012, 2015 and 2020, respectively. The reductions represent 0.08, 0.2 and a range of 1.47 – 6.49 percent reductions to the total statewide VMT in 2012, 2015 and 2020, respectively. When those percent reductions are applied to the total state mobile source inventory the emission reductions listed in Table TLU-9.3 are derived. The potential co-benefit of those emission reductions listed in Table TLU-9.4 is the absolute reductions in Table TLU-9.3 compared to the statewide emission inventory.

2.5. Air Quality Co-Benefits Data and Data Sources

- **Statewide VMT estimates.** A Presentation Smart Growth & Transportation, Funding/Investment, Blue Ribbon Commission on Transportation Funding, Richard E. Hall, AICP, Secretary, Maryland Department of Planning, November 15, 2010

- **Statewide emission inventory.** MARAMA, MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

2.6. Air Quality Co-Benefits Assumptions

The following assumptions were made:

- The reduction in VMT would result in a proportional reduction in the mobile source inventory.
- TLU-9 would impact all mobile sources equally. In actuality it would mostly impact the light duty vehicle (LDV) portion of mobile sources. LDVs emit less per VMT than other portions of the source category. So the impacts are probably lower than what has been estimated by this method. Since the conclusion was "no significant impact" a refined method would not change the results.

3.0 INTERACTION WITH OTHER POLICIES

The interactions of land uses and development and transportation infrastructure and policy decisions are many in number and complex in character. Local and regional governments and organizations nationwide have begun to recognize the importance of system-wide transportation and land-use modeling and analysis. Such modeling is outside the scope of this project, but examples of key interactions can be summarized qualitatively for TLU-5.

Some TLU policies may achieve little reductions on their own, but with the implementation of TLU-9 with others, they have large impacts. For example, which is also provided in the TLU-2 Interaction Section and the TLU-3 Interaction Section, transit service is not feasible in low-density areas where parking is plentiful, as high density development is a prerequisite for cost-effective transit system deployment. Therefore, certain transit strategies alone would not achieve reductions without compact development in place. However, transit enhancements (TLU-3) in combination with smart growth strategies (TLU-2) and pricing incentives (TLU-9) will provide significant VMT and GHG reductions. Such interactions is the subject of an anticipated 2011 Transit Cooperative Research Program project, titled: Determining the Land Use Effect of Transit's Role in Reducing Regional Greenhouse Gas Emissions. The following is an excerpt from the project background:

Evidence also suggests that there are additional synergies for reducing GHG among transit ridership, land use, and pricing strategies for transportation, including parking. Detailed information on the character and magnitude of these synergies is not currently available. Research in this area would further help local and state governments, metropolitan planning organizations, transit agencies, and others to estimate potential GHG reduction that would result from pursuing combined strategies regarding increased transit capacity, related land use planning and development, and associated pricing policies affecting related services.

Outside the TLU sector, this TLU policy could enhance the effectiveness of AFW-4, by reducing demand for sprawling development patterns, similar to TLU-2 smart growth strategies, although a detailed analysis of such interactions is beyond the scope of this project. This TLU policy is not expected to significantly interact with any other policies in other sectors.

Policy No.: TLU-10

Policy Title: Transportation Technologies

SAIC was tasked with reviewing 1) the TLU-10 policy analysis, which was conducted by a prior MDE contractor (henceforth referred to as CAP 2008), and 2) the subsequent re-analysis of the same policy, which was conducted by MDOT contractors[168] (henceforth referred to as MDOT). SAIC conducted a thorough examination of the methodologies, assumptions, source materials, and results, and documented the methodology and results, as well as provided SAIC's observations and recommendations. In addition, SAIC estimated reductions for the intermediate years that MDOT did not analyze. Finally, SAIC quantified the air quality co-benefits associated with TLU-10. SAIC's findings are described below:

3.0 GHG EMISSION REDUCTIONS

TLU-10 is designed to promote transportation technologies to reduce GHG emissions from on-road engines/vehicles by an additional 7.5 percent by 2020 from current adopted baseline policies (the Maryland Clean CarsProgram) through more efficient technologies and operations. In addition, TLU-10 seeks to reduce emissions from off-road transportation sources through use of more efficient technologies and operations by 15 percent by 2020.[169] TLU-10 contains a number of specific types of transportation technologies, as described in Table TLU-10.1 below:

[168] Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report. November 4, 2009, and Appendix B of the same report.
[169] 2008 Maryland CAP Appendix D-4.

Table TLU-10.1- Estimated Reductions of GHG Emissions and Fuel Use from TLU-10

Emissions Category	Units of Reductions	2012	2015	2020
TLU-10 Total	$MMTCO_2e$	**0.16**	**0.19**	**0.20**
TLU-10.2 – Active traffic management and traffic management centers	$MMTCO_2e$	0.06	0.05	0.05
	Mgal Gasoline	*5.9*	*5.6*	*5.2*
	Mgal Diesel	*0.5*	*0.4*	*0.4*
TLU-10.3 – Traffic signal synchronization/optimization	$MMTCO_2e$	0.01	0.01	0.01
	Mgal Gasoline	*0.24*	*0.23*	*0.21*
	Mgal Diesel	*0.56*	*0.53*	*0.49*
TLU-10.7 – Reduce idle time in light duty vehicles, commercial vehicles, buses, locomotives, and construction equipment	$MMTCO_2e$	0.05	0.07	0.07
TLU-10.9 – Promote and incentivize fuel efficiency technologies for medium and heavy duty trucks	$MMTCO_2e$	0.04	0.05	0.05
TLU-10.12 – Encourage retrofit and/or replacement of non-highway diesel engines	$MMTCO_2e$	0.01	0.01	0.02
	Mgal Diesel	*0.6*	*1.2*	*2.13*

Notes: Gasoline and diesel fuel reductions listed above represent the basis of estimate for GHG reductions

Not all digits displayed are significant figures.

1.1. Summary of GHG Emission Methodology

The MDOT quantification effort for the TLU-10 policy included the following five strategy components:

- TLU-10.2 – Active traffic management and traffic management centers,
- TLU-10.3 – Traffic signal synchronization/optimization,
- TLU-10.7 – Reduce idle times in tractor trailer trucks, transit buses, and school buses,
- TLU-10.9 – Promote and incentivize fuel efficiency technologies for medium and heavy duty trucks, and
- TLU-10.12 – Encourage retrofit and/or replacement of non-highway diesel engines.

The revised methodologies used to estimate GHG emission reductions from each of these five strategies are summarized below. MDOT explains the reasons why the other sub-strategies of TLU-10 were not quantified (e.g., lack of data).

- TLU-10.2 – Currently, the State of Maryland operates the Coordinated Highways Active Response Team (CHART) program, an active traffic management (ATM) system that encompasses a range of intelligent transportation system (ITS) technologies. MDOT estimated GHG reductions associated with TLU-10.2 by projecting the delay reduction impacts of the CHART system into the future, and converting those delays from units of time to fuel, and then to emissions.

- TLU-10.3 – Traffic signal synchronization/optimization data on 2008 fuel savings associated with specific corridors, which were provided directly from the Maryland State Highway Administration (SHA), were projected to 2020 and converted to emissions. The analysis assumes no new corridor or intersection updates.

- TLU-10.7 – Idle time reduction potential for each vehicle class was estimated based on factors found in literature, applied to 2006 vehicle and inventory data and converted to fuel units, forecast from 2006 to 2020 using assumptions, and converted to emissions using MOBILE emission rates.

- TLU-10.9 – Reductions associated with technologies for medium and heavy duty trucks were estimated using the U.S. EPA SmartWay calculator.

- TLU-10.12 – The reduction potential of retrofits and/or replacement of non-highway diesel engines was estimated using a general assumption of five percent reduction in fuel use applied to the relevant quantity of off-road diesel fuel.

1.2. Rationale for GHG Emission Methodologies

The MDOT methodology for the 2020 GHG estimates was chosen based on data availability. The interpolation method for the intermediate years of 2012 and 2015 was chosen based on expert judgment and to maximize transparency and flexibility to facilitate future updates or revisions.

Difference Between Original & Revised Methodologies and Results

The following results were reported, in $MMTCO_2e$, for 2020 (the 2008 CAP documents are inconsistent in their reporting of TLU-10 GHG reduction potential):

- 0.44 (2008 CAP[170])

- 2.83 (CAP Appendix D-4[171])

- 0.20 (MDOT[172])

[170] Comprehensive Greenhouse Gas and Carbon Footprint Reduction Strategy, Report of the Maryland Commission on Climate Change Greenhouse Gas and Carbon Mitigation Working Group, August 2008, downloaded from: http://www.mdclimatechange.us/.
[171] Maryland CAP Appendix D-4.
[172] Maryland Department of Transportation, Maryland Climate Action Plan – Draft Implementation Status Report, Appendix B. November 4, 2009.

The CAP 2008 estimates of GHG reductions are significantly greater than the MDOT methodology. For example, for 2020, the CAP 2008 methodology estimate of 2.83 $MMTCO_2e$ is an order of magnitude greater than the MDOT methodology estimate of 0.20 $MMTCO_2e$.

1.3. GHG Emission Calculations

The specific algorithms used to project the emission reductions of TLU-10 in 2020 were not reported by MDOT, however the details of the data sources and assumptions are described in MDOT's documentation,[173] and reported below.

MDOT did not calculate emission reductions associated with TLU policies for any baseline or intermediate years. Therefore, the emission reductions for 2012 and 2015 are estimated individually for each component of TLU-10 that was quantified by calculating the trend between the base year for the given strategy and 2020, either individually in gasoline and diesel fuel, if given, or in emissions. Some assumptions were developed, and are included under the *GHG EmissionAssumptions* Section below. For 10.2 and 10.3, the interim year fuel reduction estimates were converted to emissions using the implied average emission factor calculated from MDOT's reported results –tons CO_2e per gallons fuel. For 10.2 and 10.3, the gasoline to diesel fuel ratio in 2020 was assumed constant for the intermediate years.

1.4. GHG Emission Data and Data Sources

TLU-10.2

The GHG emission benefits associated with this strategy were calculated based on 2008 delay data provided directly by the Maryland State Highway Administration (SHA) for the CHART program, and projected to 2020 using assumptions.

TLU-10.3

Emissions are based on 2008 fuel data, specifically 856,266 total gallons of fuel, which represent the difference in 2008 vehicle fuel consumption between the before and after conditions of the specific regional corridors for which the traffic signals were synchronized or optimized. These data were provided directly by the SHA. These fuel savings were projected to 2020 using assumptions.

TLU-10.7

The source of the total CO_2e emissions data for each of the vehicle categories that are examined in this strategy is the MDOT contractor modeling for State transportation inventories, based on traffic volume data in the HPMS database, and emissions rates from the MOBILE model. The emissions data reflect the 2006 network, and were projected using assumptions.

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[173] Ibid.

TLU-10.12

- The source of the 5 percent reduction in fuel use estimate is an MDOT analyst estimate in absence of available data set.
- Off-road diesel fuel consumption source is the EIA Annual Energy Outlook.

1.5. GHG Emission Assumptions

MDOT documented its assumptions in the Climate Action Plan Draft Implementation Status Report, Appendix B. These and additional assumptions used are as follows:

TLU-10.2

The GHG emission benefits associated with this strategy were calculated based on 2008 data obtained from the CHART program, which were projected to 2020 utilizing the following assumptions:

- An average annual VMT growth rate of 1.11 percent, obtained from the Baltimore Regional Transportation Board (BRTB) 2035 Long Range Plan (LRP) and 2010-2013 Transportation Improvement Program (TIP) dated May 2009.
- A 2020 fleet mix of 90 percent light duty vehicles (LDV), 3 percent heavy duty gasoline vehicles (HDGV), and 7 percent heavy duty diesel vehicles (HDDV).
- A 2008 average fuel economy (mpg) of 21.4 for LDVs, 8.0 for light duty gasoline vehicles (LDGVs), 8.3 for HDDVs, and 20.1 fleet-wide.
- A 2020 average fuel economy (mpg) of 29.4 for LDVs, 8.0 for LDGVs, 8.3 for HDDVs, and 27.3 fleet-wide.
- A 2008 annual fuel savings of 6.7 million gallons.
- A delay reduction of 2.66 M vehicle-hour (veh-h) for trucks and 33.32 M veh-hr for cars.
- A fuel economy adjustment factor of 0.74.
- It is assumed that the chart system continues to operate in the same manner each year between 2008 and 2020.

TLU-10.3

Traffic Signal Synchronization / Optimization – The GHG emission benefits resulting from the implementation of this strategy were calculated using several of the same assumptions as TLU-10.2, including: average annual VMT growth rate in the BMC region, fleet mix, fuel economy adjustment factor, and 2008 and 2020 fuel economy.

The specific signals and corridors for which projects were completed prior to 2008 are not specified. It is assumed that no additional traffic signal synchronization /optimization occurred between 2008 and 2020.

Traffic signal synchronization /optimization provides fewer gallons in annual fuel savings in 2020 than in the base year because the assumed fuel economy gains, both in terms of average fleet MPG and operational efficiency in the traffic network, do not make up for increases in overall VMT.

TLU-10.7

Reducing Idling Times – The GHG emission benefits calculated from this strategy represent the sum of a reduction in 1) long term truck idling (overnight and loading), 2) transit bus idling, and 3) school bus operations.

- Long Term Tractor Trailer Truck Idling – 3.4 percent of all class 8 truck CO_2 emissions were assumed attributable to long term idling. It was assumed that a 40 percent reduction in long-term truck idling could be achieved by 2020. The source of these assumptions on long term idling- overnight and loading in the base year is a Pennsylvania study on truck idling[174] . Applying these assumptions results in a 1.36 percent reduction in class 8 truck GHG emissions in 2020 relative to 2006 class 8 truck emissions.

- Transit Bus Idling – Based on a California Air Resources Board (ARB) study,[175] it was assumed that 7 percent of transit operating time is attributable to idling in excess of 1 minute. The average emission rate at the average operating speed of 15 mph is equivalent to 3,070 grams per mile, while the CO_2 idling emission rate equals 5,337 gallons per hour, based on the MOBILE model. Assuming an 80 percent reduction by 2020, also based on the ARB study, results in a 0.86 percent reduction in transit bus emissions.

- School Bus Idling – Based on the same ARB study, 14 percent of school bus operating time is attributable to idling in excess of 1 minute. The average emission rate at the average speed of 15 mph equals 4.02 gallons per hour. The average idling emission rate is equal to 0.5 gallons per hour. Assuming a reduction in idling of 80 percent by 2020 results in a 1.98 percent reduction in all school bus emissions statewide.

TLU-10.9

Technology Improvements for On-highway Vehicles – EPA's SmartWay calculator was utilized to calculate the emission benefits from this strategy utilizing the following options: aluminum wheel sets for singlewide tires and automatic tire inflation. Bunker heaters and auxiliary power units (APUs) were not included as they are included in TLU-10.7. Based on these assumptions, the SmartWay calculator estimates a reduction in fuel burn of 4.6 percent. A 25 percent participation rate was anticipated, resulting in a 1.125 percent reduction in class 8 truck GHG emissions. MDOT assumed participation rate of 6,705 trucks in 2020. The participation rate is based on 2006 HDDV trucks registered in Maryland (43.18 percent of which are class 8 trucks) and a growth factor of 1.1897 based on regional travel demand models and 1990-2008 HPMS.

TLU-10.12

[174] Specific study is unknown. MDOT contractor was not able to identify the report
[175] IBID

Technology Advances for Non-highway Vehicles:

- MDOT assumed this strategy will result in a 5 percent reduction in fuel use in 2020 relative to 2020 off-road highway diesel fuel use in the absence of the strategy. The resulting total fuel use reduction in 2020 is assumed to be 2,133,866 gallons per year.
- MDOT assumed an average annual off-road diesel fuel usage of 40,780,000 gallons based on 2002-2006 EIA data.
- The projected annual growth rate in fuel use across all sectors, which is assumed to be conservative for off-highway diesel, is assumed to be 1.05
- MDOT acknowledged that it expects the impact of this strategy to be relatively small based on two reasons: 1) retrofitting off-road equipment with after treatment technologies does not increase fuel efficiency, and 2) engine replacements are already reflected in the inventory. We agree on these two points. We assume then that the fuel reduction estimate is based on the difference in fuel used in applicable off-road vehicles under the assumed replacement schedule, which we assume would be through attrition, and fuel used in the same categories of vehicles if they were subject to an accelerated replacement schedule.
- For the interim year estimate, we assume the strategy implementation begins in 2010 because an accelerated schedule would take time to approve and fund.

1.6. GHG Emission Analysis and Recommendations

TLU-10.3

The resulting reduction in diesel fuel consumption is roughly double the gasoline savings in 2020. This should reflect the vehicle mix on the specific corridors, although these details currently not available.

To the extent that local jurisdictions consider, plan and implement additional traffic signal timing optimization and corridor synchronization projects, the potential emission benefits would be estimated using the same tools that would be used to calculate the delay reduction benefits, e.g., traffic flow models or signal timing software tools such as TRANSYT-7F or Synchro.

Traffic signal priority is the process of proving special treatment to transit vehicles at signalized intersections. Since transit vehicles can hold many people, giving priority to transit can potentially increase the person throughput of an intersection and reduce emissions. There are many ways signal priority can be implemented. No details are available regarding whether transit vehicle prioritization at intersections was incorporated into the signal timing updates that are the basis of this TLU-10.3 strategy. To the extent that it was, this TLU-10.3 strategy would also contribute to TLU-3 transit-related reductions.

TLU-10.12

We suggest that MDOT documents additional detail on the estimation methodology when they update their TLU estimates including the baseline fuel use projection, assumed timing of replacements under each schedule and the approximate number of locomotives (and/or other vehicles) to which it is assumed that this strategy applies.

2.0 AIR QUALITY CO-BENEFITS

This policy has no measurable NAAQS co-benefits. The estimated reductions in gasoline and diesel fuel consumption are less than 0.01 hundredths and 0.03 hundredths of a percent, respectively of the statewide consumption (2008) of those fuels for transportation.

2.1. Air Quality Co-Benefits Data and Data Sources

- **Statewide Fuel Consumption**. U.S. Energy Information Administration, Independent Statistics & Analysis, Consumption, Physical Units, 1960-2008. http://www.eia.doe.gov/states/_seds.html

3.0 INTERACTION WITH OTHER POLICIES

The interactions of land uses and development and transportation infrastructure and policy decisions are many in number and complex in character. Local and regional governments and organizations nationwide have begun to recognize the importance of system-wide transportation and land-use modeling and analysis. Such modeling is outside the scope of this project, but examples of key interactions can be summarized qualitatively for TLU-10.

TLU-10 and TLU-3 are mutually supportive of one another, although the impact of either one on the other is not expected to be large. For example, the real-time information provided by the CHART system included in TLU-10, in combination with TLU-3 strategies that provide greater transit service and awareness, may influence some single occupancy drivers to choose transit as an alternative to a trip by car, under certain circumstances highlighted by the CHART system. In a similar relationship, TLU-10 is expected to interact with TLU-8 bike and pedestrian strategies. TLU-10 is not expected to interact with policies other than TLU-3 and TLU-8.

This TLU policy is not expected to significantly interact with policies in other sectors.

Chapter 5: Policy Overlap Analysis

5.1. Introduction: The Sources of Policy Overlap

The preceding chapters present and document SAIC's estimates of the GHG and criteria pollutant emission reductions that can be expected to be generated by eight of the policies included in Maryland's 2008 CAP. Some of these policies have been revised since the 2008 Climate Action Plan; all (including the revised policies will be included in the draft 2012 Greenhouse Gas Emissions Reduction Act (GGRA) plan. Table E.2 in the Executive Summary presents the GHG emission reductions SAIC re-estimated for each of these eight of policies. In developing these emission reduction estimates, each policy was treated as independent of all other policies. The purpose of this chapter is to analyze and quantify the *interactions* between these policies. These interactions take the form of overlaps between the emission reduction estimates for the policies. As a result of these overlaps the emission reduction estimates shown in Table E.2 are not additive; rather, the total emission reductions that will be generated by the eight policies will be *less* than the sum of the reductions estimated for each individual policy. In this chapter the magnitude of the overlaps is estimated, and the methodology used to quantify the overlaps is documented.

In general, overlaps between different GHG emission reduction policies may arise from three main sources:

- **Similar Methods.** Two or more policies may be targeted towards achieving similar goals using similar, explicitly-defined methods, leading to redundancy in the policies. As a hypothetical example, a policy designed to increase biomass co-firing at coal-fired power plants and an RPS policy may both tend to increase renewable usage at the expense of fossil fuels. To the extent that biomass co-firing helps to meet the RPS policy's goals for the use of biomass the two policies are duplicative and overlap.

- **Integrated Systems.** Two or more policies may seek to achieve different goals using different methods, but by targeting highly integrated systems, such as the electric power grid, consisting of components that interact closely with one another. For example, when demand for electricity from end-use devices declines, there is an immediate, commensurate decline in the amount of electricity generated by power plants serving these loads. Even when two policies target different aspects of the electricity system they may often interact in complex ways, due to the highly integrated nature of the electricity grid. Consider, for example, two different polices, one of which is designed to reduce electricity *demand* while the other affects electricity *supply* by incentivizing increased use of natural gas in place of coal. Even though the former policy is targeted towards electricity users and the latter towards electricity suppliers, the potential for overlap between the two policies is high. As emissions from the generation of electricity declines in response to the increased use of natural gas, the emission *reductions* achievable by reducing end use electricity consumption will also decline. Specifically, the natural gas policy will cause MD's electricity emissions factor to decrease, and the emission reductions generated by the parallel reduction in electricity use will decline in direct proportion to the decline in the emissions factor. Suppose, as a hypothetical example that the electricity consumption policy results in a 1 million MWh decline in the consumption of electricity generated within MD. Suppose, further, that the in-state electricity emissions factor for MD is projected to be 0.7 metric tons CO_2e/MWh under a BAU scenario. In this case, absent the effect of the natural gas policy, emission reductions would be estimated as (1,000,000 MWh x 0.7 tons CO_2e/MWh =) 700,000 metric tons CO_2e. Now, suppose that the fuel switching incentivized by the natural gas policy causes the emissions factor to decline from 0.7 to 0.6 metric tons CO_2e/MWh. With the natural gas policy included, in-state electricity emission reductions from the electricity consumption policy would now be estimated as (1,000,000 MWh x 0.6 tons CO_2e/MWh =) 600,000 metric tons CO_2e. The overlap between the two policies would thus be (700,000 – 600,000 =) 100,000 metric tons CO_2e.[176] We emphasize that this is a purely hypothetical example solely intended to illustrate the nature of the overlap between policies targeted to the electric power system.

- **Unspecified Methods.** Policies that specify emission reduction goals *without* specifying the methods used to achieve those goals may overlap with policies that define specific methods for meeting goals. The former policies in many cases may be intended to allow market forces to determine the specific methods that will be used to meet the goals. But to the extent that more narrowly-specified policies may help meet the numeric goals of the former market-based policies their impact on emissions may in effect be subsumed under these market-based policies. Consider, for example, a cap-and-trade policy that sets a quantitative limit on emissions but without specifying how the market must meet that limit. If such a policy is combined with an RPS that specifies explicit targets for the market penetration of renewables, then meeting the explicit RPS targets will also help the market to meet the emissions cap. Since there are no constraints specifying how the cap is to be met, the emission reductions caused by the RPS will count towards meeting the cap and will hence reduce the *further* emission reductions needed to meet the cap. In such a situation, the GHG impacts of the RPS are effectively subsumed under the cap-and-trade policy.

In section 5.2 we will address each set of interacting policies, and develop and apply methodologies for estimating the overlap between the policies. As shall be seen, each of the above three sources of overlap comes into play for different combinations of the policies.

5.2. Greenhouse Gas Overlap Analysis by Policy Category

Sub-sections 5.2.1 through 5.2.4 provide greater detail on the analyses of interactions within the individual policies. Each sub-section represents a different policy category. A summary is provided in sub-section 5.2.5.

5.2.1. Transportation and Land-Use (TLU) Policy

SAIC was tasked with addressing only one of the various TLU policies—namely TLU-6, Pay-As-You-Drive Insurance. This policy is designed to provide incentives for motorists to reduce their vehicle miles

[176] Another way to compute the overlap in this example would be to approach the overlap from the viewpoint of the natural gas policy rather than the electricity consumption policy. From this viewpoint, the magnitude of the emission reductions achieved will be reduced because the total quantity of electricity generated will decline as a result of the drop in electricity consumption. Since the switch to natural gas is estimated to cause a decline in emissions equal to 0.1 metric tons CO_2e/MWh (0.7 minus 0.6), and total electricity generation is expected to decline by 1million MWh as a result of the electricity consumption policy, the reduced effectiveness of the natural gas policy would be estimated as (1,000,000 MWh)(0.1 metric tons CO_2e/MWh), or 100,000 metric tons CO_2e/MWh. This result is the same as the overlap estimated above from the viewpoint of the electricity consumption policy.

travelled (VMT) by incorporating VMT as one of the factors used to determine automobile insurance premiums.

In part because it is the only policy re-estimated by SAIC that directly targets the transportation sector, there is little potential for overlap between TLU-6 and any of the other policies. One other policy—AFW-9 (Waste Management through Source Reduction and Advanced Recycling)—may have an indirect effect on transportation through its impact on the tonnage of waste that must be hauled to landfills and incinerators. However, TLU-6, as re-estimated by SAIC, explicitly excludes the heavy-duty vehicles (i.e., garbage trucks) whose VMT would be impacted by AFW-9. Therefore there should be no overlap between these two policies.

The only other potential overlap between TLU-6 and any of the other policies might result from the impact of TLU-6 on electricity consumption. As discussed in section 5.1, policies that impact the electricity sector tend to overlap in their effect on emissions, due to the highly integrated nature of the electricity grid. However, while TLU-6 can be expected to result in a reduction in the VMT of plug-in hybrid electric vehicles (PHEVs) along with conventional vehicles, the contribution of PHEVs to Maryland's total VMT—and therefore to the reduction in VMT resulting from TLU-6—is expected to be insignificant. Even in 2020, we project PHEV VMT to be a very small fraction—much less than 1 percent—of total light-duty vehicle VMT. For example, the U.S. Energy Information Administration (EIA), in its 2011 Annual Energy Outlook, projects U.S. electricity consumption by light duty vehicles to represent only 0.04 percent of the total energy consumed by these vehicles in 2020.[177] The emission reductions associated with such a small percentage falls well below the *de minimis* levels we have used in determining significant digits for our TLU-6 emission reduction estimates. Therefore, the potential overlap between TLU-6 and the other policies affecting the electricity sector has been judged to be insignificant.

5.2.2. Agriculture, Forestry and Waste (AFW) Policies

SAIC re-estimated emission reductions for two AFW policies: AFW-2 and AFW-9. Each of these two policies is addressed separately below:.

Managing Urban Trees and Forests for Greenhouse Gas (GHG) Benefits (AFW-2). The purpose of AFW-2 is to reduce GHG emissions and increase carbon sequestration through urban forestry. As AFW-2 is the only policy that seeks to affect carbon sequestration through urban trees, there is no overlap between the carbon sequestration benefits of AFW-2 and the other AFW policies. Furthermore, because the GHG emission reductions resulting from energy savings due to reduced cooling demand were determined to be *de minimis*, it necessarily follows that any overlap between AFW-2's emission reductions and those of the other policies is also *de minimis*. In short, there are no overlaps between either the carbon sequestration or emission reduction components of AFW-2.

Waste Management through Source Reduction and Advanced Recycling (AFW-9). Within the AFW policies, there is a very small possibility of interaction between AFW-9 and AFW-6 (Expanded Use of Forest and Farm Feedstocks and By-Products for Energy Production). AFW-9 seeks to reduce municipal solid waste (MSW) which is a non-preferred feedstock for biomass energy production. However, as

[177] http://www.eia.gov/forecasts/aeo/tables_ref.cfm, Table 47.

mentioned above in the AFW-6 policy discussion, MSW would only become limiting after much larger preferred sources, from agriculture and forestry, became unavailable, so even a large impact of AFW-9 upon MSW availability is judged to be inconsequential for AFW-6.

More generally, AFW-9 reduces GHG emissions through a combination of waste reduction and recycling measures. These measures may have a broad impact on a variety of GHG emission sources, including landfills, incinerators, factories that produce the goods that eventually become waste, and the various energy sources used to extract, process, transport, use or dispose of materials. However, AFW-9 is the only policy re-estimated by SAIC that affects most of these sources. The sole possible exception is electric generating stations, which may be impacted indirectly via the effect of AFW-9 on electricity consumed to produce, process, and dispose of materials. However, it is assumed that the net indirect impact of AFW-9 on electricity use is insignificant relative to its direct impact on landfills and incinerators. Therefore, the overlap between AFW-9 and other policies affecting the electricity sector is judged to be insignificant.

5.2.3. Residential, Commercial and Industrial (RCI) Policies

SAIC re-estimated all three of the remaining RCI policies: RCI-1, RCI-4, and RCI-10. Significant overlap exists both between these three policies, as well as across the RCI policies and the Energy Supply (ES) policies. This sub-section focuses on the overlap across the three RCI policies; with one exception, the interactions between the RCI and ES policies will be addressed in sub-section 5.2.4.

Government Lead-By-Example (RCI-4). Policy RCI-4 consists of two components. First, the policy includes a set of Energy Performance Contracts (EPCs) entered into by the State government. Second, the policy includes the Generating Clean Horizons program (GCH).. Overlap between the EPC component of RCI-4 and RCI-10 (EmPOWER Maryland) is addressed below in the discussion of EmPOWER Maryland (RCI-10) below. Here, we limit our analysis to the GCH component of RCI-4. As addressed below by SAIC, the GCH component will entirely be represented in the annual Renewable Portfolio Standard (RPS) compliance demonstration.

Although the GCH program is essentially voluntary participation of State government with Maryland's RPS, it is important to recognize that under the GCH program the government will *not* take title to the Renewable Energy Credits (RECs) generated via the GCH program. Instead, the generated RECs will remain within the private sector. This in effect means that all of the credits earned through the GCH program will be applicable to the RPS goals specified in ES-7 (Renewable Portfolio Standard, RPS). For this reason, *all* of the emission reductions generated via the GCH program overlap with the emission reductions from Policy ES-7. The GCH program and ES-7 are essentially examples of two polices with similar (in fact the same) quantitative goals and similar methods (increase renewable usage). Although the two policies are targeted to different sectors (the public sector in the case of GCH and the private sector in the case of ES-7), the ability of the private sector to take credit for the benefits of GCH effectively reduces the size of the emission reductions that the private sector must achieve under ES-7. As a result, GCH's emission reductions are offset 100 percent by a corresponding reduction in the emission reductions achieved under ES-7 (RPS).

EmPOWER Maryland (RCI-10). Policy RCI-10 (which incorporates and subsumes old policies RCI-2, RCI-3, RCI-7, and RCI-11 in addition to RCI-10) represents the EmPOWER Maryland Act. EmPOWER

Maryland, enacted in 2007, requires utilities and the MEA to reduce the state's per capita electricity consumption by 15 percent by 2015. The 15 percent reduction is to be achieved against a 2007 baseline.

RCI-10 is an example of a policy that specifies energy savings goals *without* specifying the methods used to achieve those goals. Therefore any other policy that reduces electricity consumption, regardless of the methods used, will help to meet the numeric goal specified under RCI-10. Specifically, those components of RCI-1 (Improved Building and Trade Codes and Beyond-Code Building Design and Construction in the Private Sector) and RCI-4 (Government Lead-By-Example) that lead to reductions in electricity consumption will help the State to meet the 15 percent consumption goal specified in RCI-10 (both RCI-1 and RCI-4 achieve their emission reductions through energy savings, although it should be stressed that only a portion of the energy savings takes the form of electricity savings). Assuming, as we have in our analysis of RCI-10 as an independent policy, that the 15 percent goal specified under EmPOWER Maryland will be met but not exceeded, it follows that the entire reduction in electricity consumption provided by RCI-1 and RCI-4 will be applied towards the RCI-10 goal. Therefore, RCI-10 will entirely subsume the RCI-1 and RCI-4 (Government Lead-By-Example) emission reductions resulting from reduced electricity use *unless* the sum of those reductions exceeds the emission reductions projected to be achieved through the implementation of RCI-10. As we shall see this is not the case.

Table 5.1 below compares the reduction in GHG emissions for the three RCI policies. This table separates out the emissions savings due to reduced electricity consumption from the savings resulting from reductions in the direct combustion of fossil fuels (e.g., in home furnaces, water heaters), etc. There are no interactions between the policies in their effect on direct combustion emissions, as the two policies that impact these emissions (RCI-1 and RCI-4) use different methods (building codes vs. Energy Performance Contracts). Therefore the overlap between the three policies is limited to the emission reductions caused by reduced electricity demand.

Table 5.1. Estimated Emission Reductions Including and Excluding Overlap for the RCI Policies

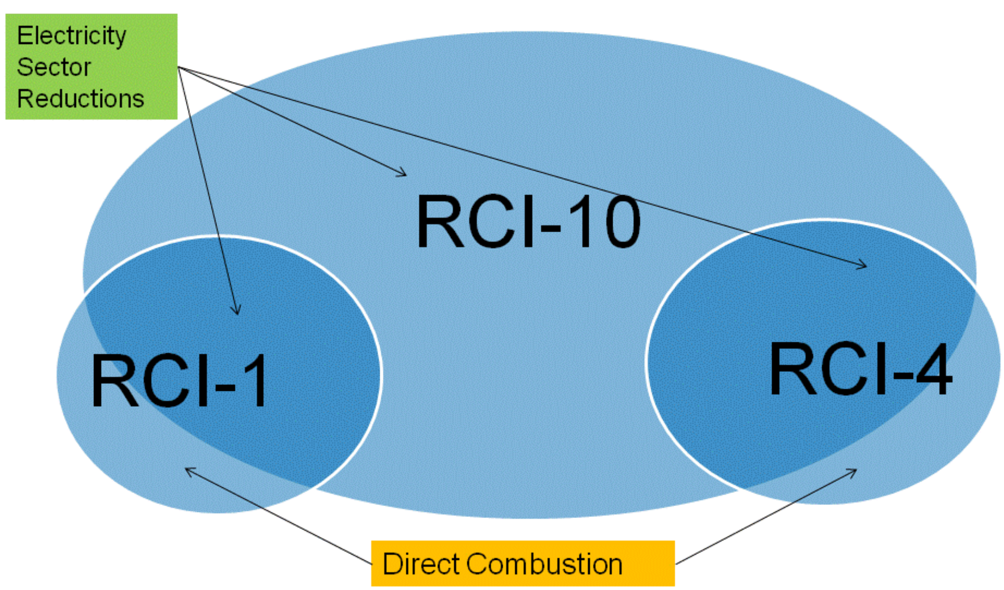
Sector/Policy	Emission Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
In-State Electricity Sector Reductions			
Including Overlap			
1. RCI-1	0.34	1.04	2.63
2. RCI-4*	0.03	0.04	0.03
3. RCI-1 & 4 Total (Sum of Rows 1 and 2)	**0.37**	**1.08**	**2.66**
4. RCI-10	2.16	4.39	3.49
5. All RCI Total (Sum of Rows 3 and 4)	**2.53**	**5.47**	**6.15**
6. All RCI Total Excluding Overlap (Equals Row 4, RCI-10)	**2.16**	**4.39**	**3.49**
Out-of-State Electricity Sector Reductions			
Including Overlap			
7. RCI-1	0.16	0.47	1.43
8. RCI-4*	0.01	0.02	0.02
9. RCI-1 & 4 Total (Sum of Rows 7 and 8)	**0.17**	**0.49**	**1.45**
10. RCI-10	0.98	2.00	1.89
11. All RCI Total (Sum of Rows 9 and 10)	**1.15**	**2.49**	**3.34**
12. All RCI Total Excluding Overlap (Equals Row 10, RCI-10)	**0.98**	**2.00**	**1.89**
Direct Combustion Reductions			
Including Overlap			
13. RCI-1	0.13	0.43	1.37
14. RCI-4*	0.02	0.03	0.03
15. RCI-10	0.00	0.00	0.00
16. All RCI Total (Sum of Rows 13, 14 and 15)	**0.15**	**0.46**	**1.40**
17. All RCI Total Excluding Overlap (Equals Row 16)	**0.15**	**0.46**	**1.40**
18. Grand Total (Sum of Rows 5, 11, and 16)	**3.83**	**8.42**	**10.89**
19. Grand Total Excluding Overlap (Sum of Rows 6, 12, and 17)	**3.29**	**6.85**	**6.78**

*This table includes only the ECP component of RCI-4. As discussed in the analysis of Government Lead-By-Example (RCI-4) above, the emission reductions generated via the GCH program component of RCI-4 overlap in their entirety with the emission reductions achieved via Policy ES-7, and hence these reductions are excluded from the table.

As the first three columns of Table 5.1 show, in each of the three forecast years the projected emission reductions from both the in-state and out-of-state electricity sectors are larger for RCI-10 than for RCI-1 and RCI-4 (Government Lead-By-Example) combined. For example, in 2012 the In-State electricity sector reductions for RCI-1 (0.35 million metric tons CO_2e) and RCI-4 (0.03 million metric tons CO_2e) total 0.38 million metric tons CO_2e; this total is less than In-State electricity reductions projected for RCI-10 (2.54 million metric tons CO_2e). Therefore in each year the electricity sector emission reductions from RCI-10 can be expected to fully subsume the electricity sector emission reductions for both other policies. This is shown in the last three columns of Table 5.1. In these three columns, electricity sector emission reductions *excluding* the overlap will be found to equate with the emission reductions for RCI-10 shown in the first three columns of the table.

Figure 5.1 is a Venn diagram illustrating the overlap between RCI-10, RCI-1, and RCI-4. Again, the building code improvements implemented under RCI-1, and the energy performance contracts signed by the government under RCI-4, will contribute directly to the EmPOWER Maryland goal of a 15 percent reduction in per capita electricity use, thereby reducing the amount of additional electricity savings that must be achieved over and above the RCI-1 and RCI-4 savings to reach the EmPOWER goal. The overlap in this case arises from the fact that EmPOWER Maryland specifies a numeric electricity savings goal without specifying the method(s) that must be used to meet the goal, thereby enabling electricity savings arising from other policies—namely RCI-1 and RCI-4—to count towards the goal.

Figure 5.1. Venn Diagram Illustrating the Overlap Between Policies RCI-1, RCI-4, and RCI-10



5.2.4. Energy Supply (ES) Policies

SAIC re-estimated emission reductions for two ES policies: ES-3(Cap-and-Trade) and ES-7 (RPS). As we have already seen, Policy ES-7, comprising Maryland's Renewable Portfolio Standard (RPS), overlaps with the GCH component of Policy RCI-4 (Government Lead-By-Example). However, we have already taken this overlap into account by excluding the GCH emission reductions from the total (overlap excluded) reductions calculated for the combined RCI policies in Table 5.1. This said, because Policy ES-7's goal is to ensure that a set *percentage* (20 percent by 2022) of Maryland's electricity generation is provided by renewable sources, any policies that reduce In-State electricity generation will also reduce the *absolute* quantity of fossil-fuel generated electricity that will be replaced by clean renewables under the ES-7 RPS. As discussed in sub-section 5.2.3, the RCI policies will have the combined effect of reducing per capita electricity consumption by 15 percent by 2015; the resulting "saved" electricity generation will not be an additional source of emission reductions from the RPS. The ES-7/RCI overlap is an example of double counting arising from the highly integrated nature of the electricity grid. Although ES-7 targets electricity supply while the RCI policies target electricity demand, changes in the latter impact the former due to the close interactions between supply and demand when it comes to the electric grid.

While some overlap exists between ES-7 (RPS) and the combined RCI policies, by far the main source of overlap arises from Policy ES-3 (Cap-and-Trade). Like Policy RCI-10 (see sub-section 5.2.3); ES-3 specifies a numeric target without specifying the method(s) to be used to meet the target. In the case of ES-3, the target is specified as a cap on total GHG emissions from Maryland's electricity sector. This cap is specified as part of an emissions allowance trading regime designed to enable the market to determine the least-cost methods of meeting the cap. However, because the only requirement is that the cap be met regardless of how this is accomplished, any and all emission reduction policies that have the effect of reducing GHG emissions from the State's electricity sector will count towards meeting the goals of ES-3. Thus, for example, emission reductions resulting from the RPS implemented under ES-7 will count towards meeting the ES-3 cap. Similarly, the reductions in electricity consumption resulting from the combined impact of the RCI policies will likewise reduce electricity sector emissions and thereby count towards meeting the cap. Like RCI-10 (EmPOWER Maryland), ES-3 (Cap-and-Trade) is an example of a policy with specific emission reduction goals but that allows the application of a wide variety of the methods to achieve those goals. In fact, ES-3 encompasses an even wider variety of methods than RCI-10. The latter policy specifies its target as a numeric reduction in electricity *consumption*, thereby limiting the methods that can be used to meet the goal to *demand-side* measures. In contrast, the cap specified in ES-3 can be met using either supply side (such as an RPS) or demand side measures (such as those specified in the RCI policies). For this reason ES-3 (Cap-and-Trade) has the potential to subsume not only ES-7 (RPS) but also the combined emission reductions from the RCI policies. Specifically, if the projected emission reductions from ES-3 exceed the sum of the reductions from ES-7 and the combined RCI policies, then ES-7 and the RCI policies will serve to help Maryland meet its emission cap under RGGI but will not provide additional GHG reductions beyond those needed to meet the cap.

Table 5.2 was developed to determine whether or not the sum of the emission reductions from ES-7 (RPS) and the combined RCI policies exceed the reductions from ES-3. This table shows the projected emission reductions from each policy/set of policies. Note that for the combined RCI policies the reductions shown in Table 5.2 are the reductions *excluding* overlap, as previously calculated in Table 5.1.

Also, in the case of ES-7 (Cap-and-Trade) we are using the *original* reduction estimates although, as discussed above, there is in fact some overlap between ES-7 and the RCI policies. In light of this overlap we present the ES-7 estimates as maximums; actual reductions for ES-7 excluding the overlap will be less than the quantities shown in Table 5.2. Finally, note that in Table 5.2 all of the emission reductions generated by the ES policies occur within the in-state electricity sector. Therefore there is no overlap between ES-3, ES-7 and the combined RCI policies for either out-of-state electricity generation sources or direct fuel combustion sources in the buildings sector. In Table 5.2 emission reductions for these two sources are simply equal to those calculated for the combined RCI policies (from Table 5.1 above).

Table 5.2. Estimated Emission Reductions Including and Excluding Overlap for the ES and Combined RCI Policies

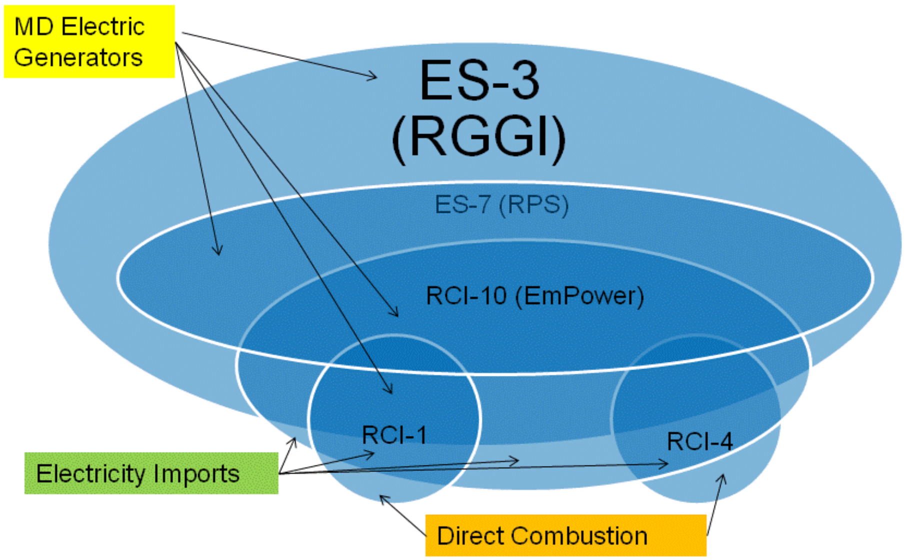
Sector/Policy	Emission Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
In-State Electricity Sector Reductions			
Including Overlap			
1. ES-7	<1.19	<2.04	<3.04
2. RCI	2.16	4.39	3.49*
3. ES-7 & RCI Total (Sum of Rows 1 and 2)	**<3.35**	**<6.43**	**<6.53**
4. ES-3	7.81	9.29	12.26
5. ES & RCI Total (Sum of Rows 3 and 4)	**<11.16**	**<15.72**	**<18.79**
6. ES & RCI Total Excluding Overlap (equals Row 4, ES-3)	**7.81**	**9.29**	**12.26**
Out-of-State Electricity Sector Reductions			
Including Overlap			
7. ES-7	0.00	0.00	0.00
8. RCI	0.98	2.00	1.89*
9. ES-7 & RCI Total (Sum of Rows 7 and 8)	**0.98**	**2.00**	**1.89**
10. ES-3	0.00	0.00	0.00
11. ES & RCI Total (Sum of Rows 9 and 10)	**0.98**	**2.00**	**1.89**
12. ES & RCI Total Excluding Overlap (Equals Row 11)	**0.98**	**2.00**	**1.89**
Direct Combustion Reductions			
Including Overlap			
13. ES-7	0.00	0.00	0.00
14. RCI	0.15	0.46	1.40
15. ES-3	0.00	0.00	0.00
16. ES & RCI Total (Sum of Rows 13, 14 and 15)	**0.15**	**0.46**	**1.40**
17. ES & RCI Total ExcludingOverlap (Equals Row 16)	**0.15**	**0.46**	**1.40**
18. Grand Total (Sum of Rows 5, 11, and 16)	**<12.29**	**<18.18**	**<22.08**
19. Grand Total Excluding Overlap (Sum of Rows 6, 12, and 17)	**8.94**	**11.75**	**15.55**

*The reader may note that electricity-related emission reductions for the RCI sector decline between 2015 and 2020. As is discussed in Chapter 1, RCI-10 (which subsumes all of the RCI sector emission reductions) reaches its final goal of a 15 percent reduction in per capita electricity demand by 2015. From 2015 to 2020, although per capita electricity demand remains constant at a level 15 percent below 2007 levels, the reduction in total electricity demand increases slightly because the population of Maryland is projected to increase. However, despite this slight increase in electricity savings, GHG emission reductions decline between 2015 and 2020. This decline in emission reductions occurs because the current trend towards lower-emitting sources of electricity (such as natural gas) is projected to continue after 2015. Thus the emission factor used to convert the electricity savings resulting from RCI-10 declines between 2015 and 2020, resulting in an erosion in the emission reductions generated by this policy, and therefore by the RCI sector as a whole.

As the first three columns of Table 5.2 indicate, the sum of In-State electricity sector emission reductions for ES-7 (RPS) and the combined RCI policies is less than the ES-3 (Cap-and-Trade) reductions in all forecast years. This is the case even though we have not eliminated the double counting described above from ES-7; without the double counting ES-3's emission reductions would exceed the sum of the ES-7 and RCI reductions by an even larger amount. Hence for the In-State electricity sector the emission reductions projected for Policy ES-3 entirely subsume the emission reductions from both ES-7 and the combined RCI policies. Total In-State electricity sector emission reductions across all policies are therefore equal to the emission reductions projected for ES-3 (as indicated in the last three columns of Table 5.2). Other policies will contribute towards meeting the emission cap set under ES-3, but they will not generate emission reductions beyond, or in addition to, the reductions necessary to meet the cap.

Figure 5.2 is a Venn diagram illustrating the overlaps between the ES and RCI policies. The overlap between ES-3 and the other policies affecting In-State electricity generation arises from the fact that ES-3 specifies a numeric emissions goal without specifying or limiting the method(s) that must be used to meet the goal, thereby enabling emission reductions arising from other policies to count towards the goal. These other policies have the effect of shifting the State's electricity emissions trend downward towards the RGGI emission cap; thereby reducing the additional emission reductions that must be achieved by ES-3 to meet the cap.

Figure 5.1. Venn Diagram Illustrating the Overlap Between the ES and RCI Policies



5.2.5. Summary of GHG Overlap Analysis Results

Table 5.3 summarizes the results of our GHG quantitative overlap analysis for 2020. In addition to presenting our overlap estimates (in the third column) for the four key sectors (RCI, RCI combined with ES, AFW, and TLU), this table also presents the sums of the GHG reductions in each sector, both unadjusted for the overlap (in the second column) and adjusted for the overlap (in the fourth column). Finally, in the bottom row the table presents the total unadjusted and adjusted GHG reductions across all four sectors, along with the total overlap.

As Table 5.3 indicates, there are no GHG overlaps for the AFW and TLU policies. However, double counting across the RCI and ES policies is significant. Of the 26.3 million metric tons CO_2e of unadjusted total reductions for these two sectors, 10.75 million metric tons (41 percent of the unadjusted total) is double counted across two or more policies. Across all four sectors, the 10.75 million metric ton CO_2e overlap represents 32 percent of the unadjusted sum of the reductions.

Table 5.3. Summary of Overlap Estimates, and Unadjusted and Adjusted GHG Emission Reductions, Across All Sectors in 2020

Sector	Unadjusted Total Reductions in 2020 ($MMTCO_2e$)	2020 Overlap Estimate ($MMTCO_2e$)	Adjusted Total Reductions in 2020 ($MMtCO_2e$)
RCI	11.00	4.11	6.89
RCI & ES	26.30	10.75	15.55
AFW	7.29*	0.00	7.29*
TLU	0.03	0.00	0.03
Grand Total	**33.62**	**10.75**	**22.87**

*Includes 1.32 $MMTCO_2e$ of carbon sequestration.

Finally, Table 5.4 presents unadjusted and adjusted total reductions for all three forecast years: 2012, 2015, and 2020.

Table 5.4. Summary of Unadjusted and Adjusted GHG Emission Reductions for 2012, 2015 and 2020

Sector	Emission Reductions Including Overlap (Million Metric Tons CO_2e)			Emission Reductions Excluding Overlap (Million Metric Tons CO_2e)		
	2012	2015	2020	2012	2015	2020
RCI	3.88	8.50	11.00	3.34	6.93	6.89
RCI & ES	12.88	19.83	26.30	8.94	11.75	15.55
AFW*	0.16	0.45	7.29	0.16	0.45	7.29
TLU	0.01	0.02	0.03	0.01	0.02	0.03
Grand Total	**13.05**	**20.3**	**33.62**	**9.11**	**12.22**	**22.87**

*Includes CO_2 sequestered as well as CO_2e reductions.

5.3. Air Quality Co-benefits Overlap

The estimated air quality co-benefits cover eighteen different policies. To understand how the policies might affect air quality within Maryland, the policies were classified based on the affected sectors:

- Emissions from Maryland Utilities
- Emissions from Maryland Transportation Mitigation Measures
- Removal of Atmospheric Pollutants by Forests, Wetlands, and Agricultural Lands
- Emissions from Area/Off-road Sources
- Emissions from Institutional Sources

Each of the sectors (and its treatment for overlap purposes) is discussed below, and the ranges in pollutant emissions reductions follow this discussion. Because policies and regulations in other states will have a significant impact on criteria pollutant emissions in those states,[178] the overlap of Maryland's policies on emissions from electricity generation that is imported into Maryland was not included in the analysis.

5.3.1. Emissions from Maryland Utilities: The RCI and ES policies cover reductions in electricity demand, the switch to cleaner fuels for electricity generation, increased energy efficiency, and compliance with energy compact goals. Similar to the discussion in sub-section 5.2.3 on GHGs, the ES-3 policy (Cap-and-Trade) will cover the components of other electricity GHG reduction policies. In other words, the adoption of the other policies (reductions in electricity demands, the switch to cleaner fuels for electricity generation, and increased efficiency) will only help Maryland reach its ES-3 goals. Because these policies do not deal directly with criteria pollutant reductions, the benefits from their implementation are straightforward and can generally be assumed to match those emission reductions that result from the implementation of ES-3.

The specific exceptions are the two cases where implementation of a GHG policy might be expected to result in increased criteria pollutant emissions. First, the ES-7 policy (RPS) introduces uncontrolled landfill gas boilers that may replace existing boilers with more controls on them (resulting in net increases in NO_X, CO, and PM emissions). Secondly, one part of the ES-8 policy (Efficiency Improvements & Repowering Existing Plants) would encourage existing coal-fired units with significant new post-combustion control technologies to be replaced by natural gas-fired units (possibly without post-combustion controls). The increases in expected criteria pollutant emissions might be prevented in both cases through Maryland regulations or if the units were large enough to trigger New Source Review offset requirements.

Table 5.5 presents the expected emissions reductions for criteria pollutants from Maryland utilities. The high range for each of the years is presented as the reduction from the ES-3 policy. The low range subtracts the emission increases from policies ES-7 and ES-8 from the reductions in the ES-3 policy. Readers should note that a narrow range or a single number does not imply confidence in the possible emission reduction but only that negative numbers were relatively small for the ES-7 and ES-8 policies.

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[178] Analysis of Emissions Trends, Air Quality Trends, and Regulations in Maryland and Nearby States in the Ozone Transport Region, SAIC Report to Maryland Department of the Environment Air Quality Planning Program, September 2010.

Table 5.5. Possible Criteria Pollutant Emissions Reductions from Maryland Utilities

Pollutant	Emissions Reductions (tons per year)		
	2012	2015	2020
SO_2	14,000	12,000	17,000
NO_X	6,300-6,800	8,000-9,000	3,200-5,700
CO	(50)-200	(370)-230	(1,000)-220
VOC	30-40	20-50	(20)-50
PM10	2,000	2,300	2,100
PM2.5	1,800	2,100	1,900

5.3.2. Emissions from Maryland Transportation Mitigation Measures: Criteria pollutant emissions reductions were calculated for the TLU-2, TLU-3, TLU-5, TLU-6, TLU-8, and TLU-9 policies, all measures designed to alter the vehicle miles traveled (VMT) for light duty vehicles by offering alternative travel modes, setting up incentives and disincentives to various commuting options, and introducing VMT fees. Because these proposed VMT reduction measures are all aimed at the same broad community (Maryland's citizens), their interactions are considerable. Some policies work synergistically (e.g., TLU-2 increases high density development while TLU-8 increases the connectivity of bike paths that can replace automobile use in high density developments), but others may compete (e.g., increasing carpooling options under TLU-3 may decrease the effectiveness of bike paths in TLU-8). A thorough overlap analysis requires an understanding of which small communities are impacted by each of the policies and how the VMT will be adjusted in each community.

Because the overlap is geographically specific for the TLU policies, direct comparisons cannot be drawn from overlap analyses in other parts of the United States and applied to Maryland communities. Detailed transportation planning modeling in consultation with the Maryland DOT would be necessary to quantify the complex interrelationships between the policies. Such modeling is outside the scope of this project.

Because some policies would have synergistic effects while others would compete, the assumption was made that the overlap for the TLU-2, TLU-3, TLU-5, TLU-6, TLU-8, and TLU-9 policies could be approximated by the sum of the emissions for these measures, in the absence of detailed transportation modeling. Table 5.6 presents the total emissions reduction estimates of criteria pollutants from these measures. Note that the presentation of a single number does not imply lack of uncertainty surrounding the value but that the input data did not present a range of VMT estimates.

Table 5.6. Possible Criteria Pollutant Emissions Reductions from Maryland Transportation Mitigation Measures

Pollutant	Emissions Reductions (tons per year)		
	2012	2015	2020
SO_2	4	12	40-70
NO_X	370	740	1,700-4,600
CO	4,900	12,000	38,000-72,000
VOC	290	640	1,800-3,800
PM10	10	10	40-200
PM2.5	4	9	39-100

The AFW-4 policy (Protection & Conservation of Agricultural Land, Coastal Wetlands & Forested Land) is expected to overlap with TLU-2 (Land Use & Location Efficiency). The TLU-2 policy that encourages high density development for commuting purposes will discourage urban sprawl and protect vegetation, and land protection measures such as AFW-4 will promote high density development over sprawl. Therefore, the joint TLU-2 and AFW-4 policy implementation will have a synergistic effect. Because the criteria pollutant emissions reductions from these two policies are calculated based on two different metrics (reduced VMT for TLU-2 and avoided carbon emissions from the conversion of forests to settlements for AFW-4), the emission reductions for the two policies may be summed as co-benefits.

5.3.3. Removal of Atmospheric Pollutants by Forests, Wetlands, and Agricultural Lands: The AFW-2, AFW-3, and AFW-4 policy measures all promote vegetation growth in different parts of the state. The AFW-2 policy (Managing Urban Trees & Forests) considers land in developed areas, AFW-3 (Afforestation, Reforestation, and Restoration of Forests & Wetlands) considers acreage that is being restored to a natural state, and AFW-4 (Protection & Conservation of Agricultural Land, Coastal Wetlands & Forested Land) protects lands that are currently in a natural or agricultural state. Because they protect different geographic areas, these three policies do not have significant overlap.

Because the policies did not overlap, the emissions reductions achieved by the vegetative removal of pollutants across Maryland were calculated as the sum of the emissions reductions from the three policies. Table 5.7 presents the totals.

Table 5.7. Possible Removal of Atmospheric Criteria Pollutants by Forests, Wetlands, and Agricultural Lands

Pollutant	Emissions Reductions (tons per year)		
	2012	2015	2020
SO_2	410	670	1,100
NO_X	620	1,000	1,600
CO	not estimated		
VOC	not estimated		
PM10	3,300	5,400	9,000
PM2.5	not estimated		

Emissions Reductions from Area/Offroad Sources: This category covers policies that are not necessarily associated with emissions from stationary point sources or onroad emissions:

- Part of RCI-1 Improved Building & Trade Codes (the direct combustion in residential and commercial space)
- AFW-5 "Buy Local" Programs
- AFW-7b In-State Liquid Biodiesel Production
- AFW-9 Waste Management & Advanced Recycling

Because some of these policies would take place at smaller facility operations that are likely below the Title V permit levels, they are generally modeled as area source emissions for air quality modeling exercises.

These four policies do not appear to have significant overlap with one another or with other policies evaluated in this study. Therefore, the expected emissions reductions were summed together to calculate the impact of all four policies on emissions reductions (Table 5.8). Policy AFW-7b did not contain emissions reduction estimates for 2012, and AFW-9 did not include estimates for 2012 or 2015. The ranges in 2020 emissions reduction estimates have large spans because the tonnage estimates for AFW-9 ranged from 10 percent reductions in the amounts sent to landfills and incineration to 50 percent reductions in the amounts.

Table 5.8. Possible Criteria Pollutant Emissions Reductions from Area/Offroad Sources

Pollutant	Emissions Reductions (tons per year)		
	2012	2015	2020
SO_2	290	950	2,600-3,400
NO_X	110	370	1,400-3,400
CO	190	1,300	2,400-2,700
VOC	170	640	2,000
PM10	160	510	1,800-1,900
PM2.5	120	360	1,200-1,300

5.3.4. Emissions Reductions from Institutional Sources: Only one evaluated policy (RCI-4 Government Lead-By-Example) dealt with emissions reductions that were likely to occur at government complexes. The emissions reductions from government complex direct combustion processes result from the development of Energy Performance Contracts by the State. The reduced natural gas usage rates at the government complexes do not overlap with emissions reductions from other policies and appear in Table 5.9.[179]

[179]The only other RCI policy that affects direct combustion in buildings is RCI-1. Policy RCI-1 reduces direct combustion of fossil fuels through the adoption of building codes governing the construction of new buildings, as well as major renovations to existing buildings. Since the EPCs affect existing buildings only there would be no overlap between emission reductions achieved at new government buildings under RCI-1 and reductions achieved at existing buildings under RCI-4. It is possible, however, that there might be overlap between RCI-1 and RCI-4 if, for example, a government building included in one of the EPCs were to undergo a major renovation at some future point in time. In such a situation, the improvement in the building's energy efficiency resulting from implementation of the EPC might reduce opportunities for further efficiency improvements under future building codes when the renovation is undertaken. However, it is not necessarily the case that implementation of the EPC would reduce efficiency improvement opportunities under future building codes; nor is it necessarily the case that any of the buildings covered under the existing EPCs will be subject to major renovations governed by the future building codes to be adopted under RCI-1. The existence of any overlap between RCI-1 and RCI-4 is thus highly speculative and, to the extent that such overlap does exist, is likely to be limited in magnitude in SAIC's judgment.

Table 5.9. Possible Criteria Pollutant Emissions Reductions from Institutional Sources

Pollutant	Emissions Reductions (tons per year)		
	2012	2015	2020
SO_2	--	--	--
NO_X	20	25	23
CO	18	23	23
VOC	1	2	2
PM10	2	2	2
PM2.5	2	2	2

Table 5.10 presents the totals from the five independent sectors (Tables 5.4 through 5.8) and might be considered the approximate emissions reductions if all eighteen policies were implemented. The highest uncertainties in Table 5.10 from an overlap perspective are likely in the CO and VOC emissions reductions because the overlapping transportation planning policies dominate those reductions.

Table 5.10. Possible Criteria Pollutant Emissions Reductions from All Sectors

Pollutant	Emissions Reductions (tons per year)		
	2012	2015	2020
SO_2	15,000	14,000	21,000-22,000
NO_X	7,400-7,900	10,000-11,000	7,900-15,000
CO	5,100-5,300	13,000-14,000	39,000-75,000
VOC	490-500	1,300	3,800-5,900
PM10	5,500	8,000	13,000
PM2.5	1,900	2,500	3,100-3,300

5.4. Conclusion

This chapter presented a general discussion of policy overlap, and a more detailed discussion of the interactions between the various greenhouse gas mitigation policies re-analyzed by SAIC. This overlap discussion of the policies included both the greenhouse gas mitigation and air quality benefits of the policies. The majority of the interactions occur within each of the policy categories (AFW, TLU, RCI, ES), but there are significant inter-category interactions between the RCI and ES policies. Among the RCI and ES categories, policies that specify broad policy goals without specifying implementation steps tend, by definition, to subsume other more specifically delineated policies, which contribute to the broad policy goals.

In addition to the co-benefit to air quality, many of the GHG mitigation policies also impact positively upon the Chesapeake Bay by reducing air pollution that is deposited directly or indirectly into the bay. A detailed discussion of this co-benefit is provided in Chapter 6.

Chapter 6: Water Quality Co-benefits Analysis

6.1. Introduction

A co-benefit of implementing measures that reduce GHG and criteria pollutant emissions is an improvement in the Chesapeake Bay's water quality. Approximately one-third of the nitrogen that reaches the Bay comes from emissions released into the air from vehicles, industries, power plants, dry cleaners, gas-powered lawn tools and other emission sources.[180] The nitrogen from these airborne emissions is delivered to the Bay directly by deposition onto that water body and indirectly by deposition onto land and tributaries within the watershed. The nitrogen on land migrates to the Bay through a series of complex physical, biological, and chemical processes. Runoff from the stream system eventually delivers a portion of the nitrogen to the Bay. Since a direct correlation between atmospheric concentrations of nitrogen and subsequent nitrogen loading to the Bay does not exist, models are used to estimate the local loading of nitrogen and are summed at the Bay level.

The purpose of this chapter is to analyze and quantify the co-benefits of Maryland's climate change strategies on improving the Chesapeake Bay's water quality. An atmospheric and hydrologic transport modeling analysis is used for this purpose. This chapter presents an estimate of the nitrogen load reduction to the Bay from select climate policies for years 2012, 2015, and 2020 and documents the methodology used to quantify it.

6.2. Methodology

This section presents the modeling approach, as well as both an overview and detailed discussion of the inputs to the models used.

6.2.1. Modeling Approach

Two types of models are required to estimate the quantity of atmospheric nitrogen that is transported to the Chesapeake Bay. One model is required to estimate the atmospheric transport, dispersion, transformation, and deposition of nitrogen species, and a second is required to estimate the delivery of deposited nitrogen to the Bay. The CALPUFF and SPARROW models were selected for this analysis because they have been used by the Maryland Department of Natural Resources and other agencies to analyze nitrogen load reductions, and have provided results that are consistent with other established modeling approaches, such as the Chesapeake Bay Program HSPF (Hydrologic Simulation Program - Fortran) watershed model. A brief description of the two models used in this analysis is as follows:

<u>CALPUFF</u> This is a multi-layer, multi-species, non-steady state Gaussian puff dispersion model which simulates the effects of time- and space-varying meteorological conditions and pollutant transport, transformation, and removal.[181] It was developed by the Sigma Research Corporation in the late 1980s under contract with the**Cal**ifornia Air Resources Board, and is designed to simulate the dispersion of buoyant, **puff** or continuous point and area pollution sources as well as the dispersion of buoyant,

[180] Chesapeake Bay Program, Air Deposition http://www.chesapeakebay.net/airdeposition.aspx?menuitem=14746
[181] Yegnan, Garrison, Joshi, and Sherwell, 2009.*Estimation and Analysis of Long-Term Trends in Nitrogen Deposition Using CALPUFF,* The Air & Waste Management Association's 96th Annual Conference & Exhibition

continuous line sources. It is currently being distributed by the Atmospheric Studies Group at the TRC Environmental Corporation. It uses surface, upper air, and precipitation observations as recorded at National Weather Service stations, and NO_X emissions obtained from the U.S. Environmental Protection Agency's (EPA) National Emissions Trends inventory (NEI). CALPUFF predicts monthly average deposition flux rates (wet and dry).

SPARROW (**SPA**tially **R**eferenced **R**egressions on **W**atershed) This hydrologic flow and nutrient transport model is used to estimate the nitrogen delivery to the Bay by simulating the migration of nitrogen over the land surface and within the stream system. It was developed by the U.S. Geological Survey to provide information that is consistent with and supplemental to the Chesapeake Bay Program HSPF watershed model. For this reason, the same input data sets for the nutrient and land-characteristic parameters are used in both the SPARROW and HSPF models; however, a separate nitrogen load data base is used in SPARROW because its statistical nature allows calibration using loading information from more locations. A limitation of the SPARROW model is a lack of temporal variability, which means that it only provides predictions for one time period, typically a year. Thus, the SPARROW model provides detailed spatial information that represents a "snapshot" in time, but does not represent cumulative deposition over longer periods.

A spreadsheet version of the SPARROW model is used in this analysis. As designed by the Maryland Department of Natural Resources,[182] the spreadsheet tool expedites the process of determining nitrogen load reductions to the Chesapeake Bay based on changes in atmospheric nitrogen levels. The SPARROW spreadsheet tool uses CALPUFF and SPARROW modeling runs that simulate the nitrogen load to the Bay during the year 2002.

6.2.2. Modeling InputOverview

In order to compare the nitrogen deposition to the Chesapeake Bay with and without Maryland's climate change policies in place, it is necessary to create separate SPARROW spreadsheets that represent base NO_X emission scenarios for 2012, 2015, and 2020. Because SPARROW spreadsheets are based on 2002 emission estimates (2002 National Emission Inventory [NEI]), the base spreadsheets for 2012, 2015, and 2020 adjust the emissions to represent activities that have taken place since 2002 and were expected to take place regardless of climate change policies (when the regional MANE-VU inventories[183]were constructed).

Base SPARROW spreadsheets for 2012, 2015, and 2020 use the NO_X emissions levels in the absence of any Maryland climate change policies (including ES-3 [Regional Greenhouse Gas Initiative (RGGI)]). The base SPARROW spreadsheets for 2012, 2015, and 2020 predict deposition to the watershed as if no climate change policies had been implemented. However, other programs (e.g., Maryland's Healthy Air Act) continued to reduce the nitrogen deposition to the watershed.

[182]John Sherwell, Power Plant Research Program, Department of Natural Resources, Annapolis, MD, jsherwell@dnr.state.md.us
[183]MANE-VU Future Year Emissions Inventory, http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory

The climate change overlap analysis (Chapter 5) presents ranges (low to high) for the expected NO_X emission reductions. These reductions are added to the base spreadsheets to determine the range of climate change nitrogen deposition rates in 2012, 2015, and 2020. The differences between nitrogen deposition in the policy cases and those in the base cases are reported.

6.2.3. Modeling InputDetails

The total NO_X emission reductions for all policies re-estimated and re-documented by SAIC, following adjustment for overlap, are entered into the SPARROW spreadsheet tool by sector. Therefore, the modeling analysis and results represent the benefits to the Chesapeake Bay of all of the policies combined. The SPARROW spreadsheet tool divides the emissions into four sectors: utility, mobile, industry, and area. The area sector represents anthropogenic activities that do not fall into the utility, mobile, and industry categories, including off-road emissions, commercial and residential emissions, and small source emissions. A description of how the Maryland policies fall into these sectors is included in Chapter 5, and the range of expected emission reductions are summarized in Table 6.1.

Table 6.1. Summary of NO_X Emission Reduction Ranges by Sector Following Overlap Analysis

Within Maryland		NO_X Emission Reductions (tons per year)					
Sector	**Policies**	**2012 Low**	**2012 High**	**2015 Low**	**2015 High**	**2020 Low**	**2020 High**
Utility	RCI electricity generation and ES	6,300	6,800	8,000	9,000	3,200	5,700
Mobile	TLU 2,3,5,6,8,9	370	370	740	740	1,700	4,600
Area	RCI-1 direct combustion, AFW-5,7b,9	110	110	370	370	1,400	3,400
Industrial	RCI-4 direct combustion	20	20	25	25	23	23
Total		**7,400**	**7,900**	**10,000**	**11,000**	**7,900**	**15,000**

The NO_X emission reductions are presented as ranges (low and high) for years 2012, 2015, and 2020. All NO_X emission reductions described in Chapter 5 are included in the analysis, except for the removal of atmospheric pollutants by forests, wetlands, and agricultural lands. Those NO_X reductions are not included in this analysis because land use changes are not represented with the SPARROW spreadsheet, which only assigns specific deposition ratios to the individual sources. To account for changes in land use, a mechanistic model such as the Chesapeake Bay HSFP model is necessary.

The SPARROW spreadsheet tool estimates how deposition to the watershed would have changed in 2002 if various emission reductions were implemented. Through CALPUFF model runs, the spreadsheet relates the 2002 National Emissions Inventory estimates to deposition within the watershed. The spreadsheet tool assumes that the projections of nitrogen deposition to water bodies and land are linear with respect to the NO_X emissions levels at each source. However, utility emissions have dropped substantially since 2002 based on the state and federal air quality programs as shown in Table 6.2. For example, Maryland's NO_X emissions have dropped 74 percent from 2002 to 2010. To account for this drop in NO_X emissions, the SPARROW spreadsheet tool has been adjusted.

Table 6.2. Summary of Actual NO_X Emission Reductions by State from EPA's Clean Air Market Division (CAMD)[184]

NO_X reductions from 2002 to 2010 at CAMD Facilities							
State	Percent Reduction	State	Percent Reduction	State	Percent Reduction	State	Percent Reduction
Alabama	61%	Iowa	44%	Nevada	76%	South Dakota	17%
Arizona	29%	Kansas	49%	New Hampshire	30%	Tennessee	80%
Arkansas	10%	Kentucky	54%	New Jersey	77%	Texas	43%
California	58%	Louisiana	42%	New Mexico	23%	Utah	15%
Colorado	24%	Maine	38%	New York	66%	Vermont	38%
Connecticut	60%	Maryland	74%	North Carolina	66%	Virginia	58%
Delaware	53%	Massachusetts	73%	North Dakota	28%	Washington	23%
District of Columbia	9%	Michigan	43%	Ohio	72%	West Virginia	77%
Florida	72%	Minnesota	64%	Oklahoma	17%	Wisconsin	63%
Georgia	59%	Mississippi	33%	Oregon	-10%	Wyoming	27%
Idaho	-24%	Missouri	58%	Pennsylvania	38%		
Illinois	56%	Montana	38%	Rhode Island	-63%		
Indiana	57%	Nebraska	21%	South Carolina	68%		

The SPARROW spreadsheet tool adjustment accounts for the statewide NO_X emission reductions that took place from 2002 to 2010 to create a new base case. The 2002 to 2010 statewide NO_X emission reductions are treated as controls on the utility sector in each state in order to estimate the 2012 emissions baselines. Because these NO_X reductions have occurred while the RGGI program has been in place, it is assumed that NO_X emissions reductions within states falling mostly within the PJM regional transmission organization have already been affected by RGGI. Those NO_X reductions and eliminations may have included fuel switching (coal-fired plant conversions to gas-fired), the development of power generation without the use of fossil fuels (e.g. increased nuclear or renewable power), or energy conservation efforts.

[184] EPA's Clean Air Market – Data and Maps. http://camddataandmaps.epa.gov/gdm/. 5/27/2011

Therefore, the base case subtracts out the control reductions that have been attributed to RGGI (see previous discussions of ES-3 policy).

The 2002 NEI for mobile source NO_X emissions also differs significantly from the 2012 MANE-VU forecast. For example, Maryland's mobile source emissions in the 2012 MANE-VU inventory are 56 percent lower than those in the 2002 NEI. Differences between the two might be attributable to control programs, new emissions models, or changes in activity levels (e.g., miles driven) implemented since development of the 2002 NEI inventory. To create the base 2012 SPARROW spreadsheet (from the 2002 NEI SPARROW spreadsheet), NO_X controls are assumed to be implemented on the mobile source sector in the MANE-VU states (ranging from 42 percent in Pennsylvania to 64 percent in New Jersey) for the baseline condition before any climate change policies are adopted.

Because the climate change policies in this study have little effect on NO_X emissions from the industry and area source sectors, the inputs for these sectors for the base 2012 SPARROW spreadsheet have not been adjusted from the original values in the 2002 NEI SPARROW spreadsheet. However, the base 2015 and 2020 SPARROW spreadsheets required additional processing, using the MANE-VU inventories for 2012 and 2018 as the benchmarks. Thus, the statewide NO_X emissions reductions from 2012 to 2018 are totaled from the area and industrial sources and converted into percentage changes over that time period, as shown in **Table 6.3**.

Table 6.3. Differences Between the 2012 and 2018 MANE-VU Inventories

State	**Area**	**Industrial**	**Mobile**	**Utility**
Connecticut	-11%	6%	-47%	-5%
Delaware	-15%	3%	-47%	-2%
District of Columbia	-14%	9%	-50%	-1400%
Maine	-10%	7%	-42%	-3%
Maryland	-11%	12%	-44%	-8%
Massachusetts	-8%	8%	-50%	4%
New Hampshire	-5%	3%	-47%	-4%
New Jersey	-13%	10%	-47%	0%
New York	-8%	7%	-44%	26%
Pennsylvania	-13%	10%	-44%	13%
Rhode Island	-9%	-1%	-36%	12%
Vermont	-12%	1%	-41%	-48%
Total	**-10%**	**9%**	**-45%**	**10%**

Just as the EPA's Clean Air Markets Division (CAMD) changes in Table 6.2 are applied to the 2002 SPARROW spreadsheet to construct the base 2012 SPARROW spreadsheet, the inventory changes in Table 6.3 are applied to convert the base 2012 SPARROW spreadsheet into the base 2015 and 2020 SPARROW spreadsheets. For the conversion of the base 2012 SPARROW spreadsheet to the base 2015 SPARROW spreadsheet, the percent inventory changes are assumed to be half what would occur from

2012 to 2018. In the absence of forecasting information, the percent inventory changes for the base 2020 SPARROW spreadsheet are assumed to match those for the 2012 to 2018 inventory changes. For states outside of MANE-VU, the percentages listed as "Total" in Table 6.3 are used.

The NO_X emission reductions are entered into the spreadsheet tool as percentage reductions. To calculate the percentages, the NO_X emission reductions[185] are divided by the total NO_X emissions[186]. These NO_X emission values are shown in Table 6.4 along with the resulting percent reductions. The out-of-state NO_Xemission reduction percentages are shown in Table 6.5.

[185] As reported by sector in the overlap analysis section of this report (Tables 5.5, 5.6, 5.8, and 5.9 of Chapter 5)

[186] As reported by sector in the MANE-VU inventory (http://www.marama.org/technical-center/emissions-inventory/2002-inventory-and-projections/mane-vu-future-year-emissions-inventory) withsector categories = MD utility, mobile, area, non-road (added to area sector) and MD nonEGU point (industrial) in years 2012 and 2018.

Table 6.4. Maryland NO_X Emission Inventory and Reduction Values by Sector and Reduction Percentages Used in the Analysis

Sector	Reductions/Inventory	NO_X Emission Reductions					
		2012 Low*	2012 High	2015 Low	2015 High	2020 Low	2020 High
Utility	Reduction (tons per year)	6,300	6,800	8,000	9,000	3,200	5,700
	Inventory with RGGI (tons per year)[187]	14,000	14,000	14,000	14,000	15,000	15,000
	Reduction (%)	**46**	**50**	**56**	**64**	**22**	**39**
Mobile	Reduction (tons per year)	370	370	740	740	1,700	4,600
	Inventory (tons per year)	50,000	50,000	39,000	39,000	28,000	28,000
	Reduction (%)	**1**	**1**	**2**	**2**	**6**	**16**
Area	Reduction (tons per year)	110	110	370	370	1,400	3,400
	Inventory (tons per year)	38,000	38,000	36,000	36,000	34,000	34,000
	Reduction (%)	**0.3**	**0.3**	**1**	**1**	**4**	**10**
Industrial	Reduction (tons per year)	20	20	25	25	23	23
	Inventory (tons per year)	20,000	20,000	22,000	22,000	23,000	23,000
	Reduction (%)	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**

*The "low" and "high" estimates are based upon the overlap analysis in Chapter 5, and are similarly presented in Table 6.1.

[187]Note that the RGGI program is a climate change program that has been included in the MANE-VU inventory estimates.

Table 6.5. NO_X Emission Reduction Percentages Used in the Analysis

Outside Maryland		NO_X Emission Reductions (%)					
Sector	Policies	2012 Low	2012 High	2015 Low	2015 High	2020 Low	2020 High
Utility	ES and RCI	42	42	49	49	56	56

6.3. Modeling Predictions

Table 6.6 shows the nitrogen load reduction estimates for years 2012, 2015, and 2020 as predicted by the SPARROW spreadsheet tool. The nitrogen load reductions that result from reduced levels of NO_X emissions being deposited on the land surface are reported by state. The nitrogen load reductions that result from reduced levels of NO_X emissions being deposited directly into the tidal Bay are reported in the row labeled "Tidal Bay". The sum of the nitrogen load reductions transported from land and deposited directly to the tidal Bay are reported in the "Total" rows.

Table 6.6 also shows the out-of-state nitrogen load reduction estimates for years 2012, 2015, and 2020 as predicted by the SPARROW spreadsheet tool. These values represent the total benefit from utility NO_X reductions in states from where Maryland imports electricity. In other words, the values represent the sum of estimated reductions in nitrogen load to the Bay due to NO_X reductions at the out-of-state utilities.

Table 6.6. Modeling Results - Nitrogen Load Reductions to the Bay from Maryland NO_X Reductions

Co-benefits (lbs)	Nitrogen Load Reductions (lbs)					
	2012 Low	2012 High	2015 Low	2015 High	2020 Low	2020 High
Maryland	113,700	116,000	145,000	148,000	184,000	290,000
New York	23,000	23,000	27,000	27,000	30,000	31,000
Pennsylvania	290,000	291,000	341,000	343,000	380,000	399,000
West Virginia	32,000	32,000	38,000	38,000	43,000	46,000
Delaware	4,000	4,000	5,000	5,000	5,000	6,000
Virginia	202,000	204,000	238,000	242,000	256,000	280,000
District of Columbia	2,000	2,000	2,400	2,500	3,000	5,000
Tidal Bay	273,000	277,000	329,000	337,000	356,000	448,000
Total	939,000	948,000	1,125,000	1,143,000	1,257,000	1,504,000

The SPARROW spreadsheet tool predictions for nitrogen load reductions transported from land to the Chesapeake Bay, as well as direct to the tidal bay, from each jurisdiction in 2012 and 2020 are also shown on **Figures 6.2 and 6.3**, respectively. The benefits within the state of Pennsylvania and Virginia are quite large relevant to other states (including Maryland) due to the contributions from the Susquehanna and Potomac basins, respectively.

Figure 6.2. Modeling Results - Nitrogen Load Reductions to the Bay by Jurisdiction in 2012

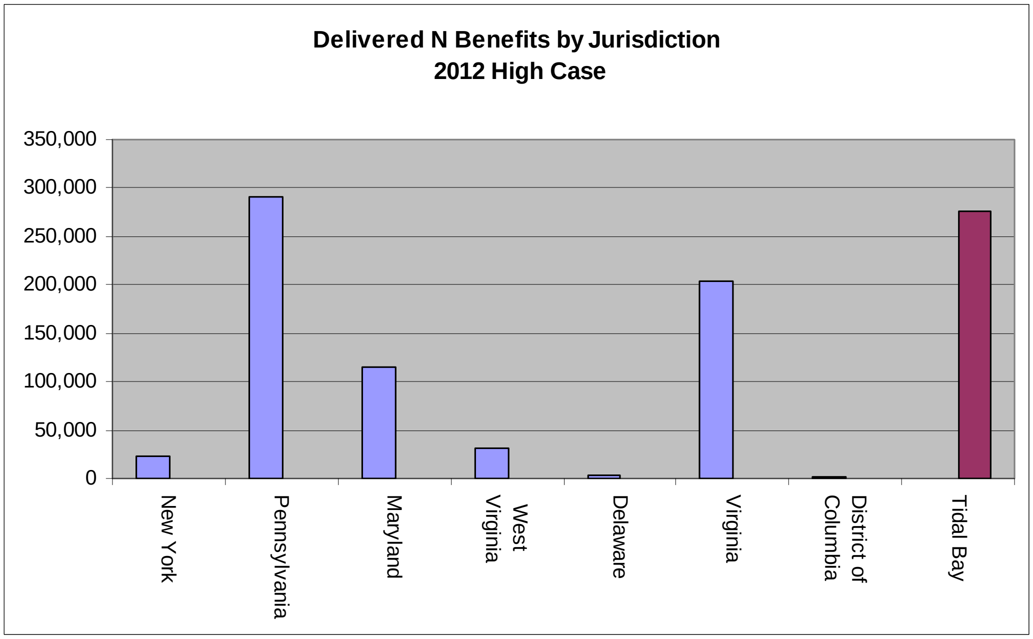
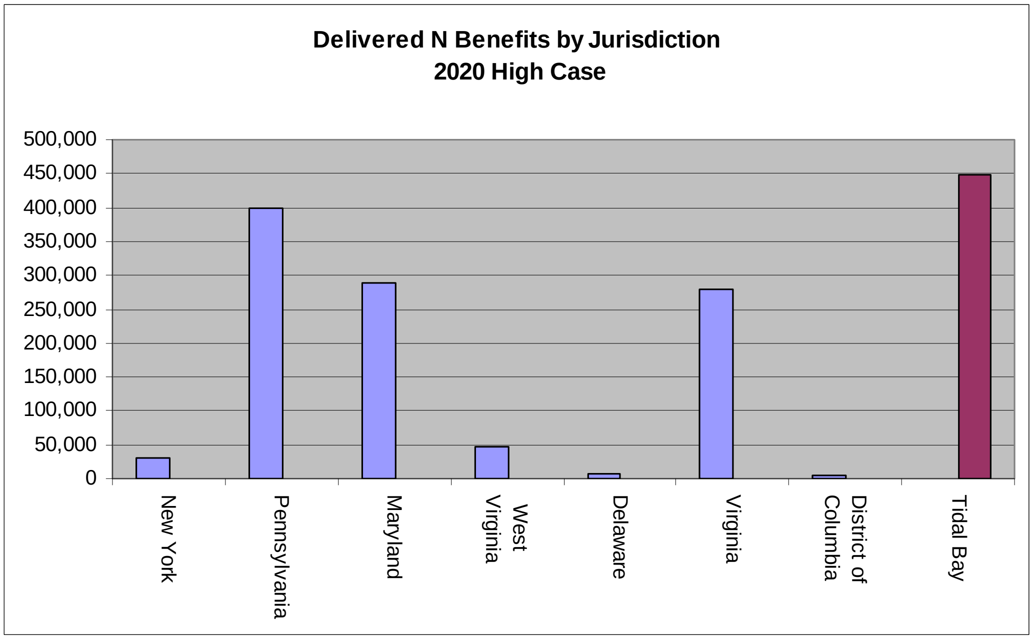


Figure 6.3. Modeling Results - Nitrogen Load Reductions to the Bay by Jurisdiction in 2020



6.4. Conclusion

This chapter estimates the nitrogen load reduction to the Chesapeake Bay from select climate policies for years 2012, 2015, and 2020. The SPARROW spreadsheet tool was used to make the predictions. The total NO_X emission reductions for policies re-estimated and re-documented by SAIC, following adjustment for overlap, were entered into the SPARROW spreadsheet tool (i.e., RCI, ES, TLU 2, 3, 5, 6, 8, 9, and AFW 5, 7b, 9 policies). The SPARROW modeling results represent the benefits to the Chesapeake Bay from all of the policies combined.

The SPARROW modeling analysis predicts that the total nitrogen load reductions to the Chesapeake Bay will be in the range of 0.94 to 0.95 million pounds in 2012. The total nitrogen load reductions will increase to the range of 1.13 to 1.14 million pounds in 2015, and increase again to the range of 1.26 to 1.5 million pounds in 2020. In Maryland, the range of nitrogen load reductions in 2012 is predicted to be between 114 to 116 thousand pounds. In 2015, the range of load reductions is predicted to increase to between 145 to 148 thousand pounds, and increase again to the range of 184 to 290 thousand pounds in 2020.

Appendix – Equations Used to Estimate GHG Reductions and Air Quality Co-benefits

This appendix lists the equations used to estimate GHG reductions and air quality co-benefits, per policy. **For detailed information on the calculations, please refer to the individual policy discussions in the body of this report.**

Chapter 1: Residential, Commercial, and Industrial (RCI) Policies

RCI-1. Improved Building and Trade Codes

$NBA_{i,t} = (NBB_{i,t})(LGAR_i)$

$EBA_{i,t} = (R_t)(NBA_{i,t})$

Where

$NBA_{i,t}$ = Number of new housing units, or million square feet of commercial space, of type t (residential or commercial) built to code in year i

$NBB_{i,t}$ = Total number of new housing units, or million square feet of commercial space, of type t (residential or commercial) built in year i

$LGAR_i$ = Fraction of MD localities adopting new code in year i

$EBA_{i,t}$ = Number of existing housing units, or million square feet of commercial space, of type t (residential or commercial) undergoing major renovations according to code in year i

R_t = Ratio of renovated to new buildings, of type t (residential or commercial)

$ES_{i,t} = [(ESG_{i,t})(NBA_{i,t}) + (RESEN)(ESG_{i,t})(EBA_{i,t})](AEU_t)$

Where

$ES_{i,t}$ = Energy saved by new and renovated buildings of type t (residential or commercial) built to code in year i (mmBtus)

$ESG_{i,t}$ = Energy saved via adoption of new code by buildings of type t (residential or commercial) in year i (fraction)

RESEN = Energy saved through renovation of existing buildings, as a fraction of energy saved by new buildings

AEU_t = Average current energy use of buildings of type t (residential or commercial) (mmBtus/square foot or unit/year)

The specific algorithms used to complete Step 3 were as follows:

$$E_i = (ES_{i,r})(1+TD)(RE_i) + (ES_{i,c})(1+TD)(CE_i) \quad (4)$$

$$FS_{i,t} = (ES_{i,r})(RFF_{i,t}) + (ES_{i,c})(CFF_{i,t}) \quad (5)$$

Where

E_i = Total electricity saved by buildings built/renovated to code in year i (mmBtus)

$FS_{i,t}$ = Total direct fuel saved by buildings built/renovated to code in year i (mmBtus), by fuel type t (e.g., natural gas, distillate oil, etc.)

$ES_{i,r}$ = Energy saved by new and renovated residential buildings built/renovated to code in year i (from Equation 3, in mmBtus)

$ES_{i,c}$ = Energy saved by new and renovated commercial buildings built/renovated to code in year i (from Equation 3, in mmBtus)

TD = Electricity losses due to transmission and distribution (fraction)

$RFF_{i,t}$ = Fraction of total energy savings by residential buildings of fuel type t (natural gas, distillate oil, etc.), in year i

$CFF_{i,t}$ = Fraction of total energy savings by commercial buildings of fuel type t (natural gas, distillate oil, etc.), in year i

RE_i = Fraction of total energy savings by residential buildings in the form of electricity

CE_i = Fraction of total energy savings by commercial buildings in the form of electricity

The specific algorithm used to complete Step 4 was as follows:

$$ER_i = (EEFIS_i)\left[\sum_{y=2009 \text{ to } i} (E_y)(FIS_y)\right] + (EEFOS_i)\left[\sum_{y=2009 \text{ to } i} (E_y)(1-FIS_y)\right] +$$

$$\sum_{2009 \text{ to } i,\, t} (FS_{y,t})(FEF_t)$$

Where

ER_i = Total emission reductions from buildings built/renovated to code in year i (metric tons CO_2e)

FEF_t = Emission factor for fuel type t (metric tons/mmBtu)

FIS_y = Fraction of total electricity from in-state generators in year y (where y is a year between 2009 and i)

$EEFIS_i$ = Electricity emissions factor for in-state generators in year i (metric tons CO_2e/mmBtu)

$EEFOS_i$ = Electricity emissions factor for out-of-state generators in year i (metric tons CO_2e/mmBtu)

RCI-4. Government Lead-By-Example

$KWH\$ = KWH_{15} / Cost_{15}$

And

$mmBTU\$ = mmBTU_{15} / Cost_{15}$

Where

$KWH\$$= average kilowatt hours saved per program dollar cost, for all fifteen EPC projects for which data was provided (KWh/$)

$mmBTU\$$ = average mmBTU saved per program dollar cost, for all fifteen EPC projects for which data was provided (mmBTU/$)

$Cost_{15}$ = total approximate cost of all fifteen EPC projects for which data was provided ($)

KWH_{15} = total electricity saved for all fifteen EPC projects for which data was provided (KWh)

$mmBTU_{15}$ = total thermal energy saved for all fifteen EPC projects for which data was provided (mmBTU)

$KWH_y = [KWH_{15} + (KWH\$ \text{ x } \sum_i NEW\$_{i,y})] \text{ x } (1+TL)$

And

$mmBTU_y = mmBTU_{15} + (mmBTU\$ \text{ x } \sum_i NEW\$_{i,y})$

Where

KWH_y = total electricity saved for all EPC projects in year *y* (KWh)

$mmBTU_y$ = total thermal energy saved for all EPC projects in year *y* (mmBTU)

$NEW\$_i$ = forecast cost of each new project ($s)

TL = transmission losses (8%)

$ERNG_y = mmBTU \text{ x } (53.08/1000)$

Where

$ERNG_y$ = total annual emissions reductions from natural gas savings per year *y* (tCO_2e)

53.08 = emissions factor for natural gas ($kgCO_2e/mmBTU$)

1000 = conversion factor from kilograms to metric tons

$ERIE_y = (KWH/1000) \times EFIE_y \times 0.71$

Where

$ERIE_y$ = total annual emissions reductions from in-state produced electricity per year *y* (tCO_2e)

$EFIE_y$ = emissions factor for in-state electricity production in year *y* (tCO_2e/MWh)

1000 = conversion factor from kilowatts to megawatts

0.71 = proportion of electricity produced in-state

$EROE_y = (KWH/1000) \times EFOE_y \times (1 – 0.71)$

Where

$EROE_y$ = total annual emissions reductions from out-of-state produced electricity per year *y* (tCO_2e)

$EFOE_y$ = emissions factor for out-of-state electricity production in year *y* (t CO_2e/ MWh)

$MD_y = [MD_{2009} \times (MAC_y / MAC_{2009})] \times (1 + TL)$

Where

MD_y = projected electricity consumption, including losses for the State of Maryland's government in year *y* (KWh)

MD_{2009} = reported electricity consumption for the State of Maryland's government in 2009 (KWh)

MAC_y = EIA projection of mid-Atlantic electricity consumption for the commercial sector in year *y* (quadrillion BTU)

MAC_{2009} = EIA reported mid-Atlantic electricity consumption for the commercial sector in 2009 (quadrillion BTU)

TL = transmission losses (8%)

$SE_y = SS_{2011} + [(SS_{2020} – SS_{2011}) / 9] (y – 2011)$

Where

SE_y = percent of total State electricity from solar sources in year *y* (%)

SS_y = solar electricity standard in year *y*

9 = yearly increments between 2011 and 2020

y = year being modeled

And

$NSE_y = NSS_{2011} + [(NSS_{2020} – NSE_{2011}) / 9] (y – 2011) – BNS$

Where

NSE_y = percent of total State electricity from non-solar Tier 1 sources in year *y*

NSS_y = non-solar Tier 1 standard in year *y*

9 = yearly increments between 2011 and 2020

BNS = baseline non-solar Tier 1 renewable electricity produced in 2008

$$AMER_i = \sum_{m=1}^{12} \sum_{j=1}^{4} PR_j * MEF_{m,j} * MER_m$$

Where

$AMER_i$ = Adjusted Marginal GHG Emissions Rate for Year i (million metric tons CO_2e per MWh)

m = month

j = Resource

PRj = Percentage of Resource j (wind, biomass, landfill gas, or hydro; solar is calculated separately)

MEF_{mj} = Monthly Energy Factor for month m for resource j (% of annual energy produced in month m)

MER_m = Marginal GHG Emissions Rate for month m (million metric tons CO_2e per MWh)

$ERSE_y = SE_y$ x MDy x $AMER_{y,s}$

And

$ERNS_y = (NSE_y$ x MDy x $AMER_{y,ns}) – \sum_i(NSE_{y,i}$ x $EF_i)$

Where

ERSE = total annual emissions reductions in year *y* from the use of solar electricity (tCO_2e)

$AMER_{y,s}$ = annual marginal emissions factor for avoided emissions from use of solar electricity in year *y* (tCO_2e/MWh)

ERNE = total annual emissions reductions in year *y* from the use of non-solar Tier 1 electricity (tCO_2e)

$AMER_{y,ns}$ = annual marginal emissions factor for avoided emissions from use of non-solar Tier 1 electricity in year *y* (tCO_2e/MWh)

$NSE_{y,i}$ = percent of non-solar Tier 1 electricity from renewable source *i* in year *y* (%)

EF_i = emissions factor for renewable source *i*

RCI-10. EmPOWER Maryland

$ES_{i,s} = (P_i)(EC_{2007}/P_{2007})(SG_i)(SF_s)$

Where

$ES_{i,s}$ = Total reduction in electricity consumption (in MWh) in year i, for sector s (where s is residential, commercial, or industrial)

EC_{2007} = Total MD electricity consumption in 2007, including losses (in MWh)

P_{2007} = MD population in 2007 (in MWh)

P_i = MD projected population in year i

SG_i = RCI-10 electricity saving's goal for year i (fraction)

SF_s = Fraction of total saving's goal to be met by each sector s (where s is residential, commercial, or industrial)

$ERIS_{i,s} = (ES_{i,s})(FIS_i)(EEFIS_i)$

$EROS_{i,s} = (ES_{i,s})(1\text{-}FIS_i)(EEFOS_i)$

Where

$ERIS_{i,s}$ = In-State emission reductions in year i (in metric tons CO_2e) for sector s (where s is residential, commercial, or industrial)

$EROS_{i,s}$ = Emission reductions from imported electricity in year i (in metric tons CO_2e) for sector s (where s is residential, commercial, or industrial)

FIS_i = Fraction of total electricity from in-state generators in year i

$EEFIS_i$ = Electricity emissions factor for in-state generators in year i (metric tons CO_2e/MWh)

$EEFOS_i$ = Electricity emissions factor for out-of-state generators in year i (metric tons CO_2e/MWh)

Chapter 2: Energy Supply (ES) Policies

ES-3. GHG Cap and Trade

$TER_i = PE_i - RC_i$

Where

TER_i = Total GHG emission reductions in year i for ES-3 (million metric tons CO_2e)

PE_i = Projected Emissions without RGGI for year i, (million metric tons CO_2e)

RC_i = RGGI Cap for year i, (million metric tons CO_2e)

ES-7. Renewable Portfolio Standard

$CGR_i = CG_i * PR_i$

Where

CGR_i = Coal Generation Replaced for year i (GWh)

CG_i = Coal Generation for year i (GWh)

PR_i = Percentage of coal generation Replaced for year i (%)

$CER_i = CGR_i * CER_i$

Where

CER_i = Coal Emissions Reduction for year i ($MMTCO_2e$)

CGR_i = Coal Generation Replaced for year i (GWh)

CER_i = Coal Emissions Rate ($MMTCO_2e$ per GWh)

$NGE_i = CGR_i * NGER_i$

Where

NGE_i = Natural Gas Emissions for year i ($MMTCO_2e$)

CGR_i = Coal Generation Replaced for year i (GWh)

$NGER_i$ = Natural Gas Emissions Rate ($MMTCO_2e$ per GWh)

Coal Plant Repowering Option: $NER_i = CER_i - NGE_i$
or

Biomass Cofiring Option: $NER_i = CER_i$

Where

NER_i = Net Emissions Reduction for year i (MMTCO$_2$e)

CER_i = Coal Emissions Reduction for year i (MMTCO$_2$e)

NGE_i = Natural Gas Emissions for year i (MMTCO$_2$e)

ES-8. Efficiency Improvements & Repowering Existing Plants

$CGR_i = CG_i * PR_i$

Where

CGR_i = Coal Generation Replaced for year i (GWh)

CG_i = Coal Generation for year i (GWh)

PR_i = Percentage of coal generation Replaced for year i (%)

$CER_i = CGR_i * CER_i$

Where

CER_i = Coal Emissions Reduction for year i ($MMTCO_2e$)

CGR_i = Coal Generation Replaced for year i (GWh)

CER_i = Coal Emissions Rate ($MMTCO_2e$ per GWh)

$NGE_i = CGR_i * NGER_i$

Where

NGE_i = Natural Gas Emissions for year i ($MMTCO_2e$)

CGR_i = Coal Generation Replaced for year i (GWh)

$NGER_i$ = Natural Gas Emissions Rate ($MMTCO_2e$ per GWh)

Coal Plant Repowering Option: $NER_i = CER_i - NGE_i$
or

Biomass Cofiring Option: $NER_i = CER_i$

Where

NER_i = Net Emissions Reduction for year i ($MMTCO_2e$)

CER_i = Coal Emissions Reduction for year i ($MMTCO_2e$)

NGE_i = Natural Gas Emissions for year i ($MMTCO_2e$)

Chapter 3: Agriculture, Forestry, and Waste (AFW) Policies

Please refer to the policy discussions for the AFW policies. The nature of the methodologies is generally such that it is important to view the equations in context with the accompanying tabular data and detailed methodological descriptions. The equations below only partially capture the quantification process.

AFW-1. Forest Management for Enhanced Carbon Sequestration

Average Annual Sequestration = 1/90 (Sequestration at year 90 - Sequestration at Year 0)

Difference = Average Annual Sequestration in Intensive Stands - Average Annual Sequestration in "Average" Stands (Expressed as a percentage difference = 5%)

Enhanced Average Annual Sequestration per Forest Type = Carbon Storage of Forest Type * Percentage Increase (e.g., 0.8 * 1.05 for oak-hickory)

Weighted Annual Sequestration per Forest Type = Fraction of Forest Type * Enhanced Average Annual Sequestration per Forest Type (e.g., 0.63 * 0.8 * 1.05 for oak-hickory)

Average Annual Sequestration Across Forest Types = Sum of Annual Sequestration per Forest Type (for oak-hickory, oak-pine, and loblolly-shortleaf pine)

Overall Average Annual Sequestration = 0.63 * 0.8 * 1.05 + 0.1 * .604 * 1.05 + 0.11 * 0.662 * 1.05 = 0.669 tons C/acre/year.

AFW-2. Managing Urban Trees & Forests

Please see the discussion of this policy. Methodology is too complex and reliant on accompanying tabular data to be represented as simple equations here.

AFW-3. Afforestation, Reforestation & Restoration of Forests & Wetlands

Average Annual Sequestration = 1/45 (Sequestration at year 45 - Sequestration at Year 0)

Weighted Annual Sequestration per Forest Type = Fraction of Forest Type * Average Annual Sequestration per Forest Type (e.g., for oak-hickory = 0.7 * 1.2 = 0.84 tons/acre/year)

Average Annual Sequestration Across Forest Types = Sum of Weighted Annual Sequestration per Forest Type = 0.7 * 1.2 + 0.15 * 1 + 0.15 * 0.9 = 1.155 tons/acre/year

Total Annual Sequestration (in a given year) = Average Annual Sequestration * CO2/C mass ratio * Annual Acreage * 1 * 10^-6 MMt/Mt (e.g., for 2008 = 1.155 * 44/12 * 6,300 * 10^-6 = 0.027 MMTCO2e)

Total Policy Acreage = 900 miles * 50 feet * 1.894*10^-4 miles/foot * 640 acres/square mile * 0.4 = 2,182 acres.

Annual Acreage = 2,182 acres / 13 years = 168 acres / year

AFW-4. Protection & Conservation of Agricultural Land, Coastal Wetlands & Forested Land

Protecting Agricultural Lands

Loss of Soil Carbon Per Acre (as CO_2) = Soil Carbon Content * Fraction of Land Cleared * Fraction of Carbon Lost * CO_2/C mass ratio

Loss of Soil Carbon Per Acre (as CO_2) = 1.7*10^-5 MMTC * 0.5 * 0.75 * 44/12 = 2.3375 * 10^-5 $MMTCO_2$/acre.

Avoided Emissions = Annual Target for Avoided Land Conversion * Loss of Soil Carbon per acre

(For example for the first year, 909 acres of agricultural land not lost to development = 909 acres * 2.3375*10^-5 $MMTCO_2$/acre = 0.021 $MMTCO_2$)

Avoided Deforestation

Non-soil forest carbon = Total Forest Carbon – Soil Carbon

Non-soil forest carbon = 73.9 - 25.5 = 48.4 metric tons carbon per acre

Carbon lost from Forest to Development Conversion = Fraction of Land Cleared * Fraction of Carbon Lost * Non-soil Forest Carbon

Carbon lost from Forest to Development Conversion = 0.67 * 1 * 48.4 = 32.43 tons carbon per acre.

CO_2 lost from Forest to Development Conversion = Carbon lost from Forest to Development Conversion * CO_2/C mass ratio = 27.9 metric tons C * 44/12 metric ton CO_2/metric ton C = 102.3 metric tons CO_2 per acre.

Avoided Emissions = Acreage * CO_2 "Lost" from Forest to Development Conversion (e.g., for 2008 = 19,200 acres * 102.3 metric tons CO_2 per acre = 1,964,160 tons CO_2 or 1.96 $MMTCO_2$)

Sequestration in Protected Forests

Average Annual Sequestration = 1/50 (Sequestration at year 75 - Sequestration at Year 25)

Weighted Annual Sequestration per Forest Type = Fraction of Forest Type * Average Annual Sequestration per Forest Type (e.g., for oak-hickory = 0.75 * 0.8 = 0.6 tons/acre/year)

Average Annual Sequestration Across Forest Types = Sum of Weighted Annual Sequestration per Forest Type = 0.75 * 0.8 + 0.15 * 0.7 + 0.15 * 0.5) = 0.78 metric tons C/acre/year. In CO_2 terms = 0.78 * 44/12 = 2.86 tons CO_2 / acre / year

Annual Sequestration = Acreage * Average Annual Sequestration Across Forest Types (e.g., for 2008 = 19,200 * 2.86 * 1* 10^-6 $MMTCO_2$= 0.055 $MMTCO_2$)

AFW-5. "Buy Local" Programs

Please see detailed policy discussion.

AFW-6. Expanded Use of Forest & Farm Feedstocks & By-Products for Energy Production

Please see detailed policy discussion.

AFW-7b. In-State Liquid Biodiesel Production

Emission reduction benefit formula: soybean lifecycle EF – (miles*fossil diesel EF)/ gallons of bio-diesel per short ton of soybeans*ton-miles per gallon of diesel = emission reduction benefit, or, 7,207 tCO_2e per million gallon = 7,261$mtCO_2e$ per million gallon – (100*(.01006 $mtCO_2e$)*10^6)/44.632 gal per ton*423 ton-miles

AFW-8. Nutrient Trading with Carbon Benefits

Please see detailed policy discussion.

AFW-9. Waste Management & Advanced Recycling

Please see detailed policy discussion.

Chapter 4: Transportation and Land Use (TLU) Policies

TLU-2. Land Use & Location Efficiency

$TER_i = MS_i * TD_{ji} * VMT * RR * BP_i$

Where

TER_i = Total GHG emission reduction with compact development in year i for Policy TLU-2 (million metric tons CO_2e)

MS_i = Market Share of Compact Development in year i (percent)

TD = Percent of total development built between years j and i (percent)

VMT = % VMT reduction per capita achievable by compact development relative to sprawl (percent)

RR = Ratio CO_2/VMT reduction with compact development

BP_i = Baseline projection of transportation CO_2 in year i (million metric tons CO_2e)

i = 2020

j = estimate base year of 2010[188]

$TBER_i = MS_j * TD_{ji} * BECR * RCI$

Where

$TBER_i$ = Total building energy emissions reductions in year i

BECR = building energy consumption reduction (%)

RCI = Baseline estimate from Residential/Commercial/Industrial (RCI) fuel use in the CAP

188 Different from CAP base year of 2006.

TLU-3. Transit

$TER_i = TER_{2020} * RUF_i$

Where

TER_i = Total GHG emission reductions in year i for Policy TLU-3 ($MMTCO_2e$)

TER_{2020} = Total GHG emission reductions in year 2020 for Policy TLU-3 ($MMTCO_2e$)

RUF_i = Ramp-Up Factor for year i, which reflects how much of the annual GHG reduction in 2020 can be expected to be achieved in year i

RUF_{2012} = 10%

RUF_{2015} = 25%

TLU-5. Intercity Travel

$TER_i = TER_{2020} * RUF_i$

Where

TER_i = Total GHG emission reductions in year i for Policy TLU-5 (million metric tons CO_2e)

TER_{2020} = Total GHG emission reductions in year 2020 for Policy TLU-5 (million metric tons CO_2e)

RUF_i = Ramp-Up Factor for year i, which reflects how much of the annual GHG reduction in 2020 can be expected to be achieved in year i

RUF_{2012} = 0%

RUF_{2015} = 15%

TLU-6. Pay-As-You-Drive Insurance

$TER_i = VMT_i * PR_i * EF * EF$

Where

TER_i = Total GHG emission reduction from TLU-6 in year i (million metric tons CO_2e)

VMT = Relevant VMT (million)

PR_i = Participation Rate in year i

ER = Effectiveness Rate

EF = Composite CO_2e emission factor

i = given year

TLU-8. Bike & Pedestrian Infrastructure

$TER_i = TER_{2020} * RUF_i$

Where

TER_i = Total GHG emission reductions in year i for Policy TLU-8 (million metric tons CO_2e)

TER_{2020} = Total GHG emission reductions in year 2020 for Policy TLU-8 (million metric tons CO_2e)

RUF_i = Ramp-Up Factor for year i, which reflects how much of the annual GHG reduction in 2020 can be expected to be achieved in year i

RUF_{2012} = 10%

RUF_{2015} = 25%

TLU-9. Incentives, Pricing & Resource Measures

$TER_{ij} = TER_{2020} * RUF_{ij}$

Where

TER_{ij} = Total GHG emission reductions in year i for component j of Policy TLU-9 (million metric tons CO_2e)

TER_{2020} = Total GHG emission reductions in year 2020 for each component of Policy TLU-9, which is assumed to be the average of the estimated range (million metric tons CO_2e)

RUF_{ij} = Ramp-Up Factor for year i, which reflects how much of the annual GHG reduction in 2020 can be expected to be achieved by component j in year i

$RUF_{2012,\ \text{VMT fees}} = 0\%$

$RUF_{2015,\ \text{VMT fees}} = 0\%$

$RUF_{2012,\ \text{congestion pricing}} = 0\%$

$RUF_{2015,\ \text{congestion pricing}} = 0\%$

$RUF_{2012,\ \text{employer commute incentives}} = 10\%$

$RUF_{2015,\ \text{employer commute incentives}} = 25\%$

TLU-10. Transportation Technologies

Please see detailed policy discussion.

Appendix C – Maryland Climate Programs

Acronyms Used:

BGE – Baltimore Gas and Electric
CO_2-equivalent – Carbon dioxide equivalent
DBED – Maryland Department of Budget and Economic Development
DGS – Maryland Department of General Services
DHCD – Maryland Department of Housing and Community Development
DHMH – Maryland Department of Health and Mental Hygiene
DNR – Maryland Department of Natural Resources
DPL – Delmarva Power and Light
EPA – U.S. Environmental Protection Agency
GGRA – Greenhouse Gas Emissions Reductions Act of 2009
GHG – Greenhouse gas
LEED – Leadership in Energy and Environmental Design
MACT – Maximum available control technology
MARC – Maryland area regional commuter
MDA – Maryland Department of Agriculture
MDE – Maryland Department of the Environment
MDOT – Maryland Department of Transportation
MDP – Maryland Department of Planning
MEA – Maryland Energy Administration
MIA – Maryland Insurance Agency
$MMtCO_2e$ – million metric tons of CO_2-equivalent
MW – Megawatt
MWh – Megawatt-hour
PE – Potomac Edison
PEPCO – Potomac Electric Power Company
PSC – Maryland Public Service Commission
REC – Renewable energy certificate
RGGI – Regional Greenhouse Gas Initiative
RPS – Maryland Renewable Portfolio Standard
SMECO – Southern Maryland Electric Cooperative
TCI – Transportation Climate Initiative
VMT – Vehicle miles traveled

Figure C-1. Maryland's Climate Programs by Sector with Range of GHG Benefits

Policy I.D.	Policy (Program)	Potential GHG Reductions ($MMtCO_2e$)
ENERGY		
A	EmPOWER	8.42 – 10.52
A.1	EmPOWER: Energy Efficiency in the Residential Sector	Included in A
A.2	EmPOWER: Energy Efficiency in the Commercial and Industrial Sectors	Included in A
A.3	EmPOWER: Energy efficiency: appliances and other products	Included in A
A.4	EmPOWER: Utility Programs	Included in A
A.5	Combined Heat and Power	Included in A
B	Maryland Renewable Energy Portfolio Standard (RPS)	6.86 – 10.96
B.1	The Maryland Renewable Energy Portfolio Standard (RPS) Program	5.86 – 9.96
B.2	Fuel Switching	1.00 – 1.00
B.3	Incentives and Grant Programs to Support Renewable Energy	Included in B
B.4	Offshore Wind Initiatives to Support Renewable Energy	Included in B
C	Regional Greenhouse Gas Initiative	0.00 – 3.60
D	Other Energy Programs	0.13 – 0.23
D.1	GHG Power Plant Emission Reductions from Federal Programs	
D.1.A	Boiler Maximum Achievable Control Technology (MACT)	0.07 – 0.07
D.1.B	GHG New Source Performance Standards (NSPS)	Included in D
D.1.C	GHG Prevention of Significant Deterioration Permitting Program	Included in D
D.2	Main Street	0.05 – 0.14
D.3	Weatherization and energy efficiency for affordable housing	0.01– 0.02
Total		15.41 – 25.31
TRANSPORTATION		
E	Transportation Technologies	8.10 – 8.61
E.1	Motor Vehicle Emissions and Fuel Standards	

E.1.A	Maryland Clean Cars Program	4.33 - 4.33
E.1.B	Corporate Average Fuel Economy (CAFÉ) Standards: Model Years 2008-2011	2.27 – 2.27
E.1.C	Federal Medium and heavy Duty GHG Standards	0.88 – 0.88
E.1.D	Renewable Fuels Standard	0.24 – 0.24
E.2	On Road, Airport, Port and Freight/Freight Rail technology Initiatives	0.38 – 0.38
E.2.A	ON Road Technology	Included in E.2
E.2.B	Airport Initiatives	Included in E.2
E.2.C	Port Initiatives	Included in E.2
E.2.D	Freight and Freight Rail Strategies	Included in E.2
E.3	Electric Vehicle Initiatives	0.00 – 0.27
E.3	Low Emitting Vehicle Initiatives	Included in E.3
F	Public Transportation	2.00 - 2.89
F.1	Public Transportation Initiatives	Included in F
F.2	Intercity Transportation Initiatives	Included in F
G	Pricing Initiatives	0.41 – 2.30
H	Other Innovative Transportation Strategies/Programs	
H.1	Evaluate the GHG Emissions Impacts from Major New Projects and Plans	Included in H
H.2	Bike and Pedestrian Initiatives	Included in H
Total		10.51 – 13.80
AGRICULTURE AND FORESTRY		
I	Forestry and Sequestration	4.56 – 4.56
I.1	Managing Forests to Capture Carbon	1.80 – 1.80
I.2	Planting forests in Maryland	1.79 – 1.79
I.3	Creating and protecting wetlands and waterway borders to capture carbon	0.43 – 0.43
1.4	Biomass for energy production	0.33 – 0.33
I.5	Conservation of agricultural land for GHG benefits	0.18 – 0.18
I.6	Increasing urban trees to capture carbon	0.02 – 0.02
J.1	Creating ecosystems markets to encourage GHG emission reductions	0.11 - 0.11
J.2	Nutrient trading for GHG benefits	0.09 – 0.57
Total		4.76 – 5.24
BUILDING		

K	Building and Trade Codes	3.15 – 3.15
ZERO WASTE		
L	Zero Waste	2.80 – 4.80
Leadership-By-Example		
M	Leadership-By-Example	1.45 – 1.77
M.1	Leadership-By-Example: State of Maryland initiatives	0.56 – 1.77
M.2	Leadership-By-Example – Maryland Colleges and University	0.37 – 0.37
M.3	Leadership-By-Example – Federal Government	0.27 – 0.27
M.4	Leadership-By-Example – Local Government	0.25 – 0.25
N	Maryland's Innovative Initiatives	0.21 – 0.21
N.1	Voluntary Stationary Source Reductions	0.17 – 0.17
N.2	Buy local for GHG benefits	0.02 – 0.02
N.3	Pay-As-You-Drive® Insurance in Maryland	0.02 - 0.02
N.4	Job creation and economic development initiatives related to climate change	Included in N
O	Future or Developing Programs	0.02 – 0.02
O.1	The Transportation Climate Initiative	0.01 – 0.01
O.2	Clean Fuel Standard	0.00 – 0.00
Total		1.68 – 2.00
LAND USE		
P	Land Use Programs	0.54 – 1.14
P.1	Reducing Emissions through Smart Growth and Land Use/Location Efficiency	Included in P
P.2	Priority Funding Area (Growth Boundary) related benefits	Included in P
Total		0.54 – 1.14
OUTREACH		
Q	Outreach and public education	0.03 – 0.03

Total		0.03 – 0.03

TOTAL RANGE OF ESTIMATED GHG EMISSIONS REDUCTIONS

Sector	Total Expected GHG Reductions ($MMtCO_2e$)
Energy	15.41 – 25.31
Transportation	10.51 – 13.80
Agriculture and Forestry	4.76 – 5..24
Buildings	3.15 – 3.15
Zero Waste	2.80 – 4.80
Leadership-By-Example	1.68 – 1.77
Land Use	0.54 – 1.14
Outreach and Public education	0.03 – 0.03
Total	**38.87 – 55.47**

Sub-Appendix C-1: Energy Programs

EmPower Maryland

Estimated GHG Emission Reductions in 2020

Figure C-2. Low and High GHG Benefits for Energy-6

Initial Reduction	8.42 $MMtCO_2e$	MEA Quantification
Enhanced Reduction	10.52 $MMtCO_2e$	MEA Quantification Below

A.1: EmPOWER: Energy Efficiency in the Residential Sector

Lead Agency: MEA

Program Description

MEA's residential programs are part of the EmPOWER Maryland suite of energy efficiency programs it administers using revenues paid into the Strategic Energy Investment Fund from the auction of RGGI allowances.[1] Together with utility-funded

[1] The SEIF fund was created by legislative act of the General Assembly, "Regional Greenhouse Gas Initiative – Maryland Strategic Energy Investment Program", Md. Public Utility Companies Code § 7-701 et seq. (Senate Bill 268/House Bill 368, General Assembly 2008). A portion of the fund is allocated to the MEA to administer programs in the residential, commercial and industrial sectors to reduce consumer demand for electricity and natural gas through energy efficiency measures.

programs, MEA's programs in all sectors, including residential, commercial and industrial, are intended to achieve the EmPOWER Maryland goal of a 15 percent reduction in per capita energy use by 2015.[2] Programs funded and administered through other State agencies including DHCD also contribute to the EmPOWER goal.

Existing Programs. MEA administers a number of programs that target energy efficiency improvements in the residential sector. Many of these programs are funded with federal American Recovery and Reinvestment Act money, which are only available through early 2012.

- *EmPOWER Maryland Empowering Finance Initiative.* This initiative is targeted at helping residential consumers afford clean energy improvements. MEA made a grant to the Maryland Clean Energy Center and is working with private banks to leverage sustainable capital that will continue to serve Marylanders past the end of federal funding. MEA is also working with the EmPOWER utilities to propose program enhancements using utility funds.
- *EmPOWER Maryland Residential Incentives.* These incentives include various programs such as a grant/loan program called Multifamily Energy Efficiency and Housing Affordability which is offered in coordination with DHCD. The program conducts energy audits and energy efficiency retrofits in apartment units and common space to reduce energy bills for low and moderate income families. The program has awarded $9.7 million that will benefit approximately 3,800 families by reducing their energy bills an estimated 20 percent, saving about $52.8 million over the life of the investments.
- *MEA Home Performance Rebate Program.* When it was in place, this program offered homeowners rebates for home energy efficiency improvements. By combining a 35 percent rebate, and up to $3,100 total, from MEA with a 15 percent rebate from the utility company, homeowners saved a total of 50 percent on home energy improvements. MEA encouraged homeowners to upgrade the energy efficiency of their homes to ENERGY STAR standards. This is a one-time federally-funded program and likely will not continue when the $1.5 million in rebate funding is expended. However, learning from the success of this program, Maryland's utility companies increased rebate levels from 15% to 50% starting in early 2012.
- *DHCD Weatherization.* DHCD is awarded funding on an annual basis from the U.S. Department of Energy to improve the energy efficiency in homes owned by limited-income Marylanders. Thanks to an uptick in federal funding, DHCD has retrofitted more than 7,000 homes since 2009. When the federal funding is fully expended, DHCD is likely to revert back to its previous annual budget.
- *Clean Energy Communities Grants.* MEA has awarded over $8.6 million to local governments and non-profit organizations in every county in Maryland for energy

[2] EmPOWER Maryland Energy Efficiency Act of 2008, Md. Public Utility Companies Code § 7-211 (House Bill 374, General Assembly 2008). The law requires utilities to reduce per capita electricity consumption in Maryland by 10 percent by 2015 and peak demand by 15 percent by 2015 by implementing energy efficiency programs targeted to consumers. Working together with demand-side management programs implemented by the MEA and other state agencies, the law targets a 15 percent reduction in per capita and peak demand by 2015.

efficiency projects that benefit low-to-moderate income citizens. These awards have helped more than 9,000 Marylanders reduce their energy usage through lighting improvements, energy efficient appliances, and whole home energy retrofits *Maryland Home Energy Loan Program.* Funded by a grant from MEA, the Maryland Clean Energy Center currently manages this program to offer unsecured, low-cost loans for efficiency upgrades to primary single-family detached and townhouse residences in Maryland. The primary focus is replacing furnaces, heat pumps and air conditioners that are at least 10 years old, as well upgrading insulation, plugging air leaks and sealing ducts. The program launched in December 2010 and, by June 2011, had cleared $400,000 in loan commitments.[3]

- *Energy Workforce Training*. MEA worked closely with DHCD and Maryland's community colleges to create a comprehensive training program for contractors working in the energy improvement field. The program has trained more than 1000 contractors to date, and the focus moving forward will be improving the skill sets of contractors already participating in the Maryland Home Performance program or DHCD Weatherization program. This program is now independently managed by Maryland's community colleges.
- *State Energy Efficient Appliance Rebate Program.* MEA worked with Maryland's five major utilities to enhance their existing appliance rebate programs for homeowners.[4] This was a one-time program, made possible by a $5.4 million federal American Recovery and Reinvestment Act grant in 2009. This program provided additional rebates for super-efficient clothes washers and refrigerators, room air conditioners, freezers, electric heat pump water heaters, central air conditioners, and air source heat pumps, adding onto the amount offered by the utilities. More than 33,000 Marylanders participated in the enhanced program. Based on the program's popularity and success, Maryland's utilities enhanced their appliance rebate offerings in their 2012-2014 plans.

<u>Programs Under Consideration.</u> MEA continues to analyze new initiatives to help meet the EmPOWER Maryland goals. Some programs under consideration by MEA specifically target the residential sector; others have a broader sector-based reach.[5]

- MEA continues to systematically evaluate other states' best practices and lessons learned and, where appropriate, will adapt and incorporate program elements into existing programs. The American Council for an Energy-Efficient Economy has recognized the programs of several states as national models for spurring energy

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[3] Maryland Clean Energy Center, MHELP program, http://MCECloans.org. The program is funded through federal stimulus dollars. Loans are capped at $20,000 with a 6.99 percent interest rate. Audits must be performed by certified auditors and contractor must have a MHIC license.

[4] Each utility offers a slightly different program. See program links at the end of this Section. The full suite of the utilities' EmPOWER Maryland programs are addressed in Sections 6.3.5 through 6.3.10.

[5] Maryland Climate Action Plan, August 2008, Appendix D-3, pp. 14-15, and Chapter 4, p. 79, contains the recommendations of the Maryland Commission on Climate Change for MEA-run energy efficiency programs. Appliances and lighting programs are addressed in Section 6.3.11 – "Energy Efficiency in Appliances and Other Products".
http://www.mde.state.md.us/assets/document/Air/ClimateChange/Appendix_D_Mitigation.pdf
http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter4.pdf

efficiency in the residential sector and these programs are summarized in its September 2010 report.[6]

- MEA will continue to engage in ongoing, high-level Statewide resource planning in coordination with PSC.
- MEA will continue to analyze and if appropriate pursue additional tax policies, revolving loan funds and other measures to reduce energy efficiency transaction costs for consumers/ratepayers.
- MEA will continue to analyze and if appropriate work to encourage or require Energy Star or comparable energy labeling standards for new homes and for the sale or lease of existing homes.[7]
- MEA proposed three residential program enhancements for the utilities to consider for their 2012-2014 EmPOWER Maryland planning periods: higher incentives for residential retrofit and energy efficient product replacement programs, a program to conduct energy efficiency retrofits in market-rate multifamily dwelling units, and an educational program for schools. The utilities will be proposing various iterations of these programs in their 2012-2014 EmPOWER Maryland plans. The utilities were approved to offer 50% rebates on residential retrofits and enhanced product replacement programs.
    - For appliances and equipment which do not have energy efficiency levels established by federal or Maryland laws, MEA will work with the Governor and the general Assembly to consider legislation establishing energy efficiency standards.[8]
    - MEA will continue to work with federal authorities and energy officials from other states to advocate for more stringent and comprehensive national energy efficiency appliance standards.

Estimated GHG Emission Reductions in 2020

In order to account for similarities across programs, all emission benefits and costs associated with this program have been aggregated under A: EmPOWER

[6] States Stepping Forward: Best Practices for State-Led Energy Efficiency Programs, Sciortino, Michael, American Council for an Energy-Efficient Economy, September 2010, Report Number E106. See, e.g.: Colorado Energy Star New Homes Program at 12-14; Alaska Home Energy Rebate Program at 26-27; Connecticut Home Energy Joint Solutions Program at 28-29; and Louisiana Home Energy Rebate Program at 30-31. http://www.aceee.org/research-report/e106

[7] The Colorado Energy Star New Homes Program presents an excellent model for promoting Energy Star certification in new residential construction. The state energy office forms regional partnerships with counties, cities, nonprofit organizations, and utilities to offer locally tailored programs. The program was recently recognized by American Council for an Energy-Efficient Economy as one of the top five state-led energy efficiency programs in the nation.

[8] Maryland has two laws that establish energy efficiency standards for certain appliances and equipment: Maryland Energy Efficiency Standards Act, Annotated Code of Maryland, Sec. 9-2006 (became law per Maryland Constitution, Chapter 2 of 2004 on January 20, 2004); and Maryland Energy Efficiency Standards Act of 2007, Annotated Code of Maryland, Sec. 9-2006. Maryland Efficiency Standards Act - Televisions (House Bill 349/Senate Bill 455) was introduced in the 2010 Session but did not pass. It would have added televisions to the list of regulated products.

High Estimate – MEA Quantification

Figure C-3. Estimated GHG Benefits from EMPOWER Maryland

Generation	Intensity (MMt)	Emission MMt	Reduction	Overlap Adj
66,398,431	0.660	43.8	10.6	8.42

Implementation

Maryland's demand-side management programs are mandated and funded by Maryland law. The utilities are responsible for at least 10 of the 15 percentage point EmPOWER goal, and MEA and other State agencies are responsible for the remaining amount. MEA tracks the savings Statewide and is responsible for reporting to the Governor and the Legislature on the progress. PSC is required by law to calculate per capita electricity consumption and peak demand each year and report the calculations to the General Assembly as part of its annual report.[9] In consultation with PSC, MEA is required to submit annual reports to the General Assembly on the Strategic Energy Investment Fund status, including receipts and disbursements; administrative expenses; loan and grant evaluation criteria, amounts, number, and recipients; status of outstanding loans; and plans for Strategic Energy Investment Fund resources for the current year.[10]

A.2: EMPOWER: Energy Efficiency in the Commercial and Industrial Sectors

Lead Agency: MEA

Program Description

MEA's commercial and industrial programs are part of the EmPOWER Maryland suite of energy efficiency programs it administers using revenues paid into the Strategic Energy Investment Fund from the auction of RGGI allowances.[11] Together with utility-funded programs, MEA's programs in all sectors, including residential, commercial and industrial, are intended to achieve the EmPOWER Maryland goal of a 15 percent reduction in per capita energy use by 2015.[12] Programs funded and administered through other State agencies also contribute to the EmPOWER goal.

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[9] EmPOWER Maryland Energy Efficiency Act of 2008, Md. Public Utility Companies Code § 7-211 (House Bill 374, General Assembly 2008).

[10] Regional Greenhouse Gas Initiative – Maryland Strategic Energy Investment Program, Md. Public Utility Companies Code § 7-701 et seq. (Senate Bill 268/House Bill 368, General Assembly 2008).

[11] The Strategic Energy Investment Fund was created by legislative act of the General Assembly, "Regional Greenhouse Gas Initiative – Maryland Strategic Energy Investment Program", Md. Public Utility Companies Code § 7-701 et seq. (Senate Bill 268/House Bill 368, General Assembly 2008). A portion of the fund is allocated to the MEA to administer programs in the residential, commercial and industrial sectors to reduce consumer demand for electricity and natural gas through energy efficiency measures.

[12] EmPOWER Maryland Energy Efficiency Act of 2008, Md. Public Utility Companies Code § 7-211 (House Bill 374, General Assembly 2008). The law requires utilities to reduce per capita electricity

Existing Programs. MEA administers a number of programs that target energy efficiency improvements in the commercial and industrial sectors, which represent approximately 60 percent of electricity consumption in Maryland.[13] Four programs are summarized here: 1) Maryland Save Energy Now; 2) the Lawton Loan Program.; 3) the Energy Efficiency and Conservation Block Grant Program; and 4) the State Agencies Loan Program.

1. *Maryland Save Energy Now:* MEA offers assistance to the State's industrial sector through the Maryland Save Energy Now Program. Support offered through the program includes:

- Energy Assessments for industrial facilities:[14] The assessments include a one-to-three-day site visit by the University of Maryland Manufacturing Assistance Program to evaluate energy use at the facility, identification of opportunities for energy efficiency improvements and combined heat and power, and a report on the assessment findings and recommendations.
- Free monthly training webinars on various industrial energy efficiency topics, including combined heat and power.
- Information on financial incentives and other helpful resources for businesses, including those offered by Maryland's utilities, MEA and federal agencies, such as U.S. Department of Energy, and third party investors.

2. *Jane E. Lawton Conservation Loan Program*: The Jane E. Lawton Conservation Loan Program is a revolving loan fund available to local governments, non-profit organizations, and businesses seeking to reduce operating expenses by implementing energy conservation measures. Lawton Loans are structured so borrowers use the cost savings generated by the conservation improvements as the primary source of revenue for repaying the loans. Projects financed with Lawton Loans must have paybacks of 10 years or less. Lawton Loans have low interest rates (currently 2.5 percent) and fall between a minimum financed amount of $40,000 and a maximum of $500,000.

3. *Energy Efficiency and Conservation Block Grant Program:* The federal Energy Efficiency and Conservation Block Grant program is funded by the American Recovery and Reinvestment Act through 2012. Through this grant program, MEA is using $9.593 million to provide approximately 130 local Maryland governments with an energy audit and a sub-grant to finance some or all of the energy projects identified in the energy audit. The energy improvements must occur on a facility that is either owned and/or

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consumption in Maryland by 10 percent by 2015 and peak demand by 15 percent by 2015 by implementing energy efficiency programs targeted to consumers. Working together with demand-side management programs implemented by MEA and other state agencies, the law targets a 15 percent reduction in per capita and peak demand by 2015.

[13] EmPOWERing Maryland Clean Energy Programs FY11 Draft, MEA, p. 5. energy.maryland.gov/documents/fy11programbook.pdf

[14] University of Maryland Manufacturing Assistance Program conducts site visits to evaluate energy use, identify opportunities for energy efficiency and CHP improvements, and provide a report. This program then works with facility managers to identify financing tools and resources, including state and federal incentives.

operated by the local government. Both energy efficiency and renewable energy projects are eligible for funding under the federal grant program. The energy audit portion of this project identified approximately 4,200 MWh per year of electricity opportunity, 33,000 therms of natural gas opportunity, and 35,000 gallons of oil opportunity.

4. *State Agencies Loan Program*: The State Agencies Loan Program is a revolving loan program dedicated to directly assisting energy efficiency programs and improvements in Maryland State agencies so that Maryland agencies can lead by example. The bulk of the loans have been awarded to agencies in support of their energy performance contracts. Each year, about 20 percent of the loan fund is directed to support State agencies' specific energy efficiency measures such as higher efficiency lighting and HVAC systems. These loans are made at zero interest with a 1 percent administrative fee. In 2011, nearly 11,000 MWh in annual savings resulted from eight loans.

Programs under Consideration. MEA continues to create, evaluate and improve its programs. Commercial and industrial programs under consideration by MEA include the following:

- The Green Buildings Tax Credit: MEA re-opened the tax credit program through the end of 2011 to ensure developers of the green commercial and multi-family buildings will get tax credits for designing and constructing energy-efficient buildings that meet specified energy goals. The details of the program were announced by MEA in September 2011. The program closed in December 2011 and was able to issue an additional $1 million in Maryland tax credit allotment. MEA will work with Maryland utilities and PSC in promoting new and emerging technologies. MEA has proposed that the utilities take up combined heat and power as a custom energy efficiency measure in their programs. MEA will be coordinating a pilot demonstration of the technology in the Pepco Holdings and BGE territories in 2011 in an attempt to collect quantitative information on the cost and benefits of the technology versus EmPOWER Maryland goals. An RFP has been issued with an expected program allocation of $11 million through 2015.
- MEA will develop incentives and assistance for follow-up on audit recommendations.
- MEA will systematically evaluate other states' best practices and lessons learned and, where appropriate, will adapt and incorporate program elements into existing programs. American Council for an Energy-Efficient Economy has recognized the programs of four states – New York, Minnesota, Washington, and Texas – as national models for spurring energy efficiency in the commercial and industrial sectors. These are summarized the American Council for an Energy-Efficient Economy's September 2010 report.[15]

Estimated GHG Emission Reductions in 2020

In order to account for similarities across programs, all emission benefits and costs associated with this program have been aggregated under A: EmPOWER.

[15] For program detail, see American Council for an Energy-Efficient Economy report, supra, at 15-17 and 41-43 (New York); pp. 38-40 (Minnesota); pp. 46-48 (Texas); and pp. 49-52 (Washington). http://www.aceee.org/research-report/e106

Implementation

Maryland's demand-side management programs are mandated and funded by Maryland law. The utilities are responsible for at least 10 percent of the 15 percent EmPOWER goal, and MEA and other State agencies are responsible for the remaining. MEA tracks the savings Statewide and is responsible for reporting to the Governor and the Legislature on the progress. PSC is required by law to calculate per capita electricity consumption and peak demand each year and report the calculations to the General Assembly as part of its annual report.[16] In consultation with PSC, MEA is required to submit annual reports to the General Assembly on the Strategic Energy Investment Fund status, including receipts and disbursements; administrative expenses; loan and grant evaluation criteria, amounts, number, and recipients; status of outstanding loans; and plans for Strategic Energy Investment Fund resources for the current year.[17]

A.3: EMPOWER: Energy Efficiency Appliances and Other Products

Lead Agency: MEA

Program Description

As indicated in A.1: Energy Efficiency in the Residential Sector, MEA's appliances, equipment and lighting programs are part of the EmPOWER Maryland suite of energy efficiency programs it administers using revenues paid into the Strategic Energy Investment Fund from the auction of RGGI allowances.[18] Together with utility-funded programs, MEA's programs are intended to achieve the EmPOWER Maryland goal of a 15 percent reduction in per capita energy use by 2015.[19]

Existing/Past Programs. MEA administered several appliance and equipment rebate programs for homeowners in the past years. It currently administers low-interest loans for residential and commercial energy efficiency improvements, which may include appliances, equipment and lighting. These programs include the State Energy Efficient

[16] EmPOWER Maryland Energy Efficiency Act of 2008, Md. Public Utility Companies Code § 7-211 (House Bill 374, General Assembly 08).

[17] Regional Greenhouse Gas Initiative – Maryland Strategic Energy Investment Program, Md. Public Utility Companies Code § 7-701 et seq. (Senate Bill 268/House Bill 368, General Assembly 2008).

[18] The Strategic Energy Investment Fund was created by legislative act of the General Assembly, "Regional Greenhouse Gas Initiative – Maryland Strategic Energy Investment Program", Md. Public Utility Companies Code § 7-701 et seq. (Senate Bill 268/House Bill 368, General Assembly 2008). A portion of the fund is allocated to the MEA to administer programs in the residential, commercial and industrial sectors to reduce consumer demand for electricity and natural gas through energy efficiency measures.

[19] EmPOWER Maryland Energy Efficiency Act of 2008, Md. Public Utility Companies Code § 7-211 (House Bill 374, General Assembly 2008). The law requires utilities to reduce per capita electricity consumption in Maryland by 10 percent by 2015 and peak demand by 15 percent by 2015 by implementing energy efficiency programs targeted to consumers. Working together with demand-side management programs implemented by the MEA with RGGI funds, the law targets a 15 percent reduction in per capita and peak demand by 2015.

Appliance Rebate Program, the Maryland Home Energy Loan Program, and the Jane E. Lawton Conservation Loan Program.

Programs Under Consideration.

MEA continues to analyze new initiatives to help meet the EmPOWER Maryland goals. MEA is considering programs to support and advance existing federal and State energy efficiency standards and to establish new standards where none exist. It is also analyzing options for improving existing programs and expanding their funding and scope. These should include the following:

- The Energy Independence and Security Act of 2007 established federal energy efficiency standards for certain residential and commercial appliances and lighting.[20] MEA should continue analyzing opportunities to advance and exceed federal lighting standards. For example, some states are pushing to have compact fluorescent bulbs make up 95 percent of residential light bulb sales in the State by 2014. A key aspect of this would involve designing and implementing a public awareness campaign coupled with incentives to encourage residential customers to replace incandescent light bulbs with compact fluorescent bulbs or other energy efficient bulbs such as light emitting diodes. MDE continues to explore current disposal problems associated with compact fluorescent bulbs containing mercury within the bulbs, and ensure that appropriate disposal/recycling facilities are available to protect the environment from contamination.
- For appliances and equipment which do not have energy efficiency levels established by federal or Maryland laws, MEA would work with the Governor and the general Assembly to consider legislation establishing energy efficiency standards recommended by the Appliance Standard Awareness Program.[21]
- MEA would work to significantly ramp up its education/outreach and incentive programs to promote purchases of energy efficient appliances.
- MEA should look for opportunities to significantly ramp up its existing energy efficiency loan programs. This effort should continue to target an increase in government funding to a minimum level of $15 million ($10 million for the residential sector and $5 million for the commercial sector). This funding would leverage private sector capital at the minimum level of $60 million ($40 million for the residential sector and $20 million for the commercial sector).

Estimated GHG Emission Reductions in 2020

[20] Energy Independence and Security Act (P.L. 110-140, H.R. 6). The law requires light bulbs sold in and after to be 25 percent more efficient than current incandescent bulbs. It directs the U.S. Department of Energy to set standards that will reduce energy use to no more than about 65 percent of current lamp use by 2020. The sale of most incandescent light bulbs will be banned. Exempt from this ban are various specialty bulbs, including appliance bulbs, colored lights, and 3-way bulbs.

[21] Maryland has two laws that establish energy efficiency standards for certain appliances and equipment: Maryland Energy Efficiency Standards Act, Annotated Code of Maryland, Sec. 9-2006 (became law per Maryland Constitution, Chapter 2 of 2004 on January 20, 2004); and Maryland Energy Efficiency Standards Act of 2007, Annotated Code of Maryland, Sec. 9-2006. Maryland Efficiency Standards Act - Televisions (House Bill 349/Senate Bill 455) was introduced in the 2010 Session but did not pass. It would have added televisions to the list of regulated products.

In order to account for similarities across programs, all emission benefits and costs associated with these programs have been aggregated under A: EmPOWER.

A.4: EMPOWER: Utility Responsibility, including:

A BGE
B Pepco
C SMECO
D Potomac Edison
E Delmarva Power and Light

Lead Agency: MEA

Program Description

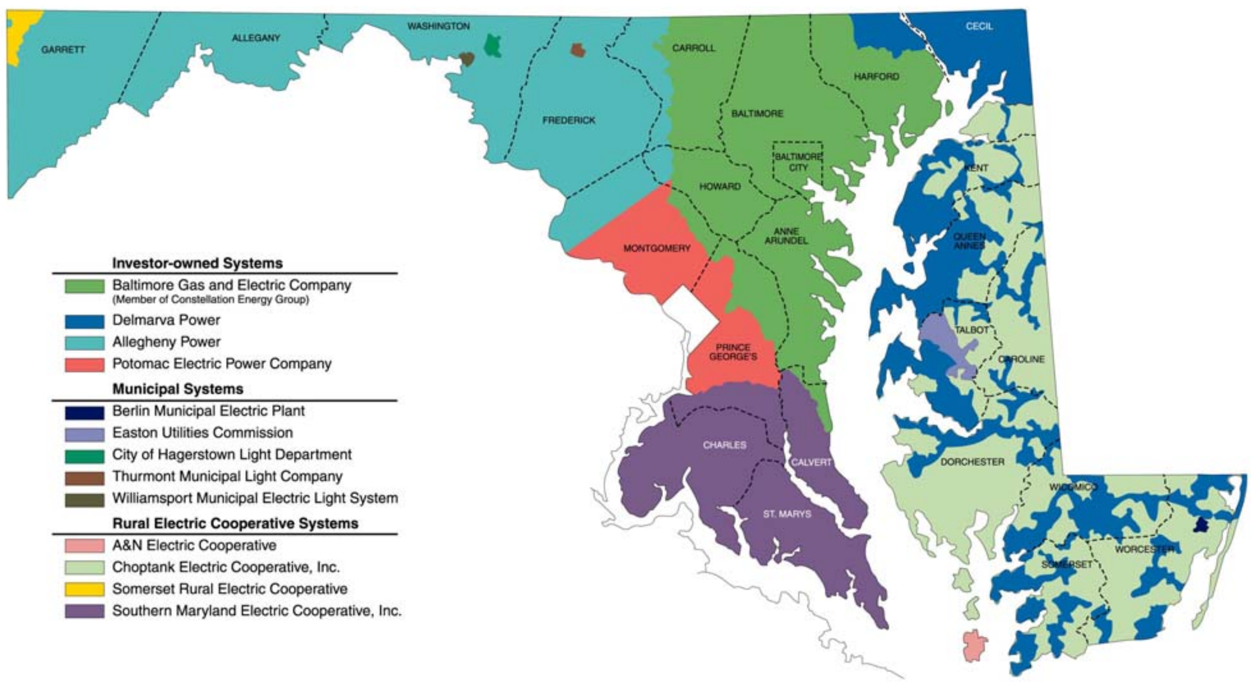
Enacted on April 24, 2008, EmPOWER Maryland Act calls for the State to reduce its energy consumption 15 percent by 2015, in order to reduce energy bills, protect our environment and reduce global warming pollution, while also creating new jobs and sources of clean, reliable energy. EmPOWER Maryland mandated that PSC require each utility to propose cost-effective energy efficiency and conservation programs and services designed to achieve targeted per capita energy reductions of at least five percent by the end of 2011 and ten percent by the end of 2015. Among other things, EmPOWER Maryland required the companies to consult with MEA and file proposed programs in order for PSC to approve any cost-effective programs by December 31, 2008. EmPOWER Maryland's electricity consumption goal calls for a reduction of 15 percent of the 2007 per capita electricity consumption by 2015. Together with utility-funded programs, the State's programs in all sectors, including residential, commercial and industrial, are intended to achieve the EmPOWER Maryland goal of a 15 percent reduction in per capita energy use by 2015.[22] Electric utilities are responsible for two thirds of the EmPOWER goal. Energy savings targets are spread amongst all customer classes, including low-to-moderate income customers. The utilities will submit program enhancements and improvements to PSC in early September 2011 for the 2012-2015 program cycle, which will help to improve current programs and add new energy efficiency measures. In 2012, MEA will begin evaluating the EmPOWER Maryland goals for beyond 2015. In the meantime, MEA assumes that programs will work to ensure the 15 percent per capita reduction is maintained after 2015.

EmPOWER Maryland also requires the five utilities to implement cost-effective demand response programs designed to achieve a reduction in their per capita peak energy demand of five percent by 2011, ten percent by 2013, and 15 percent by 2015. The five

[22] EmPOWER Maryland Energy Efficiency Act of 2008, Md. Public Utility Companies Code § 7-211 (House Bill 374, General Assembly 2008). The law requires utilities to reduce per capita electricity consumption in Maryland by 10 percent by 2015 and peak demand by 15 percent by 2015 by implementing energy efficiency programs targeted to consumers. Working together with demand-side management programs implemented by the MEA and other state agencies, the law targets a 15 percent reduction in per capita and peak demand by 2015.

utilities include: Potomac Edison (PE), formerly known as Allegheny Power; Baltimore Gas and Electric (BGE); Delmarva Power and Light (DPL); Potomac Electric Power Company (PEPCO); and Southern Maryland Electric Cooperative (SMECO). In instances of system reliability or high electricity prices during critical peak hours, these programs commonly use a switch or thermostat for a central air conditioning or an electric heat pump to briefly curtail usage.

Figure C-4: Service Territories of Utilities in Maryland



Source: PSC, Ten-Year Plan (2009 – 2018) of Electric Companies in Maryland (February 2010).

To generate a portion of this savings, the five utilities each developed energy efficiency and conservation portfolios, based on a three-year planning cycle beginning with the Program Planning Year 2009 – 2011. Subsequent plans are currently being developed for the 2012 – 2014 program cycle. Residential energy efficiency and conservation programs include discounted compact fluorescent light bulbs and appliances, heating ventilation and air conditioning (HVAC) rebates, home energy audits and incentives for energy efficiency upgrades, and low income programs. Commercial energy efficiency and conservation programs are designed to encourage businesses to upgrade to more efficient equipment, such as lighting, HVAC or motors, or improve their building performance through weatherization or building shell upgrades. For larger commercial buildings or industrial facilities, the utilities can customize its incentives for cost-effective improvements.

PSC expects that the utilities will continue to revise or enhance their plans to provide additional resources, especially the deficient energy savings, to meet their 2011 and 2015 goals. These additional resources may be derived from new energy efficiency and conservation programs, advanced metering initiatives, and/or increased development and use of distributed generation and demand response resources.

Figure C-5: Number of Customers by Customer Class (As of December 31, 2008)

Utility	Residential	Commercial	Industrial	Other	Total	Percentage of Total
AP	218,661	27,339	2,835	345	**249,180**	**10.6%**
BGE	1,108,503	117,633	5,345	0	**1,231,481**	**52.5%**
DPL	172,766	25,573	250	272	**198,861**	**8.5%**
PEPCO	472,874	46,756	11	102	**519,743**	**22.2%**
SMECO	133,560	13,204	5	267	**147,036**	**6.3%**
Total	**2,106,364**	**230,505**	**8,446**	**986**	**2,346,301**	**100.0%**

Source: PSC, Ten-Year Plan (2009 – 2018) of Electric Companies in Maryland (February 2010).

Estimated GHG Emission Reductions, by 2020, for each Utility

In order to account for similarities across programs, all emission benefits and costs associated with this program have been aggregated under A.1: EmPOWER: Energy Efficiency in the Residential Sector.

Implementation:

A.4.A: Baltimore Gas and Electric

Baltimore Gas and Electric (BGE) received its PSC Order on December 31, 2008, and began implementing six residential and three commercial energy efficiency and conservation programs throughout 2009,[23] which were designed to save approximately 1,105,612 MWh by 2011 and 2,778,606 MWh by 2015. Since it was the first to receive its PSC Order, BGE continues to achieve the most energy savings and demand reduction to date.

All programs were fully operational during 2010. Overall, the residential suite of programs has made progress toward goals throughout the service territory in 2010, with nearly 300,000 participants since the programs launched in 2009. Of those participants, nearly 220,000 took part in the programs in calendar year 2010. The commercial programs failed to meet annual forecasted energy savings estimates. However, the commercial programs reported fourth quarter energy savings that exceeded the reported energy savings from the prior two quarters.

[23] Approved residential programs include: the Lighting and Appliance Program; Energy Star for New Home; Home Performance with Energy Star; Quick Home Energy Check-up; Online Energy Calculator; Residential HVAC Rebate Program; Limited Income Energy Efficiency Program. Approved commercial programs include: Energy Solutions for Small Business; Small Business Lighting Solutions Program; Retro-commissioning Program for industrial and commercial businesses.

In 2010, BGE's energy efficiency and conservation programs achieved 274,068 MWh, of its 2011 energy efficiency and conservation electric consumption reduction target. Since the programs started in 2009, they have achieved almost 444,000 MWh of savings, about 40 percent of the 2011 estimated reduction. BGE's portfolio of programs, including demand response, achieved 47 percent, or 555 MW of its 2011 peak demand reduction target. BGE fell short of its forecasted annual energy and demand savings in order to remain on target for 2011, reaching only 80 percent and 70 percent of its 2010 forecasted benchmark for energy savings and demand reduction, respectively. Primarily, this is attributable to the commercial programs ramping up more slowly due to economic conditions. In 2010, these commercial programs have shown improved participation and savings, with this trend is expected to continue in 2011.

Energy Efficiency and Conservation Programs:[24]
Residential Programs
BGE's lighting and appliance rebate programs achieved more than 135,000 MWh of energy savings in 2010, accounting for more than half of the overall portfolio savings. Rebates on HVAC equipment saved another 7,600 MWh, surpassing the forecast by more than 2,000 MWh. This was largely thanks to MEA's addition of federal American Reinvestment and Recovery Act funding into the program. BGE provided rebates for 3.1 million light bulbs, 58,000 appliances (including refrigerators, clothes washers, and room air conditioners), and 15,000 HVAC units. Program participation has been strong and BGE will continue to enhance the program in coming years by adding more appliances and new lighting technologies.

Performing well was BGE's Residential Retrofit program, the Quick Home Energy Check-up Program. In calendar year 2010, the residential retrofit program (including both Quick Check-ups and Home Performance with ENERGY STAR) had forecasted 1,235 participants and 12,965 measures. The Quick Home Energy Check-up program alone reported 8,605 participants and 79,494 measures. This helped the residential retrofit program achieve an almost seven-fold increase in participants over full program expectations, and energy savings nearly on par with its annual 2010 targets. The Quick Home Energy Check-up program also met or exceeded most of its energy savings goals for 2010. The Home Performance with ENERGY STAR Program, the more comprehensive of the two residential retrofit programs, showed improvement over 2009 results, but was still trailing in its forecasted targets. BGE is working closely with MEA and the other utilities to make improvements to the Home Performance with ENERGY STAR program.

In addition to the existing home retrofit program, BGE has an ENERGY STAR for New Homes program, which works with builders on making new construction more energy efficient. The program was on target in 2010, achieving 98 percent of its participation goal and 103 percent of its energy saving goal.

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[24] Participant, measure, and energy savings number are taken from the January 31, 2011 Q4 2010 EmPOWER Maryland Report (Case 9154); Premise Level – Full Year 2010 Program Summary chart.

BGE's Low Income program met or exceeded forecasts in most of its metrics in 2010. There were 1,691 participants, 10 percent more than the forecast. Additionally, BGE achieved 94 percent of its annualized energy savings. BGE also improved the time it took for a customer to receive an audit, decreasing the wait time from 44 days calendar days in 2009 to 24 days in 2010. BGE's partnership with Baltimore City Weatherization for boiler, furnace, and heat pump replacement ended in April 2010 as planned after 6 months of pilot activity. Forty-eight referrals were received in 2010 with each receiving a replacement.

BGE continued marketing efforts in line with the themes developed by under its *Learning to Speak the Language of Energy Efficiency* campaign. BGE utilized television, radio, print, transit, outdoor, internet and events to market their programs. BGE also combined direct mailings and phone calls to effectively promote its Residential programs to homeowner associations reaching over 3,000 units in 2010.

BGE's OPOWER pilot was approved in July 2010 with mailings being sent to 25,000 customers in October and November. The OPOWER program aims to improve energy efficiency knowledge by providing customers with comparison charts of their energy use compared with similar BGE customers, as well as, providing energy efficiency information. Only 34 customers have opted out at this point and fewer than 50 calls have been made to the call center.

Commercial and Industrial Programs

BGE's commercial and industrial energy efficiency programs include custom, prescriptive, and direct install energy efficiency measures for large and small customers. Participants range from small businesses to large manufacturers. The Prescriptive Lighting program is the largest contributor to energy savings in the commercial & industrial program suite, representing 70 percent of commercial & industrial program savings. Overall, the commercial & industrial programs saved 106,000 MWh in 2010, about 60 percent of their 187,000 MWh annual goal.

Demand Response

Demand response is defined as the change in electricity usage by end-use customers either in response to price changes or to incentive payments designed to induce lower electricity use when demand is higher. BGE launched its demand response program, PeakRewards, in June 2008. Participants can choose to have either a thermostat or a digital switch on their air conditioner or electric heat pump installed, which gives BGE the ability to cycle electricity usage during periods of high demand. Events are usually called on the hottest summer days when electricity usage is at its peak and system reliability may be jeopardized. In 2010, PeakRewards enrolled 131,000 participants and installed a total of 159,000 air conditioning cycling devices. A total of 299,500 participants are enrolled in the program since its inception, with 326,000 installed devices (thermostats and switches). The estimated load reduction as of the end of 2010 was about 489 MW, 164 MW of which was achieved in 2010.

BGE deployed its PeakRewards water heater program in April 2010. As of December 31, 2010, there were approximately 2,850 water heater switch installations. BGE continues to seek ways to move forward in the counties where water heater switch installation permitting issues have not been resolved.

Advance Metering Infrastructure

Advance Metering Infrastructure or "Smart Grid" technology is generally defined as a two-way communication system and associated equipment and software, including metering equipment installed on an electric customer's premises, that use the electric company's distribution network to provide real-time monitoring, diagnostic, and control information and services. Advanced metering infrastructure is generally considered to be an initiative that can reduce peak demand and energy consumption beyond those reductions achieved through energy efficiency and conservation and demand response programs. Additionally, advanced metering infrastructure and Smart Grid technology will improve the efficiency and reliability of the distribution and use of electricity by reducing blackout probabilities and forced outage rates and restoring power in shorter time periods.

In 2010, PSC approved the advanced metering infrastructure initiative for BGE. Since authorization, BGE, in conjunction with Pepco Holdings, Inc., PSC Staff and other stakeholders established a Smart Grid Collaborative Work Group. The Work Group offers a venue to discuss issues such as the consumer education plan and the comprehensive set of performance metrics. BGE proposes the deployment period to take place from 2011-2014, with installation of smart meters beginning in October 2011.

Figure C-6. BGE Energy Efficiency & Conservation and Demand Response Reported Achievements*

	2010 Reduction	Percentage of 2010 Interim Target**	Program-to-Date Reduction	Percentage of 2011 Target
BGE				
Electric Consumption Reduction (MWh)	274,068	80%	443,824	44%
Demand Reduction (MW)***	214	70%	555	47%

*Based on preliminary energy and demand savings from quarterly programmatic reports. These savings will be verified through a process currently under development.
** Percentage of energy savings forecasted to be achieved in 2010 minus 2009 forecast.
***Demand reduction is from both the Peak Rewards program and the demand savings created through energy efficiency program savings.

A.4.B: Pepco

Pepco received its Commission Order on August 13, 2009. Pepco's approved plan included four residential and four non-residential energy efficiency and conservation programs,[25] as well as demand response, and street lighting programs, which were designed to save 588,628 MWh by 2011 and 1.290 million MWh by 2015. Opportunities range from using the information provided through customer information and education, to incentives to purchase lighting and energy efficient HVAC and housing or building upgrades.

Energy Efficiency and Conservation Programs[26]

By the end of 2010, Pepco's energy efficiency and conservation programs achieved 23 percent, or 134,179 MWh, of its 2011 energy efficiency and conservation electric consumption reduction target. This number includes all programs, including those started in 2009. Pepco's portfolio of programs, including Demand Response, achieved 13 percent, or 68 MW of the company-set 2011 peak demand reduction target. The company-set demand response target was significantly higher than the 2011 EmPOWER Maryland goal; Pepco achieved 30 percent of the 230 MW EmPOWER goal. Due to the fact that Pepco was still ramping up its programs well into 2010, Pepco fell short of its rough incremental annual energy and demand savings in order to remain on target for 2011, reaching only 43 percent and 59 percent of its 2010 Interim Target for energy savings and demand reduction, respectively. Pepco does not anticipate that it will achieve its 2011 goal or target.

Residential Programs

At the conclusion of 2010, all programs in Pepco's suite were up and running. Among the residential offerings, Pepco's most successful program to date continued to be the Lighting and Appliance program. The Appliance portion of the program experienced double the number of rebated appliances during 2010 compared to 2009 due to the increased rebates available through MEA's State Energy Efficiency Appliance Replacement Program funded by the American Reinvestment and Recovery Act of 2008. This program ran from April 2010 through November 2010 and offered additional rebates on utility rebated appliances as well as new rebates not offered under the EmPOWER portfolio.

The Lighting and Appliance Program exceeded several annual forecasts for Pepco. The Lighting Program had 860,282 participants -- 88 percent more than forecasted. The resulting energy savings were 41 percent higher than forecasted. The Appliance Program rebated 159 percent more appliances than forecasted for 2010, generating a total of 762 MWh savings. Pepco plans to enhance its Appliance Program to include additional appliances and rebates to match the levels resulting from the collaborative effort with MEA.

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[25] Approved residential programs include: the Lighting and Appliance Program; the Home Performance with Energy Star Program which includes Quick Home Energy Check-up and the Online Audit Calculator; the a no cost appliance replacement program for Low Income; the residential HVAC Program. Approved commercial programs include: the Prescriptive Program; the Heating, Ventilation, and Air-Conditioning Program, Custom Incentive Program; the Building Commissioning and Operations & Maintenance Program.

[26] Participant, measure, and energy savings number are taken from the January 31, 2011 Q4 2010 EmPOWER Maryland Report (Case 9155); Premise Level – Full Year 2010 Program Summary chart.

Pepco offered HVAC rebates throughout 2010, which were not as successful as anticipated. Rather than the expected 14,067 participants, Pepco rebated just 1,176 pieces of equipment in 2010. Like in the DPL service territory, low participation was due in part to Pepco's requirements for participating contractors, which were much more stringent than other utilities. Those requirements have since been modified, and Pepco expects that contractor and customer participation will improve dramatically through 2011.

Pepco began its Income Eligible Energy Efficiency Program, a limited income energy improvement program, in March 2010, completing its first audits in the third quarter of 2010. In 2010, Pepco weatherized forty-seven homes, in which they installed a total of 554 measures, compared to their forecast of 5,174 participants. Pepco achieved just 139 MWh savings during 2010, compared to its expected 1,885 MWh savings. In late 2010, Pepco filed and was approved for an expansion of its limited income program to include electric appliance replacement. Pepco works in coordination with DHCD to provide appliance replacement for homes being retrofitted under DHCD Weatherization program, as well. Measures include air conditioning units, heat pumps, refrigerators and hot water heaters. Pepco anticipates that this portion of the program will be available through 2011. Pepco has expanded its contractor pool in 2010 as part of its execution plan to complete more audits and installations during 2011.

Throughout 2010, Pepco's campaign targeted various audiences with program specific messages, beginning with radio spots, but later expanding its campaign to include television, newspaper, cinema, billboards and direct mail. A majority of the marketing was focused on building awareness around Pepco's suite of program to improve winter energy bills. During the cooling season, Pepco heavily promoted its demand response program, Energy Wise Rewards.

In a unique approach, Pepco sponsored a Home Energy Makeover contest with a local television station. Pepco aired television advertisements to promote EmPOWER programs and did special on air spots with the news station to answer customer questions regarding energy efficiency. In addition, Pepco chose two winners from its Maryland territory to receive $10,000 towards energy efficiency upgrades.

Commercial and Industrial Programs

Pepco offers prescriptive, custom, retrocomissioning, and HVAC programs for commercial and industrial customers. Overall, the commercial and industrial programs were well below their 2010 program targets, achieving just 28,055 MWh of the expected 114,434 MWh savings. Among its commercial and industrial programs, the Prescriptive Program contributed the most savings, and was the only commercial and industrial program to exceed its forecasted participant number, with 17 more participants than expected. This program offers rebates on standard commercial items such as overhead lighting, occupancy sensors and motors.

Pepco is proposing modifications to their commercial and industrial programs to begin in 2012. Proposed program improvements include higher incentives levels and programs that include direct installation of measures for small businesses. The company is also proposing an updated marketing strategy that will target appropriate energy efficiency measures by sector. Program managers will expand their outreach to previously untapped markets, including small retail and convenience stores which may have significant refrigeration or HVAC needs.

For industrial customers, Pepco hopes to focus on motors, pumps, fans and compressors, a key set of measures for this sector. Pepco may be interested in doing a demonstration trial utilizing combined heat and power technology.

Demand Response

Demand response is defined as the change in electricity usage by end-use customers either in response to price changes or to incentive payments designed to induce lower electricity use when demand is higher. Pepco launched its EnergyWise Rewards program (similar in program design to BGE's PeakRewards) in June 2009. Participants can choose to have either a thermostat or a digital switch installed on their air conditioner or electric heat pump, which gives Pepco the ability to cycle electricity usage during periods of high demand. Events are usually called on the hottest summer days when electricity usage is at its peak and system reliability may be jeopardized. Pepco installed 36,057 air conditioning measures in 2010 and a total of 39,987 measures since program inception. The number of installed measures is below the estimated target levels of 60,600 measures in 2010 and 75,760 measures program to date.

One of contributing factors to this shortfall was that PSC temporarily suspended the installation of thermostats due to a potential safety hazard with the devices. On September 23, 2010, Pepco Holdings, Inc. notified PSC of a potential fire hazard associated with the model of programmable thermostats Pepco was installing as part of its EnergyWise program.[27] PSC issued Order No. 83588 on September 23, 2010 that directed Pepco to cease the installation of the affected thermostats immediately. On September 24, 2010, PSC issued Order No. 83592 reinforcing the decision to cease thermostat installation in Order No. 83588 and directed Pepco to notify PSC when the Consumer Protection Safety Commission issued a decision on corrective actions for the safety issue with the thermostats. Pepco has not installed any thermostat since PSC issued Order No. 83588. However, Pepco is still able to install load control devices on central air conditioners and heat pumps.

Advance Metering Infrastructure

Advance metering infrastructure or "Smart Grid" technology is generally defined as a two-way communication system and associated equipment and software, including metering equipment installed on an electric customer's premises, that use the electric company's distribution network to provide real-time monitoring, diagnostic, and control information and services. Advanced metering infrastructure is generally considered to be an initiative that can reduce peak demand and energy consumption beyond those

[27] The safety issue for Model 1F88 of programmable thermostat was reported to the Consumer Protection Safety Commission by the manufacturer of the thermostat, White Rogers. The manufacturer notified Pepco Holdings Inc.'s contractor, Comverge and Comverge informed Pepco Holdings, Inc.

reductions achieved through "traditional" energy efficiency and conservation and demand response programs. Additionally, advanced metering infrastructure and Smart Grid technology will improve the efficiency and reliability of the distribution and use of electricity by reducing blackout probabilities and forced outage rates and restoring power in shorter time periods.

On September 2, 2010, PSC authorized Pepco to deploy its Advanced Metering Infrastructure Initiative. Some highlights of the approved Advanced Meter Initiative in Pepco territory are:

- Install 570,000 electric meters;
- Total benefits over the life of the project are estimated at $311.6 million;
- 100 percent of all meters to be installed by 2011; and,
- Pepco awarded $104.8 million in Smart Grid Investment Grant funds.

Figure C-7. Pepco Energy Efficiency & Conservation and Demand Response Reported Achievements*

	2010 Reduction	Percentage of 2010 Interim Target**	Program-to-Date Reduction	Percentage of 2011 Target
Pepco				
Electric Consumption Reduction (MWh)	68,149	42%	134,179	28%
Demand Reduction (MW)***	58	51%	68	13%

*Based on preliminary wholesale energy and demand savings from quarterly programmatic reports. These savings will be verified through a process currently under development.
** Percentage of energy savings forecasted to be achieved in 2010 minus 2009 forecast.
***Demand reduction is from both the Peak Rewards program and the demand savings created through energy efficiency program savings.

A.4.C: SMECO

SMECO received its Commission Order on August 13, 2009. The approved plan included six residential energy efficiency and conservation programs and two non-residential energy efficiency and conservation programs.[28] SMECO's programs were designed to reduce energy consumption by 68,627 MWh by the end of 2011 and 165,542 MWh by the end of 2015. SMECO's plan consists of a traditional set of programs, such as market buy-down or other incentives for the purchase and/or installation of energy efficient products or measures.

[28] Approved residential programs include: Lighting Program; Appliances Program; Home Performance with Energy Star; Quick Home Energy Check-up; HVAC; Energy Star New Home Construction; Limited Income Energy Efficiency Program. Approved commercial program includes: Prescriptive/Custom Program.

SMECO's suite of programs was fully operational by the first quarter of 2010. During the year, SMECO worked to ramp up its program participation through marketing and general awareness. The residential programs have proven to be successful throughout the service territory, exceeding their forecasted annualized energy savings by 54 percent. The coincident peak demand reduction for residential programs was 25 percent better than expected, achieving 2.94 MW instead of the expected 2.35 MW. The Commercial and Industrial programs performed below expectations for 2010, achieving just 1,383 MWh of savings instead of the forecasted 10,536 MWh, which affected the overall savings reductions. However, SMECO has several projects in the pipeline for 2011 that will help to improve its Commercial and Industrial Programs.

Energy Efficiency and Conservation Programs

Just in 2010, SMECO's programs achieved 18,461 MWh of the 21,630 MWh 2010 annual goal, an 85 percent achievement. SMECO's portfolio of programs, including the Cool Sentry peak demand response program, reduced demand by 19 MW since starting in 2009. The EmPOWER Maryland peak demand goal for SMECO is 28.7 MW, and the company estimated that they could achieve 13 MW of demand reduction by 2011, so they've already exceeded their own target by 32 percent. SMECO does not anticipate that it will achieve its 2011 goal.

Residential Programs

SMECO's appliance and lighting programs achieved more than 20,000 MWh of energy savings in 2010, 81 percent more savings than the expected 11,000 MWh. Participation was also very strong. SMECO had expected to rebate about 226,000 light bulbs in 2010, but ended up providing rebates for more than 365,000 bulbs. Appliance rebates were nearly double the forecasted measure quantity, thanks in part to the MEA State Energy Efficient Appliance Rebate Program. Based on the success of the MEA program, SMECO will continue to enhance the program in coming years by adding more appliances and new lighting technologies.

SMECO's HVAC rebate program also exceeded program forecasts, rebating nearly 1,300 units instead of the expected 767. However, energy savings were only about half of what was expected, likely due to customers' choice of equipment.

SMECO's Quick Home Energy Checkup program launched in January 2010 and its Home Performance with ENERGYSTAR program launched in June 2010. Because of the late launch, this program had just two participants by the end of 2010. However, SMECO is working to market this program aggressively in its service territory, and SMECO is working closely with MEA and the other utilities to make improvements to the Home Performance with ENERGYSTAR program. Enhancements include proposed rebates of up to 40 percent. If approved by PSC, these higher rebates would begin in early 2012. The Quick Home Energy Checkup was a strong performer, with 1,071 participants in 2010 compared to an expected 767.

SMECO's New Homes Program was well-received by the construction industry despite the housing market downturn and surpassed forecasted results for both 2010 and program-to-date. The program incentivizes builders to build homes that contain measures equivalent to or greater than ENERGY STAR code. In 2010, SMECO forecasted that the program would complete 71 homes generating 155 MWh in annualized energy savings and 0.11 MW in demand reduction. At the conclusion of 2010, builders had completed 245 homes, 245 percent more than anticipated. This resulted in SMECO realizing a 273 percent increase in both annualized energy savings and coincident peak demand reduction. There were 600 homes committed to the program prior to the conclusion of 2011.

SMECO launched its Limited Income Energy Efficiency Program in February 2010. Since the program began there have only been 52 active leads. This has resulted in 42 completed audits and 17 homes have received installation of measures. As a unique approach, SMECO's low income program compliments the DHCD program by providing shell improvements to bring homes up to code to allow for weatherization to occur.

SMECO continued its "Save Energy. Save Money" campaign in 2010. Through this campaign, SMECO utilized print advertisements in local publications to promote various tips to save energy. Through online messaging, its Facebook fan base and video on demand, SMECO has been able to connect with customers. SMECO also developed and produced "Save Some Bacon" tee-shirts as promotional items to get customers excited about the initiative as well as to generate word of mouth buzz.

Commercial and Industrial Programs

SMECO's prescriptive and custom commercial and industrial programs launched in December 2009. Response to both programs was slower than expected, with the prescriptive program attracting 65 of an expected 3,400 participants and the custom program attracting 13 of an expected 385 participants. The program attracted a lot of interest from trade allies, contractors, and industry associations. Projects grew in size throughout the year, and SMECO expects programs to continue to grow in 2011, thanks largely in part to the submetering that is taking place on the Patuxent River Naval Air Station. Working with the Patuxent River Naval Air Station will allow SMECO to achieve a great deal of savings. For 2012 and beyond, SMECO will be proposing to offer a small business lighting and retrofit program, similar to what BGE and the other utilities are proposing.

Overall, SMECO faces the challenge of having very little industry in its service territory. However, the company is preparing to focus more on small business direct install measures, including lighting, refrigeration, and compressed air. Other opportunities for energy savings are available through the hotel, food chain, and small hospital sectors, where waste-heat recovery and refrigeration upgrades may be possible.

The prescriptive commercial and industrial program will be enhanced with new measures and higher incentive levels, as well as increased marketing efforts. Targeted marketing will also help increase participation in the custom program by reaching out directly to customers rather than relying on trade allies.

Demand Response

Demand response is defined as the change in electricity usage by end-use customers either in response to price changes or to incentive payments designed to induce lower electricity use when demand is higher. SMECO launched its demand response program, CoolSentry, in November 2008. Participants can choose to have either a thermostat or a digital switch on their air conditioner or electric heat pump installed, which gives SMECO the ability to cycle electricity usage during periods of high demand. Events are usually called on the hottest summer days when electricity usage is at its peak and system reliability may be jeopardized. In 2010, SMECO installed 9,599 measures, which was below the 2010 target of 11,520 and also less than the number of devices installed in 2009 (9,874). Similar to Pepco, SMECO attributed this shortfall to the Commission Order that directed it to cease installations of thermostats due to the same safety issue discussed in the Pepco and DPL sections of this report.

Advance Metering Infrastructure

Advance metering infrastructure or “Smart Grid” technology is generally defined as a two-way communication system and associated equipment and software, including metering equipment installed on an electric customer’s premises, that use the electric company’s distribution network to provide real-time monitoring, diagnostic, and control information and services. Advanced metering infrastructure is generally considered to be an initiative that can reduce peak demand and energy consumption beyond those reductions achieved through “traditional” energy efficiency and conservation and demand response programs. Additionally, advanced metering infrastructure and Smart Grid technology will improve the efficiency and reliability of the distribution and use of electricity by reducing blackout probabilities and forced outage rates and restoring power in shorter time periods.

SMECO has a proposed a two-phase Advanced Metering Infrastructure Pilot Program to test the operational benefits of deploying this technology, such as savings from eliminating meter readings and improved outage restoration. Phase I of the pilot, approved by PSC in December of 2009, includes the installation of 1,000 meters in one section of the territory and went into effect in 2010. SMECO will attempt to quantify the level of operational benefits attainable through deployment of advanced metering infrastructure in SMECO’s service territory, and it will report the results of Phase I to PSC prior to implementing Phase II, which will be a 10,000 meter deployment across the entire service territory.

Figure C-8. SMECO Energy Efficiency & Conservation and Demand Response Reported Achievements*

	2010 Reduction	Percentage of 2010 Interim Target**	Program-to-Date Reduction	Percentage of 2011 Target
SMECO				

Electric Consumption Reduction (MWh)	18,461	73%	18,494	27%
Demand Reduction (MW)***	11	48%	19	32%

*Based on preliminary wholesale energy and demand savings from quarterly programmatic reports. These savings will be verified through a process currently under development.
** Percentage of energy savings forecasted to be achieved in 2010 minus 2009 forecast.
***Demand reduction is from both the Cool Sentry program and the demand savings created through energy efficiency program savings.

A.4.D: Potomac Edison

Potomac Edison (PE, formerly Allegheny Power) received its PSC Order on August 6, 2009. The approved plan includes a portfolio of six residential and five commercial energy efficiency and conservation programs.[29] PE's programs as modified by PSC's Order, including transformer and streetlight replacement, are designed to save 109,955 MWh by the end of 2011 and 263,867 MWh by the end of 2015.

Energy Efficiency and Conservation Programs

PE's suite of programs was fully operational by the first quarter of 2010. The programs, for both residential and commercial, continued to ramp up during the year. Including the fast-track programs that began in 2009, PE's energy efficiency and conservation programs achieved 37 percent, or 40,227 MWh, of its 2011 energy efficiency and conservation electric consumption reduction target. Just in 2010, the company reported 15,068 MWh of savings toward the 38,056 MWh annual goal, or about 40 percent of this interim target. PE's portfolio of programs achieved 14 percent, or 5 MW of its 35 MW 2011 peak demand reduction target. While PE fell short of its 2010 targets, over 52 percent of PE's reported energy savings for the year occurred in the fourth quarter of 2010. The company also reports that there is an additional 12,000 MWh of electricity savings under contract which will be able to be counted in early 2011.

Residential Programs

To capture more participation, PE enhanced several of its programs. For its Lighting Program, PE altered its program approach from a mail-in rebate form to a point of purchase buy-down. After the alteration of the program method, the program experienced a 212 percent increase in participation from the previous quarter. However, the lighting program still was far from its 2010 goal, rebating just 107,000 bulbs rather than the expected 446,000.

Likewise, the PE appliance rebate program did not meet its forecasted number of participants, reporting 12,222 participants instead of the expected 20,651. Though

[29]Approved residential programs: Compact Fluorescent Light Rebate Program; Energy Star Appliance Program; Home Performance Program; Low Income Program; Air Conditioner Efficiency Program; Heat Pump Efficiency Program. Approved commercial programs: Lighting Efficiency Program; Air Conditioning Efficiency Program; Heat Pump Efficiency Program; Commercial and Industrial Efficient Drives; Commercial and Industrial Custom Applications.

participation was lower, the energy savings numbers show that participants are choosing appliances with higher energy savings than expected – the company reports a savings of 4,083 MWh, while the expected savings was 4,621 MWh.

PE experienced success with its Heating Ventilation Air Conditioner Efficiency Program in 2010. The program generated 193 percent, or 1,522 MWh more in annualized energy savings than forecasted. This is largely due to the higher rebates available from MEA's program. PE doubled the number of rebates processed under this program between the third and fourth quarters. The success of this program through late 2010 may be an indicator of the results to be anticipated for the 2011 cooling season.

In addition to the Quick Home Energy Checkup and Home Performance programs, PE also offers a free online energy audit as part of its suite of residential retrofit programs. Energy savings are counted when customers accept an energy efficiency kit containing compact fluorescent light bulbs. Participation was well below the forecasts, with just 3,500 participants across all three programs instead of the expected 23,700.

PE began its Limited Income Program in November 2009. Rather than develop its own contractor base, PE developed a partnership with DHCD that utilizes local weatherization agencies in the utility's service territory to conduct weatherization audits and install measures. This allows the local weatherization offices and PE to leverage funds to provide the most energy savings to customers in its service territory. In August 2010, PE filed and was approved for an expansion of its low income program to include refrigerator and freezer replacement. PE incorporated this into its limited income program in November 2010 and anticipates that the installation of these particular measures will increase in 2011. In 2010, the program completed 228 audits within its territory, installing approximately 3,501 measures. PE anticipates that as the American Reinvestment and Recovery Act funds deplete, the local weatherization agencies will complete significantly more projects under PE's low income program.

PE used its Watt Watcher Energy Awareness and Market Transformation campaign to educate all customer classes, motivate customers to participate in one or more programs, help customers make informed decisions and increase understanding of the benefits of the program. The "little decisions" could yield "big savings" campaign utilized print, radio, cinema, and on-line advertising outlets throughout 2010. PE partnered with Radio Disney for a school program that launched in October 2010. This initiative reached out to 12 schools through a Jeopardy-style quiz show.

Commercial and Industrial Programs

The first savings for the commercial and industrial programs was reported in the fourth quarter of 2010. While the reported commercial and industrial energy savings and participation numbers were drastically lower than forecasted, the company had an additional 12,000 MWh of savings under contract at the end of 2010, representing 385 percent of the cumulative 2010 plan forecast.

Moving into the next program cycle, PE will lower participation eligibility requirements (i.e., minimum levels of energy usage and demand) for its commercial and industrial custom and lighting efficiency programs. These changes allow for a greater penetration of the programs with small businesses and expand the measures and rebates available. Program changes will also include an expedited energy efficiency path for small commercial customers and additional marketing support for programs.

PE does not have a residential demand response program but is proposing three commercial and industrial demand response programs for the 2012 – 2014 EmPOWER cycle:

- The Conservation Voltage Reduction Program, which will target select distribution circuits where voltage reductions can be achieved while maintaining voltage within the regulatory requirements;
- The Customer Resources Demand Response Program, in customers would participate in the program by engaging the services of the Curtailment Service Providers who are under contract with Potomac Edison; and
- The Distributed Generation Program, which will target commercial, industrial and governmental customers that have a load of 300 kilowatts or larger and have existing backup generators rated at least 500 kilowatts. The focus of the program is to have these customers operate their existing backup generators during peak load periods; hence, reducing the demand on the grid.

Figure C-9. Potomac Energy's Energy Efficiency & Conservation and Demand Response Reported Achievements*

	2010 Reduction	**Percentage of 2010 Interim Target****	**Program-to-Date Reduction**	**Percentage of 2011 Target**
PE				
Electric Consumption Reduction (MWh)	15,068	55%	40,227	37%
Demand Reduction (MW)***	5	36%	5	14%

*Based on preliminary energy and demand savings from quarterly programmatic reports. These savings will be verified through a process currently under development.
** Percentage of energy savings forecasted to be achieved in 2010 minus 2009 forecast.
***PE does not have a residential demand response program, so all reductions are from energy efficiency program savings

A.4.D: Delmarva Power and Light

DPL received its Commission Order on August 13, 2009. DPL's approved plan included four residential and four non-residential energy efficiency and conservation programs,[30]

[30]Approved residential programs include: the Lighting and Appliance Program; the Home Performance with Energy Star Program which includes Quick Home Energy Check-up and the Online Audit Calculator; the a no cost appliance replacement program for Low Income; the residential HVAC Program. Approved

as well as demand response and street lighting programs, which were designed to save 149,288 MWh by 2011 and 321,619 MWh by 2015. DPL's portfolio of energy efficiency and conservation programs is applicable across the residential, commercial, government, and institutional customer base. DPL's plan consists of a traditional set of programs, such as market buy-down or other incentives for the purchase and/or installation of energy efficient products or measures.

Energy Efficiency and Conservation Programs

In 2010, DPL's energy efficiency and conservation programs achieved 15 percent, or 22,925 MWh, of its 2011 energy efficiency and conservation electric consumption reduction target. This number includes all programs, including those started in 2009. DPL's portfolio of programs, including demand response, achieved 13 percent, or 18 MW of the company-set 2011 peak demand reduction target. The company-set demand response target was significantly higher than the 2011 EmPOWER Maryland goal; DPL achieved 25 percent of the 73 MW EmPOWER goal. Due to the fact that DPL was still ramping up its programs well into 2010, DPL fell short of its 2010 Interim Target for annual energy and demand savings in order to remain on target for 2011, reaching only 32 percent and 65 percent of its 2010 unofficial incremental benchmark for energy savings and demand reduction, respectively.

At the conclusion of 2010, DPL all programs in DPL's suite were up and running. Among the residential program offerings, DPL's most successful program to date continued to be the Lighting and Appliance program. The Appliance portion of the program experienced double the number of rebated appliances during 2010 from 2009 due to the increased rebate available through MEA's State Energy Efficiency Appliance Replacement Program funded by the American Reinvestment and Recovery Act of 2008. This program ran from April 2010 through November 2010 and offered additional rebates on utility rebated appliances as well as new rebates not offered under EmPOWER portfolio.

The appliance program exceeded several annual forecasts for DPL, rebating 1,879 appliances rather than the expected 830, 126 percent more than forecasted for 2010. In turn, this success generated 237 percent, or 147 MWh more in annualized energy savings than anticipated. DPL plans to enhance its appliance program to include additional appliances and rebates to match the levels resulting from the collaborative effort with MEA. The lighting program achieved 92 percent of its 2010 annual goal, rebating more than 152,000 bulbs. Lighting, alone, was responsible for more than half of the 2010 energy savings for DPL. To keep up with changing technology, DPL is proposing the addition of light emitting diode bulbs for future program years.

DPL offered HVAC rebates throughout 2010, which were not as successful as anticipated. Instead of rebating their forecasted 7,070 HVAC units, the company rebated just 199. Like in the Pepco service territory, low participation was due in part to DPL's

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commercial programs include: the Prescriptive Program; the Heating, Ventilation, and Air-Conditioning Program, Custom Incentive Program; the Building Commissioning and Operations & Maintenance Program.

requirements for participating contractors, which were much more stringent than other utilities. Those requirements have since been modified, and DPL expects that contractor and customer participation will improve dramatically through 2011.

DPL began its Income Eligible Energy Efficiency Program, a limited income energy improvement program, in March 2010, completing its first group of audits in the third quarter of 2010. In 2010, DPL weatherized nine homes, in which it installed a total of 129 measures, compared to their forecast of 3,031 participants. In late 2010, DPL filed and was approved for an expansion of its limited income program to include electric appliance replacement. Pepco works in coordination with DHCD to provide appliance replacement for homes being retrofitted under the DHCD Weatherization program, as well. Measures include air conditioning units, heat pumps, refrigerators and hot water heaters. DPL anticipates that this portion of the program will be available through 2011. DPL has expanded its contractor pool in 2010 as part of its execution plan to complete more audits and installations during 2011.

Throughout 2010, DPL's campaign targeted various audiences with program specific messages, beginning with radio spots, but later expanding its campaign to include television, newspaper, cinema, billboards and direct mail. A majority of the marketing was focused on building awareness around DPL's suite of program to improve winter energy bills. During the cooling season, DPL heavily promoted its demand response program, Energy Wise Rewards.

DPL attended several special events throughout its service territory to foster two-way dialogue with its customers. DPL also turned to social marketing, such as Twitter and Facebook, to target its customers with energy efficiency tips and programs.

Commercial and Industrial Programs

DPL offers prescriptive, custom, retrocomissioning, and HVAC programs for commercial and industrial customers. Overall, the commercial and industrial programs were well below their 2010 program targets, achieving just 3,290 MWh of the expected 19,539 MWh savings. Among its commercial and industrial programs, the Prescriptive Program contributed the most savings, but still only had 62 of an expected 80 participants and 3,086 MWh of an expected 8,922 MWh savings. This program offers rebates on standard commercial items such as overhead lighting, occupancy sensors and motors.

Demand Response

Demand response is defined as the change in electricity usage by end-use customers either in response to price changes or to incentive payments designed to induce lower electricity use when demand is higher. Pepco launched its EnergyWise Rewards program (similar in program design to BGE's PeakRewards) in June 2009. Participants can choose to have either a thermostat or a digital switch installed on their air conditioner or electric heat pump, which gives Pepco the ability to cycle electricity usage during periods of high demand. Events are usually called on the hottest summer days when electricity usage is at its peak and system reliability may be jeopardized. DPL installed 11,554 air conditioning measures in 2010, exceeding its annual installation target. The utility has installed 13,807 measures program to date.

As discussed in the Pepco section, PSC temporarily suspended the installation of thermostats due to the same safety issue. However, DPL was still able to install load control devices on central air conditioners and heat pumps.

Advance Metering Infrastructure
Advance metering infrastructure or "Smart Grid" technology is generally defined as a two-way communication system and associated equipment and software, including metering equipment installed on an electric customer's premises, that use the electric company's distribution network to provide real-time monitoring, diagnostic, and control information and services. Advanced metering infrastructure is generally considered to be an initiative that can reduce peak demand and energy consumption beyond those reductions achieved through "traditional" energy efficiency and conservation and demand response programs. Additionally, advanced metering infrastructure and Smart Grid technology will improve the efficiency and reliability of the distribution and use of electricity by reducing blackout probabilities and forced outage rates and restoring power in shorter time periods.

In Order No. 83571, PSC postponed the decision on DPL's request to proceed with deployment of its Advanced Metering Infrastructure Initiative. This deferment stemmed primarily from the U.S. Department of Energy's decision not to grant DPL an award for American Recovery and Reinvestment Act funding under the Smart Grid Investment Grant. Without such federal funding the cost-effectiveness for the advanced metering infrastructure proposal became untenable. DPL's request to establish a regulatory asset for the incremental costs associated with its proposed advanced metering infrastructure deployment was deferred as well.

Figure C-10. Delmarva Power & Light Energy Efficiency & Conservation and Demand Response Reported Achievements*

	2010 Reduction	Percentage of 2010 Interim Target**	Program-to-Date Reduction	Percentage of 2011 Target
DPL				
Electric Consumption Reduction (MWh)	11,706	32%	22,925	21%
Demand Reduction (MW)***	15	65%	18	13%

*Based on preliminary wholesale energy and demand savings from quarterly programmatic reports. These savings will be verified through a process currently under development.
** Percentage of energy savings forecasted to be achieved in 2010 minus 2009 forecast.
***Demand reduction is from both the Peak Rewards program and the demand savings created through energy efficiency program savings.

A.5: Combined Heat and Power

Lead Agency: MEA and MDE

Program Description

Combined heat and power, also called co-generation, is a system which is designed to generate both power and thermal energy from a single fuel source. When electricity is generated, thermal energy is a by-product that is traditionally not used, however a combined heat and power system can utilize the thermal energy for heating or cooling. The conventional method of producing thermal energy and power separately has a typical combined efficiency rate of 45 percent, while combined heat and power systems can reach 80 percent efficiency levels. The increased efficiency means more energy is generated from a single fuel source, therefore, GHG emissions from a combined heat and power system is less than a typical system which produces electric and thermal energy separately. Adding these systems can greatly increase a facility's level of energy efficiency and decrease energy costs. Moreover, combined heat and power is an efficient, clean, and reliable approach to generating power while also reducing GHG emissions.

State agencies, such as MEA, MDE and DNR, continue to evaluate opportunities for combined heat and power in Maryland. Combined heat and power systems can be promoted by State agencies, such as MEA, through the enactment of incentives such as: (1) direct subsidies, tax credits or exemptions for purchasing, selling or operating combined heat and power systems; (2) tax credits for each kilowatt-hour or BTU generated from a qualifying facility; and, (3) feed-in tariffs. Also, education and outreach to inform the public of the many benefits associated with combined heat and power.

Currently, there are approximately 21 combined heat and power units located throughout Maryland. These units are fueled by a range of primary fuels, including fossil fuels, biomass, municipal solid waste, and other industrial waste products.

Estimated GHG Emission Reductions in 2020

In order to account for similarities across programs, all emission benefits and costs associated with these programs have been aggregated under A: EmPOWER.

Implementation

MEA has offered assistance to the State's industrial sector through the Maryland Save Energy Now program. Support offered through the program includes:

- Low cost energy assessments for industrial facilities in Maryland. The assessments include a one- to three-day site visit by the University of Maryland Manufacturing Assistance Program to evaluate energy use at the facility, identification of opportunities for energy efficiency improvements and combined heat and power, and a report on the assessment findings and recommendations.

- Free monthly training webinars on various industrial energy efficiency topics, including combined heat and power. The webinar series started in September 2010 and concluded in March 2011.

- Information on financial incentives and other helpful resources for businesses, including those offered by Maryland's utilities, MEA, and federal agencies such as the U.S. Department of Energy, and third party investors.

The Jane E. Lawton Conservation Loan Program provides eligible non-profit organizations (including hospitals and private schools), local governments (including public school systems and community colleges), and businesses in Maryland a unique opportunity to reduce operating expenses by identifying and installing energy conservation improvements. The program honors the late Delegate Lawton for her dedication to Maryland's environment and energy efficiency. The program allows borrowers to use the cost savings generated by added improvements as the primary source of revenue for repaying the loans. This neutral budget impact makes this an attractive financing opportunity for interested organizations.

Projects applying for funding through the Jane E. Lawton Conservation Loan Program should have a simple payback of ten years or less. All costs necessary for implementing an energy conservation project can be considered for funding, including the technical assessment, reasonable fees for special services, plans and specifications, and the actual costs of the conservation measures. The interest rate for all program loans made during FY11 will be 2.5 percent.

By offering the Jane E. Lawton Conservation Loan Program as a revolving loan fund rather than a one-time grant, Maryland is able to maximize the use of the funds. Repayments and interest earned by the fund will allow the program to continue making loans for the foreseeable future. To date, more than fifty loans have been made providing about $21 million for energy efficiency improvements across Maryland.

Maryland Renewable Energy Portfolio Standard (RPS)

B.1: The Maryland Renewable Energy Portfolio Standard Program

Lead Agency: MEA

Program Description

The objective of the Renewable Energy Portfolio Standard (RPS) Program is to recognize and develop the benefits associated with a diverse collection of renewable energy supplies to serve Maryland. The State's RPS does this by recognizing the environmental and consumer benefits associated with renewable energy. The RPS requires retail suppliers of electricity to meet a prescribed minimum portion of their energy supply needs with various renewable energy sources, which have been classified within the RPS Statute as Tier 1 and Tier 2 renewable sources. The program is implemented through the creation, sale and transfer of RECs. Electricity suppliers are required to purchase specified minimum percentages of their electricity resources via RECs from Maryland-certified Tier 1 and Tier 2 renewable resources. Tier 1 and the Tier 1 solar set-aside requirements gradually increase until they peak in 2022 at 18 percent and 2 percent, respectively, and are subsequently maintained at those levels.[31] Maryland's Tier 2 requirement remains constant at 2.5 percent through 2018, after which it sunsets. The development of renewable energy sources is further promoted by requiring electricity suppliers to pay a financial penalty for failing to acquire sufficient RECs to satisfy the RPS. The penalty is used to support the creation of new Tier 1 renewable sources in the State.

The Maryland RPS is designed to create a stable and predictable market for energy generated from renewables, and to foster additional development and growth in the renewable industry. Implementation of the RPS assists in overcoming market barriers seen as impediments for the development of the industry; moreover, increasing reliance upon renewable energy technologies to satisfy electric power requirements can provide benefits including reductions in emissions of pollutants, increases in fuel diversity, and economic and employment benefits to Maryland.

Estimated GHG Emission Reductions in 2020

Figure C-11. Low and High GHG Benefits for Energy-11

Initial Reductions	5.86 $MMtCO_2e$	MEA Quantification
Enhanced Reductions	9.96 $MMtCO_2e$	MEA Quantification

Reduction above account for overlap which was handled separate from othe programs but did account for RGGI, EmPOWER, and Fuel Switching. Note that the SAIC Quantification handled RGGI reductions in a different way. After accounting for overlap between the energy programs, the MEA quantification and SAIC quantification of all energy programs produces net reductions within 4% of each other.

MEA Quantification

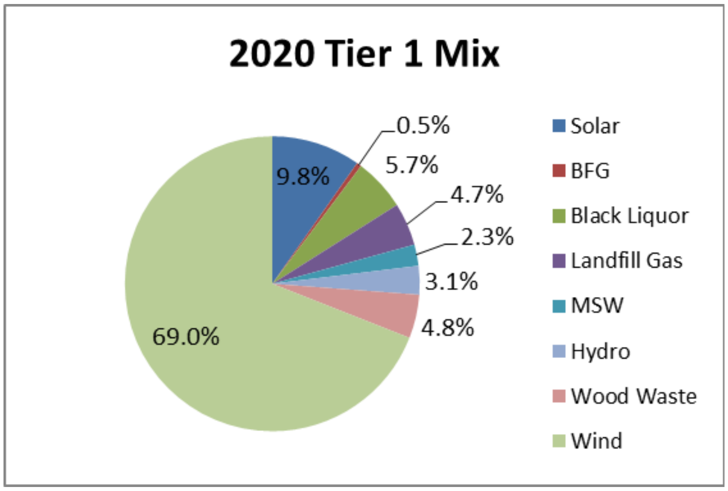
The current RPS escalates to 18 percent of electricity sales from renewable energy by 2020. The estimated avoided GHG emissions for the current RPS program range from 3.04 $MMtCO_2e$ to 7.36 $MMtCO_2e$.

MEA made an estimate based on the historic and projected mix of RECs that would be used to meet the 2020 RPS compliance. Based on the BAU forecast, Maryland would

[31]"Tier 1 solar set-aside" refers to the set-aside (or carve-out) of Tier 1 for energy derived from a qualified solar energy facilities. The Tier 1 solar set-aside requirement applies to retail electricity sales in the State by electricity suppliers and is a sub-set of the Tier 1 standard.

need approximately 13.7 million RECs in 2020. The following chart depicts the projected REC mix used

Figure C-12. 2020 Tier 1 REC Mix



Based on this mix, and using conversion factors from EPA, the RECs would contain approximately 0.16 $MtCO_2e/MWh$. Using projections from conventional energy, the same 13.7 million MWh would contain approximately 0.64 $MtCO_2e/MWh$. When the reduction is applied to the appropriate mix of in-state and imported electricity, the net impact of the policy is a reduction of 7.36 $MMtCO_2e$.

In addition to reducing carbon dioxide, the current RPS goal of 18 percent of the energy supply from renewable energy sources by 2020, would displace 6,300 metric tons of nitrogen oxides and 46,534 metric tons of sulfur dioxides.

Figure C-13. Current RPS Program

	Carbon Dioxide (million metric ton)	Nitrogen Oxides (metric ton)	Sulfur Dioxides (metric ton)
Business As Usual 2020 Emissions	54.50	72,502	261,541
Estimated 2020 Emissions with RPS	47.01	6,750	543
Net Emissions Avoided	**7.36**	**6,300**	**46,534**

Implementation

Under the RPS, electricity suppliers are required to meet a renewable energy portfolio standard. This is an annual requirement placed upon Maryland load serving entities, which include electricity suppliers and the utilities. Load serving entities file compliance reports with PSC verifying that the renewable requirement for each entity is satisfied.

Maryland's RPS requires electric suppliers to obtain RECs for a minimum percentage of their power generated from renewable energy resources. Implementation of the Maryland RPS can provide an incentive for renewable generators to locate in the PJM region and generate electricity. The renewable requirement establishes a market for renewable energy, and to the extent Maryland's geography and natural resources can be utilized to generate renewable electricity, power plant developers may locate projects within the State. Moreover, Maryland's RPS requires suppliers that do not meet the annual obligations to pay penalties, which in turn are used to support the creation of new Tier 1 renewable sources within the State. Additionally, on or before December 31, 2011, Tier 1 solar resources that are not located in Maryland are eligible only if sufficient offers from instate resources are not made.

Compliance fees are deposited into Maryland's Strategic Energy Investment Fund, dedicated to provide loans and grants that can indirectly spur the creation of new renewable energy sources in the State. As a special, non-lapsing fund, the Strategic Energy Investment Fund is also the depository of revenues generated through the sale of carbon allowances under RGGI. Indeed, the majority of the Strategic Energy Investment Fund results from the RGGI carbon dioxide allowance auctions. Auctions are held quarterly. At least 6.5 percent of the funds from RGGI allowances sold between March 1, 2009 and June 30, 2011 are to be allocated to renewable and clean energy, climate change programs, and energy related public education and outreach programs; an allocation of up to 10.5 percent of RGGI funds is provided for in subsequent auctions. Responsibility for developing renewable energy sources has been vested with MEA.

B.2: GHG Emission Reductions from Fuel Switching

Lead Agency: MDE

Program Description

GHG emissions from the energy supply sector in Maryland include emissions from fossil fuel-fired electricity generation and represent a substantial portion of the State's overall GHG emissions. On a consumption basis, Maryland imports a considerable amount (about 30 percent) of electricity generated out-of-state in the surrounding PJM grid region to meet retail electricity demand.[32] In the absence of State programs to curb emissions from out-of-state resources, the level of GHG emissions associated with meeting electricity demand in Maryland is expected to increase over time.

The 2008 Climate Action Plan included a policy, which defined a generation performance standard as a mandate for load serving entities, which include electricity suppliers and the utilities. The mandate would require load serving entities to acquire electricity on a portfolio basis, with the portfolio meeting a per-unit GHG emission rate below a specified standard. The generation performance standard policy would promote

[32] The PJM wholesale market includes all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia.

the purchase of energy and capacity from low-carbon or renewable technologies. The policy's goal is to enact a standard of no more than 1,125 pounds of GHGs per megawatt-hour (MWh) by 2013.

It is expected that the generation performance standard would reduce the amount of imports from states with a higher concentration of coal in the fuel mix. For example, Pennsylvania is a net exporter to Maryland and the majority of the emissions from the fuel mix are from coal-fired units. Even though Pennsylvania does not participate in RGGI, the generation performance standard would effectively limit the amount of electricity from coal-fired unit which would be imported from Pennsylvania into Maryland. Unless Pennsylvania coal-fired plants could sell the excess power elsewhere, the effect could potentially reduce the output from such plants and cause an economic loss. Whereas, low-carbon and renewable energy technologies would receive a premium from Maryland rate-payers.

Estimated GHG Emission Reductions in 2020

Figure C-14. Low and High GHG Benefits for Energy-2

Initial Reductions	1.00 $MMtCO_2e$	MDE Quantification Below
Enhanced Reductions	1.00 $MMtCO_2e$	MDE Quantification Below

Estimates – MDE Quantification
Quantification of GHG emissions will be driven by two numbers which will be affected by a myriad of factors. The GHG emissions from imported electricity are calculated simply by the multiplication of the amount of imported electricity (in MWh) and carbon-intensity of that electricity (in pounds of CO_2-equivalent per MWh). But numerous assumptions have to be made before this calculation can be completed.

The baseline year for GGRA is 2006. For 2006, fossil-fuel electric generating units in Maryland supported 31.16 million MWh of consumption (from GHG inventory and SAIC ES-3 Page 80, Appendix B). While, imported power was 10.02 million MWh of Maryland’s consumption (for a total of 42.18 million MWh). To calculate the amount of imported electricity in 2020, it is necessary to first calculate the total amount of electrical consumption in Maryland in that time frame. From previous work (SAIC Policy ES-3 Page 80, Appendix B), total Maryland consumption is estimated to be 58.8 million MWh, of which 42.88 million MWh are generated instate. So, in 2020 Maryland will import 15.92 million MWh of electricity. This assumption will remain the same for both the low and high quantification analysis. However, other factors could drive this number higher or lower. For example, electrical distribution in Maryland is currently constrained by congestion, this may or may not be relieved by the building of additional transmission lines (which may or may not be built). Further, the EmPOWER Maryland program (and possible new programs) could reduce Maryland’s consumption such that the percentage of imported power decreases in the future.

One of the difficulties in quantifying the carbon-intensity of electricity is the availability of data. The PJM Interconnection's Environmental Information Services, Inc. (PJM EIS) data system has the carbon intensity for the total PJM region system. The data for the PJM region is divided into RGGI (Delaware, Maryland, and New Jersey) and non-RGGI (7 remaining states and D.C.), but Maryland-specific data is not available. For the PJM region from 2006 to 2010, the carbon-intensity decreased from 1,251.8 to 1,167.6 pounds of CO_2-equivalent per MWh. This is a reduction 84.2 pounds of carbon dioxide, which represents an annual reduction of 1.68 percent. This reduction was not consistent and factors like economic activity and weather can have a significant effect on the carbon-intensity of electricity. In general, an increase in economic activity and more intense weather tends to increase the carbon-intensity of electricity. However, the general trend of carbon-intensity in PJM has been decreasing over time.

For the 2006 baseline, the GHG emissions from imported power is 10.02 million MWh multiplied by 1,251.8 pounds of carbon dioxide per MWh, which equals 5.7 $MMtCO_2e$ (or 12,538,165,966 pounds). For 2020, the business-as-usual calculation is 15.92 million MWh multiplied by the same carbon intensity (1,251.8 pounds of carbon dioxide per MWh), which equals 9.0 $MMtCO_2e$ (19,927,889,748 pounds).

For the low quantification, it is assumed that the carbon-intensity trend from 2006 to 2010 continues to 2020. Therefore, the 2010 carbon-intensity of 1,167.6 pounds of carbon dioxide per MWh is reduced annually by 1.68 percent, which results in a low-case 2020 carbon intensity of 985.5 pounds of carbon dioxide per MWh). Multiplying this by the calculated 2020 electrical importation of 15.92 MWh equals 7.1 $MMtCO_2e$ (15,688,413,839 pounds). So the low-estimated reduction is 1.9 $MMtCO_2e$ (9.0 – 7.1).

Overlap is an issue which <u>must be</u> accounted for as part of this GHG emissions mitigation program, since these reduction could be partially or totally subsumed as part of other mitigation programs. So, only 1.00 MMtCO2e was attributed to this program.

B.3: Incentives and Grant Programs to Support Renewable Energy

Lead Agency: MEA

Program Description

MEA administers a number of incentives and grant programs to promote and accelerate the development of renewable energy production and a vital renewable energy economy in Maryland, from utility scale facilities to on-site distributed generation. The regulatory driver for these programs is Maryland's RPS. The RPS is a statutory goal committing the State to obtain 20 percent of the electricity consumed in Maryland from renewable resources by 2022, with interim targets of 7.5 percent by 2011 and 18 percent by 2020.[33]

[33] The original RPS has been strengthened by the General Assembly in recent years. <u>See</u>" Renewable Portfolio Standard Percentage Requirements – Acceleration" (Senate Bill 209/House Bill 375, General Assembly 2008), which increased the RPS percentage requirements to 20 percent by 2022, including a 2 percent level for solar; and "Renewable Energy Portfolio Standard - Solar Energy" (Senate Bill 27, General Assembly 2010), which accelerates RPS requirements for solar energy in the early years (2011 through

Commercial Clean Energy Grant Program. The Commercial Clean Energy Grant Program provides financial assistance to businesses, non-profits, and government entities who install solar photovoltaic, solar water heating, geothermal heating and cooling and wind turbine systems at their place of business.

Residential Clean Energy Grants Program. The Residential Clean Energy Grant Program provides financial assistance to residents who install solar photovoltaic, solar water heating, geothermal heating and cooling and wind turbine systems at their residence. In 2012, MEA added Clean Burning Wood Stove incentives for both stick and pellet-fueled wood stoves to the Program to make its portfolio of clean energy conversion technologies available to a wider base of Maryland residents.

Through these two programs, MEA has awarded thousands of grants (ranging from $500-$50,000) to homeowners and businesses to offset the cost of installing wind, geothermal and solar photovoltaic systems. Demand has increased from 200 systems a year to 200 systems a month in 2010 and 2011, even with reduced incentives.

Clean Energy Incentive Tax Credit Program. Started in 2006, this program offers a State income tax credit to Maryland individuals and corporations that build and produce electricity generated by qualified renewable resources, in the amount of 0.85 cents per kilowatt-hour, and 0.50 cents per kilowatt-hour for electricity generated from co-firing a qualified resource with coal. The resources must be operational before 2016. MEA issues five-year credit certificates on a first-come, first-serve basis. Total program credits are capped at $25,000,000 by 2016, with individual credits ranging between $1,000 and $2,500,000 per eligible project.[34] As of June 30, 2011, more than $8.5 million in credits had been claimed over the past three years.

Generating Clean Horizons Program. Electricity is a significant part of the State's purchasing budget and has a considerable impact on Maryland's energy use and GHG emissions. By 2009, the State government spent approximately $160 million per year on electricity and using 1.5 billion kilowatts per year.[35]

In 2009 MEA and DGS, in partnership with the University System of Maryland, launched the Generating Clean Horizons program to reduce the GHG footprint of the purchased electricity of State government and the University of Maryland. Through a competitive bid process, long-term power purchase agreements were awarded to three new, utility-scale renewable energy sources that collectively will provide 78 MW, approximately 16 percent of the annual electricity needs of State agencies and University

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2016), from 0.35 percent to 0.50 percent, while leaving unchanged the 2022 RPS goal of 2 percent for solar.

[34]Maryland Clean Energy Incentive Act of 2010" (House Bill 464) extended the existing clean energy incentive State income tax credit for 5 years, through December 31, 2015.

[35]Telephone conversation with Hatim Jabaji, Office of Energy Projects and Convervation, DGS, May 12, 2009.

of Maryland's institutions over a 20-year period.[36] The awards were made to Constellation Energy for a 13 MW solar project on the Mount St. Mary's University campus in Emmitsburg, Maryland; Synergics for a 10 MW solar project as part of its Roth Rock development in Western Maryland; and U.S. Wind Force, LLC, for a 55 MW on-shore wind energy project at the Pinnacle Wind Farm in West Virginia. See Figure C-22 below for project details.

The *Generating Clean Horizons* initiative significantly advances both the purchasing and building energy usage "lead by example" policies first articulated in the *2008 Climate Action Plan* and supports the development of utility-scale, commercial projects to provide clean energy to Maryland's grid. Additionally, the State retains valuable renewable energy certificates (RECs) that can be used for its own RPS compliance needs.

Figure C-15. Clean energy purchase partnership

Bidder	Project	Project Type	State	Project Capacity (MW)	Annual Energy Output (MWh/yr)	Contract Escalation	Start Date	Term (yr)	Annualized Project Rate ($/kWh)
US Windforce	Pinnacle	wind	WV	55	173,542	0%	Dec 2011	20	0.082
Synergic-SBR	Roth Rock Phase II	Wind	MD	10	30,605	50% CPI	Dec 2011	20	0.120
Constellation	St. Mary's Solar	Solar	MD	13	22,291	0%	Jan 2013	20	0.224

Project Sunburst. In 2010 MEA launched *Project Sunburst* to install major solar photovoltaic arrays on as many as 17 government buildings around the State. When completed in 2011, the installations will have a generating capacity of 8.91 MW, which at the time it was planned, would have more than doubled the amount of solar on Maryland's grid. The program, administered by MEA, leverages federal stimulus funds to award grants to selected government entities at a rate of $1,000 per kilowatt on installations. Award recipients include public school systems throughout the State, the City of Baltimore, Talbot County facilities, BWI Airport, and the Maryland Port Authority Marine Terminal.[37]

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[36] The "Generating Clean Horizons" joint request for proposal, issued in February 2009, solicited proposals for renewable and low-carbon energy projects to supply electricity and RECs to State agencies and University System of Maryland institutions. Under its terms, State government and universities can purchase up to 20 percent of their annual electricity needs through as-needed contracts, not to exceed 20 years, with providers in Maryland and surrounding states. Power must be made available by December 31, 2014.

[37] "Governor O'Malley's Project Sunburst Puts Solar Energy on 31 State Buildings, Nearly Tripling Solar Energy Produced in Maryland", MEA Press Release, April 22, 2010. http://www.energy.state.md.us/press.html

MEA provides ongoing technical project assessment and procurement assistance to the Department of General Services and the University System of Maryland as a follow-on project.

A CEEDI Grant Prince George's County to Develop Residential Solar Water Heating Business Models. The goal of this 2012 project is to develop three Solar Water Heating (SWH) business models that present a compelling economic value proposition for Prince George's County residents to invest in up to 5,000 SWH systems at greatly reduced installed costs achieved through economies of scale. Three business models—based on water utility, electric utility, and private sector financing paradigms—will include an analysis of costs and benefits of surveys to assess demand, targeted marketing to create demand, installed SWH product, services such as installation and maintenance, warrantees, billing methodologies, administration, etc. After all costs are calculated, there must be sufficiently high return and low risk to incent developers, utilities, and residents to invest in this technology.

Biomass Programs. MEA administers several tax and other incentive programs to promote the use of organic materials such as agricultural crops and residues, household, industrial, and forestry wastes, for biofuels and energy.[38]

Two new (2012) programs include the Clean Burning Wood Stove Incentive addition to the Residential Clean Energy Grant Program and the Game Changer Competitive Grant Program award to a large biomass boiler at Catoctin Mountain Growers.

Geothermal Heating & Cooling Program. Geothermal, or ground source, heat pumps provide cost-effective, eco-friendly heating and cooling for homes and buildings with energy savings of 25-50%, according to the International Ground Source Heat Pump Association. In Maryland, the earth maintains a constant 55°F, below frost level (from 4-8 feet deep). This reservoir of energy can be converted for heating and cooling.

HB 1186 was signed into law on May 22, 2012, the day that Maryland became the first state in the country to make the energy generated by geothermal heating and Cooling (GHC) technologies eligible for the Renewable Portfolio Standard (RPS) as a Tier 1 renewable source. To qualify, the GHC technologies must meet ENERGY STAR standards and displace electric or non-natural gas heating and/or old and presumed inefficient air conditioning. Home owners will be eligible to receive Renewable Energy Credits (RECs) for GHC systems that are commissioned on or after January 1, 2013.

Land-based Wind Programs: The wind industry in Maryland currently produces over 120,000 kilowatts of power. MEA's efforts to expand land-based wind energy

[38] Biomass, along with other types of renewable energy sources, is eligible for the Maryland Clean Energy Production Tax Credit administered by the MEA. The tax credit is equal to 0.85 cents per kilowatt hour, up to $2.5 million during a five year period. The commissioning deadline to qualify for the grant has recently been extended by five years, to December 31, 2015.Maryland Clean Energy Incentive Act of 2010 (House Bill 464).

production have focused on three sectors: i) small and residential scale, ii) community, or mid-size scale, and iii) utility scale:

- Residential: MEA administers the *Windswept* grant program, which supports the deployment of small and residential wind energy systems. This program typically supports between 10 percent and 30 percent of the total cost of installation, leveraging private and federal funds to expand small and residential wind energy below 100 kilowatts. As of June 30, 2011, the *Windswept* program resulted in 72 residential wind installations and 421 kilowatts of deployed capacity. MEA also works with local planning and zoning officials to remove zoning and permitting barriers to small and residential wind energy systems. Currently, 15 counties have enacted enabling wind ordinances, and 2 more are in some phase of development.
- Community and mid-size: MEA works with local governments and entrepreneurs to facilitate development of community-scale wind projects, suitable for such facilities as wastewater treatment plants, military installations, college campuses and communities.
- Utility: MEA supports developers as they investigate State policies and incentives, navigate through local ordinance rules, Certificate for Public Convenience or Necessity or exemption processes. MEA participates in public hearings to advocate for greater renewable energy deployment in the State.

Game Changer Competitive Grant Program. MEA launched this program in 2012 to provide cost-sharing grants for innovative clean energy generation projects in Maryland. The winning grantees embrace either a new technology or a new methodology that extends beyond existing renewable energy generation; the Game Changers seek to advance the market into uncharted territory. Winners were evaluated on the merits of their energy production, cost-effectiveness, market potential, project viability, cost share, project performance measurement and verification methodology, and project visibility. The projects are funded based on their ability to help the State meet its renewable energy portfolio standard of 20% by 2022. Grant recipients' progress towards that goal will be evaluated for two years following their award.

The five 2012 winning projects included:

- Catoctin Mountain Growers (CMG) Greenhouse Biomass Boiler Project. An award of $250,000 (8.3% of the total project cost of $3,000,000) will assist CMG replace its traditional boiler fuels with clean woody biomass fuel in a clean, efficient, cost-saving biomass boiler. This boiler will be Maryland's first modern, large-scale biomass boiler project and will be the first of many other large biomass boiler projects that can take advantage of the state's 780,000 dry tons of available woody biomass.
- Skyline Innovations Multi-Family Solar Water Heating Project to Compare and Improve Efficiencies of Traditional & New Collector Technologies. An award of $176,000 (13.2% of a total project cost of $1,329,700) will help Skyline Innovations collect hot water consumption data and solar thermal collector performance data on three types of collectors from 6,000 multi-family housing

- MD Goes Green, Division of Land and Cultural Preservation Fund, Inc. Community-Scale Wind Project Assessments to Develop Community-Scale Wind Projects. An award of $219,200 (9.1% of a total project cost of $2,391,050) will help create opportunities for community-scale wind projects across Maryland. Led by the non-profit organization, MD Goes Green, Division of Land and Cultural Preservation Fund, Inc., five sites will be identified, resulting in the deployment of at least 850 kW of new community-scale wind generation within the next five years. The experiences of these sites will provide guidance for other communities to deploy wind energy generation throughout the state.
- TimberRock Energy Solutions with General Motors (GM) Development of a Solar PV/Energy Storage/Electric Vehicle Charging System. An award of $170,118 (46% of a total project cost of $365,481) will aid TimberRock Energy Solutions to install an electric vehicle (EV) charging system that collects and stores solar energy. The system will be located at GM's White Marsh electric vehicle motor plant. It is the first integrated configuration that enables solar energy to power a local building, an EV, as well as the power grid. This ground breaking project will demonstrate the viability of electricity as a transportation fuel and renewable energy to create that power.
- Standard Solar Installed Solar Energy Microgrid at the Konterra Mixed-Used Development. An award of $250,000 (12.4% of a total project cost of $2,007,000) will implement a 320-kW solar PV array and lithium ion battery storage system at a mixed-use development that will allow solar energy to flow after a power outage, thus creating the first solar powered microgrid in Maryland. The highly-visible project located at the intersection of I-95 and the Intercounty Connector will feature billboard-sized monitors visible from nearby highways that show motorists how much solar energy is being generated at any given time even during power outages.

Funding for the program comes from the Strategic Energy Investment Fund, which was created from public auctions of carbon credits through the Regional Greenhouse Gas Initiative.

Estimated GHG Emission Reductions in 2020

In order to account for similarities across programs, all emission benefits and costs associated with this program have been aggregated under B.1: The Maryland Renewable Energy Portfolio Standard Program.

B.4: Offshore Wind Initiatives to Support Renewable Energy

Lead Agency: MEA

Program Description

Maryland waters are part of the Mid-Atlantic Bight region, a coastal area spanning from North Carolina to Massachusetts with substantial wind resources located in close proximity to coastal population centers. In fact, this area has the greatest renewable energy potential relative to other U.S. offshore regions in the Gulf of Mexico, Pacific, and Alaska.[39] Research indicates that the potential power supply available from offshore wind substantially exceeds the region's current energy use.[40] Maryland, therefore, has the potential to access large energy resources off the coast that could contribute to meeting future energy demands while simultaneously displacing fossil fuel generation.

The available offshore wind energy resources in the Mid-Atlantic Bight region without exclusions could produce on average a power output of 330 gigawatts,[41] according to researchers from the University of Delaware and Stanford.[42] According to the National Renewable Energy Laboratory, the shallow waters (typically 0 - 30 meters), which are characteristic of the Mid-Atlantic Bight region, are the most likely to be technically and commercially feasible at this time.[43] For 2006, the total demand for delivered power was estimated to be 185 gigawatts for the coastal jurisdictions of Connecticut, Delaware, Massachusetts, Maryland, North Carolina, New Jersey, New York, Rhode Island, and Virginia.[44] Estimates indicate that the available offshore wind energy resources in the region have the potential to provide for both current energy needs and up to 50 percent of the additional growth expected in regional demand for energy.[45]

Since there are negligible GHG emissions associated with the production of energy from wind resources, development of offshore wind energy can reduce the amount of air emissions from electricity by displacing conventional fossil fuel generation. In addition to providing clean energy, offshore wind would contribute to meeting the Maryland RPS, which requires 20 percent of the State's energy needs to be satisfied by renewable energy sources by 2022. The U.S. Department of Energy advises that wind turbines typically have a service life of at least 20 years and transmission lines can last more than 50 years; therefore, investments in achieving 20 percent wind power by 2020 could continue to

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[39] Mineral Management Service & U.S. Geological Survey, Survey of Available Data on OCS Resources and Identification of Data Gaps, OCS Report MMS 2009-015, Available: http://www.doi.gov/ocs/report.pdf (March 30, 2010).

[40] The Bight region is largely characterized by a Class 6 Wind Power Density. Wind power density is a measure of the energy available at a specific site that can be converted using a wind turbine. Wind power density ranges from the lowest measure, Class 1, to the highest measure, Class 7; therefore, the region with a Class 6 wind rating has the potential to provide significant high-quality wind resources.

[41] Noteworthy is that there were no exclusions (e.g., areas not suitable for wind energy development due to environmentally sensitive areas, shipping lanes and other constraints) considered in this analysis and that the actual numbers would be less.

[42] Kempton et al., Large CO2 Reductions via Offshore Wind Power Matched to Inherent Storage in Energy End-Uses, GRL, Vol. 34 (2007).

[43] Musial, W.; Butterfield, S., "Future for Offshore Wind Energy in the United States." National Renewable Energy Lab Report No. CP-500-36-313, (2004).

[44] Ibid.

[45] Ibid. When the efficiency of the turbines, related fuel use, and leakage are considered.

supply renewable energy through at least the year 2044 and transmission lines through at least 2072.[46] An offshore wind energy project is expected to provide economic and employment benefits as well as improvements to air quality.

Estimated GHG Emission Reductions

In order to account for similarities across programs, all emission benefits and costs associated with this program have been aggregated under B.1: The Maryland Renewable Energy Portfolio Standard Program.

Implementation

In April of 2009, the U.S. Dept. of Interior published a Final Rule that established protocols for the development of offshore wind energy projects.[47] These regulations empowered the Dept. of Interior's Minerals Management Service (now the Bureau of Ocean Energy Management) to offer leases for offshore wind energy on the Outer Continental Shelf after consultation with adjacent State governments through a State/Federal Task Force.

Upon request of Governor O'Malley, the Bureau of Ocean Energy Management established such a Task Force for Maryland, comprised of officials from state and federal agencies as well as elected officials from Maryland's coastal communities. In order to inform the Task Force, MEA and DNR's Chesapeake and Coastal Program developed a plan to collaborate on marine spatial planning, resource characterization and environmental impact assessment related to offshore wind energy.

In 2009, MEA and DNR partnered with The Nature Conservancy and Towson University to map habitat and wildlife data. DNR also engaged directly with groups representing both commercial and sport fisheries to determine the highest density of fisheries use of the planning area. MEA contracted with AWS TruePower to develop maps and wind-roses detailing wind speed and power over the planning area. In partnership with MEA, the University of Maryland's Center for Integrative Environmental Research studied and provided data layers for both military uses of the offshore wind planning space as well as transmission and interconnection opportunities.

In April, 2010, DNR and MEA conducted public open houses to allow citizens to ask questions and provide input. All of this information and several other physical, administrative and ecological datasets were compiled and published in an interactive online mapping tool called *Maryland Coastal Atlas*. With this information, Maryland made a recommendation to the Task Force. Upon consideration, the Task Force adopted the recommendation and the Bureau of Ocean Energy Management published the designated area in a Request for Interest to developers. Eight offshore wind developers responded with development proposals, and twelve stakeholders submitted comments.

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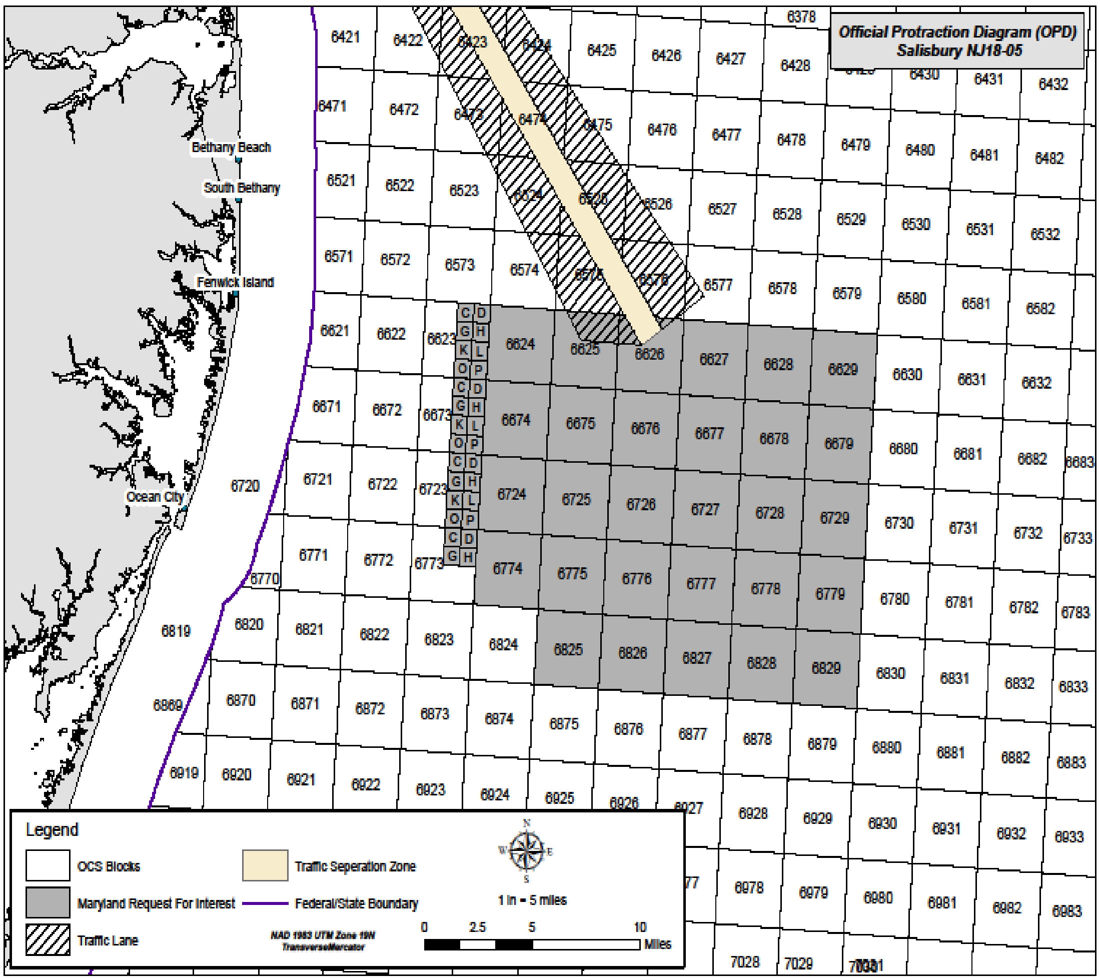
[46] US Department of Energy, 20% Wind Energy by 2030, Increasing Wind Energy's Contribution to U.S. Electricity Supply, Available: http://www1.eere.energy.gov/windandhydro/pdfs/41869.pdf

[47] PART 585—RENEWABLE ENERGY AND ALTERNATE USES OF EXISTING FACILITIES ON THE OUTER CONTINENTAL SHELF, 30 CFR, pt.585, http://www.boem.gov/uploadedFiles/30_CFR_585.pdf

Comments submitted to the Bureau of Ocean Energy Management regarding the Request for Interest planning area focused largely on potential impacts on marine transportation, navigation, commerce and safety. The area was located adjacent to, and partially overlapped, a Transportation Separation Scheme that served the southern approaches to the Delaware Bay. (Figure C-23)

Figure C-16. Bureau of Ocean Energy Management, Regulation and Enforcement Maryland Request for Interest Area Map[48]



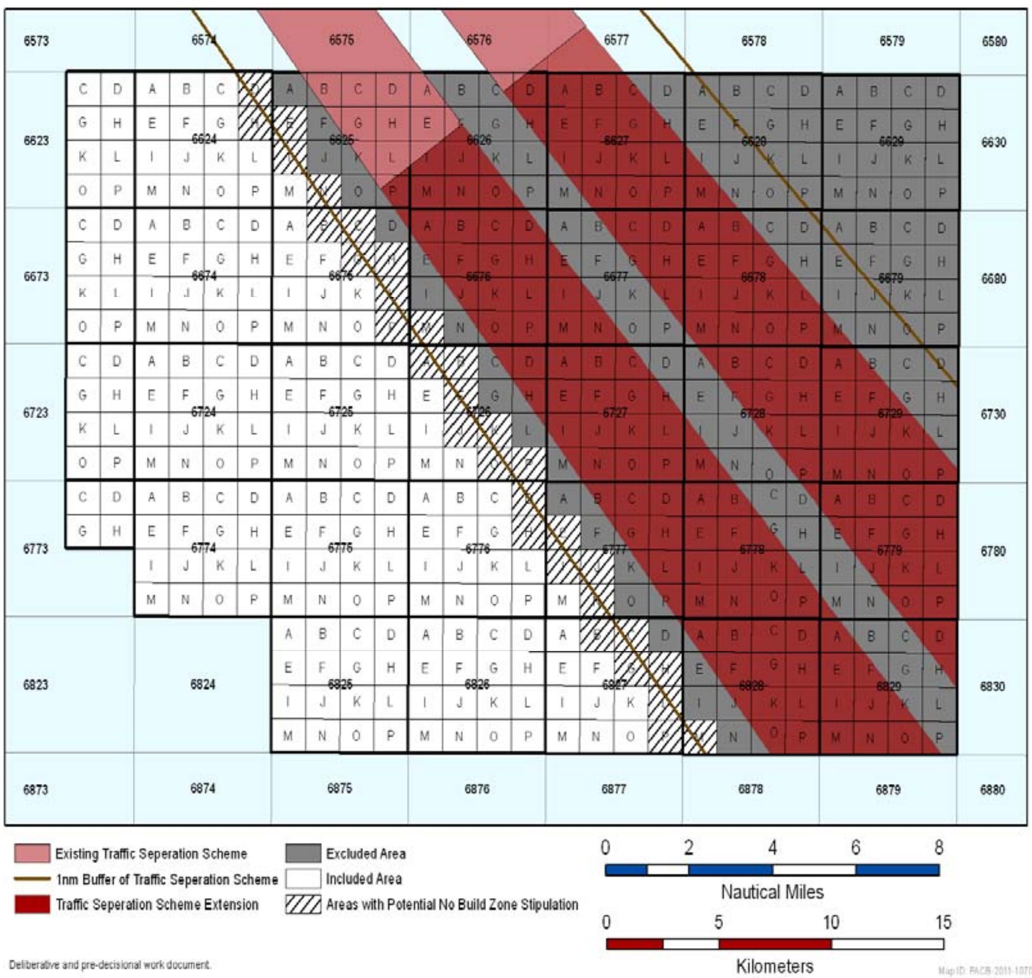
The Bureau of Ocean Energy Management convened a third Task Force meeting on March 23, 2011, to prepare for issuance of a Call for Information – the next administrative step towards area identification and leasing for development of offshore wind energy. At this meeting, MEA committed to engage stakeholders and gather

48 http://www.boemre.gov/offshore/RenewableEnergy/PDFs/stateactivities/MD_DEFiles/MarylandRFIMap_forBOEMREwebsitev2.pdf

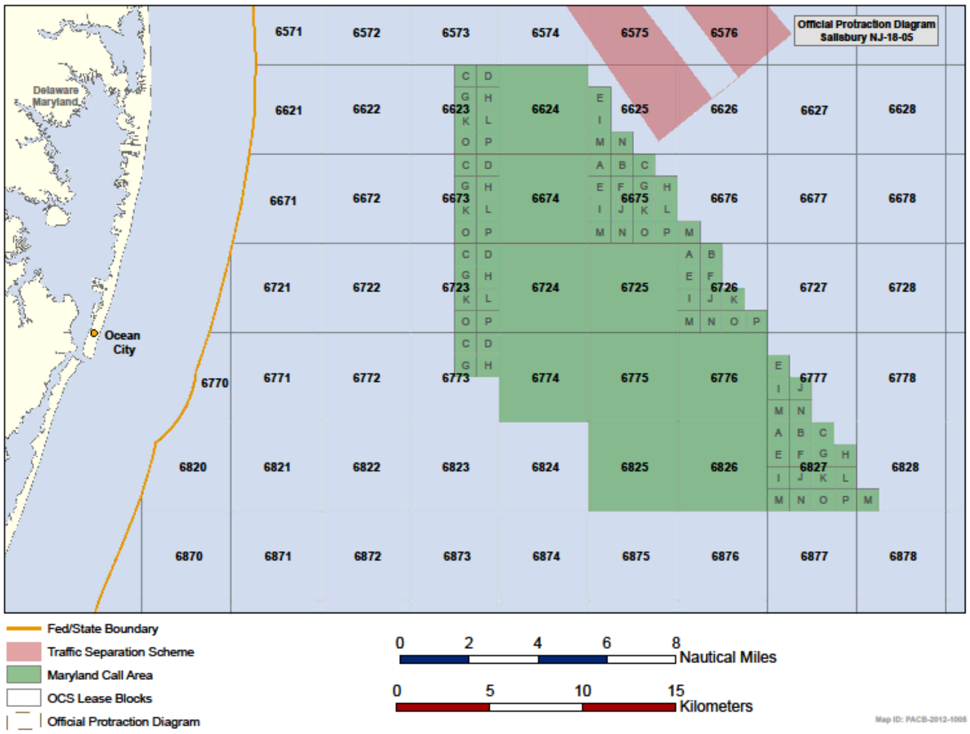
information related to marine transportation, navigation, commerce and safety in order to provide a State level recommendation on boundaries of an area.

On May 11th, 2011, MEA held a stakeholder discussion with groups that had offered comments to the Bureau of Ocean Energy ManagementRFI docekt regarding maritime safety and navigation. Based on this additional input, the Bureau of Ocean Energy Management issued a new Call for Information and Nominations on Feb 3, 2012. (Figure C-24)

Figure C-17. Bureau of Ocean Energy Management, Regulation and Enforcement Maryland Interest Area, proposed at June 24th Task Force Meeting



BOEM Maryland Call for Information and Nominations Area



http://www.boem.gov/uploadedFiles/BOEM/Renewable_Energy_Program/State_Activities/MD%20Call%20Map%20Without%20NOAA%20chart.pdf

The Bureau of Ocean Energy Management received expressions of interest from new developers in addition to the RFI respondents. Stakeholder comments also seemed to indicate that the new area configuration represented less concern to shipping. However, the reduced area provides less deployment opportunity – ultimately no more than 1,000 megawatts of capacity.

In early 2013, the Bureau of Ocean Energy Management is expected to issue a Proposed Sale Notice that will ultimately culminate in a lease sale in the first half of the calendar year.

C: The Regional Greenhouse Gas Initiative (RGGI)

Lead Agency: MDE

Program Description

The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort by ten Northeast and Mid-Atlantic States to design and implement a regional GHG cap-and-trade program to reduce carbon dioxide emissions from fossil fueled power plants in the region. Electric generating units with a capacity of 25 megawatts (MW) or greater are subject to RGGI. RGGI is an unprecedented collaboration of environmental and energy agencies in the following states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont.

Cap-and-trade programs limit the amount of pollution to a significantly lower level through an emissions cap applied to a specific geographic region. Cap-and-trade programs issue “allowances” equal to the number of tons of pollution allowed under the cap. An allowance permits a source to emit one ton of pollution. At the end of the year or specified time period, a source must have obtained, in this case purchased, allowances sufficient to cover each ton of pollution they released.

The current RGGI regional cap, which is based on the 2000-2002 average annual emissions from the power plants subject to RGGI, is 188,076,976 tons per year. The regional cap is apportioned among the participating states. Maryland's share of the regional cap is 37,503.983 tons. The goal of RGGI is to reduce carbon dioxide emissions from the regulated power sector by 10 percent by 2019.

The Healthy Air Act of 2006 required Maryland to join RGGI contingent upon an independent economic analysis showing that RGGI would benefit Maryland consumers and that RGGI would not increase electricity reliability concerns. MDE worked with a comprehensive group of stakeholders and adopted RGGI into Maryland regulations (Code of Maryland Regulations 26.09.01-04) in 2007. Details of the program are contained in the regulations and on the RGGI website: www.rggi.org

Most of the electricity generating plants in Maryland are subject to the RGGI program. Two industrial plants, New Page and RG Steel, are also subject to the RGGI program but may apply for an exemption under certain conditions. Figure C-2 lists the Maryland sources that are subject to RGGI.

Figure C-17. Maryland Sources Subject to RGGI.

Owner	Plant	Location	Fuel
AES Enterprise	Warrior Run	Allegany County	Coal
Allegheny Energy	R P Smith	Washington County	Coal
Con Edison Development & Old Dominion Electric Cooperative	Rock Springs	Cecil County	Natural Gas
Constellation Power	Brandon Shores	Anne Arundel County	Coal
	C P Crane	Baltimore County	Coal
	Gould Street	Baltimore City	Natural Gas
	Perryman	Harford County	Oil/Natural Gas
	Riverside	Baltimore County	Oil/Natural Gas
	Herbert A Wagner	Anne Arundel County	Coal/Oil/Natural Gas
	Westport	Baltimore City	Natural Gas
Gen-On	Chalk Point	Prince George's County	Coal/Natural Gas
	Dickerson	Montgomery County	Coal/ Natural Gas
	Morgantown	Charles County	Coal
RG Steel, LLC.	Sparrows Point	Baltimore County	Natural Gas/Blast Furnace Gas
New Page	Luke Mill	Allegany County	Coal
NRG Energy	Vienna	Dorchester County	Oil
Panda Energy	Brandywine	Prince George's County	Natural Gas

RGGI is a market-based control program that drives emission reduction in three ways. First, regional emissions must be below the defined cap. Over time, the cap gets smaller and smaller. Only enough allowances are made available each year to equal the cap. Sources that fail to hold enough allowances to cover their emissions are subject to serious enforcement actions and fines. In simple terms, the caps guarantee emission reductions over time. The second way that RGGI drives emission reductions is through the auction process, where sources are required to buy the allowances they need. By adding a cost to every ton of carbon dioxide emitted, sources have an economic incentive to minimize emissions whenever possible. This second option could result in emission levels ending up being below the cap level.

The third way that RGGI can drive emission reductions is linked to the way that some of the auction proceeds are used to promote energy efficiency programs and development of renewable energy. Unlike other pollutants, no control technologies exist to reduce carbon dioxide pollution at this time. Most of the RGGI emission reductions will be achieved through increased energy efficiency and reduced demand for electricity. Rather than provide allowances for free, the RGGI states auction a majority of their allowances and use the proceeds to, among other things, promote energy efficiency programs and develop renewable energy. RGGI has raised approximately $800,000,000 in auction revenue to date. Maryland has received almost $150,000,000. RGGI is moving forward with its thirteenth auction.

Some PJM states contiguous to Maryland, such as Pennsylvania, are not participating in RGGI; however, economic modeling determined that Pennsylvania electricity customers were paying for the effort in the RGGI region to lower emissions, through higher wholesale power prices in the PJM region market. However, the energy efficiency investments not funded through the auction in Pennsylvania, which are funded by the auction in the RGGI states, are not leading to similar changes in Pennsylvania electricity bills.

There are some general buyers in the auction but most of the participants have relationships to sources that have compliance obligations under one or more of the states' RGGI programs. The auctions run smoothly on an electronic platform and are monitored for misconduct.

As part of the original RGGI memorandum of understanding, there was a 2012 review of the program that will look at several programmatic issues including whether RGGI should lower the cap to achieve greater reductions. A cap of 91 tonnes was adopted and all RGGI states are in the process of update their regulations to reflect this change.

Estimated GHG Emission Reductions in 2020

If RGGI is strengthened because of the scheduled 2012 program-wide review or because a federal program is adopted, it is not unreasonable to assume that an additional 10 percent to 15 percent emission reduction could be achieved by 2020. By 2030, if there is a federal program, the RGGI reductions could be doubled. By 2050, the reductions could be three to four times greater than the currently projected reductions.

Additional analysis is being conducted by MDE to further evaluate the additional reductions that could be achieved between 2020 and 2050

Figure C-18. Low and High GHG Benefits for Energy-1

Initial Reductions	0.00 $MMtCO_2e$	
Enhanced Reductions	3.60 $MMtCO_2e$	MDE Quantification Below

MDE Quantification

For the original cap (188/166) it was agreed between state agencies that deal with energy that it would act as a framework for reductions of other energy sector programs.

RGGI and the signatory states made extensive modeling runs in the process of selecting 91 ton cap (http://www.rggi.org/design/program_review/materials-by-topic/modeling). From the baseline run it is projected the CO2e emission would be reduced 8.0 Million tonnes. RGGI's cap is in short tonnes so these are then converted to metric tonnes. Further, the model used (IPM) shut down plants based on an economic basis. The model projected two facitilies closing in MD. However, MDE in consultation received confirmation from the sources that they didn't plan on closing. Therefore, the emission from these facilities where then added back in and the reduction calculated from there.

Other Environmental Benefits

RGGI was included as part of the Maryland Healthy Air Act in 2006. The Healthy Air Act also requires significant reductions in nitrogen dioxide, sulfur dioxide and mercury.

Over 95 percent of the air pollution emitted from Maryland's power plants comes from the largest and oldest coal burning plants. The emission reductions from the Healthy Air Act come in two phases. The first phase requires reductions in the 2009/2010 timeframe and, compared to a 2002 emissions baseline, reduce nitrogen oxide emissions by almost 70 percent, sulfur dioxide emissions by 80 percent, and mercury emissions by 80 percent.

The second phase of emission controls occurs in the 2012/ 2013 timeframe. At full implementation, the Healthy Air Act will reduce nitrogen oxide emissions by approximately 75 percent from 2002 levels, sulfur dioxide emissions will be reduced by approximately 85 percent from 2002 levels, and mercury emissions will be reduced by 90 percent.

Other Energy Programs

D.1: GHG Power Plant Emissions Reductions from Federal Programs

Lead Agency: MDE

Program Description

The federal Clean Air Act Amendments of 1990 established the statutory authority for the Title V operating permits program. Prior to 1990, the federal Clean Air Act required permits only for new construction. States were required to issue air pollution permits to businesses that built new pollution sources or modified existing pollution sources. In creating these permit programs-- known as "preconstruction" or "new source review" permit programs--some states, such as Maryland, also chose to establish enhanced programs for regulating air pollution emissions from sources already in operation. These "operating permit programs," though not uniform in requirements or other characteristics, proved to be effective tools for air pollution control. With Title V of the 1990 Clean Air Act Amendments, Congress adopted measures that required all states to develop and implement operating permit programs. Congress' main goal in establishing the Title V program was to achieve a broad-based tool to aid in implementing the Clean Air Act effectively and enhancing enforcement. Within this overarching goal, Congress intended the Title V program to realize nine more specific goals, as follows:

1. Improving State air pollution programs through better emissions inventories;
2. Providing resources through Title V fees;
3. Providing a vehicle for implementing the air toxics and acid rain programs;
4. Improving enforcement;
5. Achieving faster compliance;
6. Requiring compliance certifications from facility operators;
7. Listing all the applicable regulatory requirements in one document;
8. Providing regulatory certainty; and
9. Improving public participation.

The operating permit program is meeting these goals and is achieving enhanced compliance with air pollution requirements for industrial and commercial sources. Nationally, an estimated 17,000 sources of air pollution are required to obtain permits under operating permit programs administered by 112 state, territory, and local permitting authorities.

The Title V Program does not establish any new emissions limitations, standards, or work practices on an affected facility. There may, however, be additional record keeping, monitoring, and reporting requirements. Maryland received final full approval from EPA of its Title V permit program in February 2003.

Estimated GHG Emission Reductions in 2020

This program will not result directly in any GHG reductions. However, Title V permitting will result in improved compliance with federal Clean Air Act requirements including GHGs and other pollutants, via the following:

- Improved clarity regarding applicability of requirements;
- Discovery and required correction of noncompliance prior to receiving a permit;
- Improved monitoring, recordkeeping, and reporting concerning compliance status;
- Self-certification of compliance with applicable requirements initially and annually, and prompt reporting of deviations from permit requirements;
- Enhanced opportunity for the public to understand and monitor sources' compliance obligations; and
- Improved ability of EPA, permitting authorities, and the public to enforce federal Clean Air Act requirements

Implementation

Requirements for the Title V air operating permits program, with respect to GHG emissions, are established by the EPA's Greenhouse Gas Tailoring Rule, which was finalized in May 2010. As of July 1, 2011, new sources or existing sources, that were not previously subject to Title V requirements and that emit or have the potential to emit at least 100,000 tons per year CO_2-equivalent, are now subject to the requirement to obtain a Title V air operating permit. MDE adopted the Tailoring Rule into appropriate locations throughout Title 26 of the Code of Maryland Regulations as of June 2011.

Beginning July 1, 2013, additional sources will be included under the Title V requirements and a possible permanent exclusion from permitting will be determined for some source categories. Additional details will follow in supplemental rulemaking. EPA is also establishing an enforceable commitment that EPA will complete a streamlining study by April 30, 2015 to evaluate the status of Title V permitting for GHG emitting sources. No sources with emissions below 50,000 tons per year CO_2-equivalent and no modification resulting in net GHG increases of less than 50,000 tons per year CO_2-equivalent will be subject to Title V permitting before at least 6 years from now to April 30, 2016.

D.1.A: Boiler Maximum Achievable Control Technology (MACT)

Agency: MDE

Program Description

EPA has developed new air-emissions requirements for industrial, commercial, and institutional boilers. A boiler is a fuel-burning apparatus or container usually used for heating water. The new regulation, known as National Emission Standard for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers, will affect thousands of boilers at facilities considered to be major and area sources of hazardous air pollutants. Major sources are defined as facilities with the potential to emit ten tons per year of any single hazardous air pollutant or twenty-five tons per year of any combination of hazardous air pollutants. Area sources include facilities with emissions below these major source thresholds. The federal Clean Air Act requires the development of national emission standards for hazardous air pollutants to reflect the application of maximum-achievable control technology (MACT) for boilers. These regulations were finalized for boilers at area sources for hazardous air pollutants on March 21, 2011. Standards for boilers located at major sources of hazardous air pollutants were also published in the federal register on March 21, 2011 but will not become effective until proceedings for judicial review are completed or until EPA completes its reconsideration of the rule, whichever is earlier.

The area source MACT requirements vary based on a boiler's size, fuel, and installation date. Requirements can include implementing improved work practices, boiler tune ups, energy assessments, and emission limits for mercury, carbon monoxide, and particulate matter. New area source boilers must comply with the applicable requirements upon startup. Existing boilers have until March 21, 2012, to perform the required tune ups, and until March 21, 2014, to demonstrate compliance with emission limits and performs energy assessments. As currently stated, the major source Boiler MACT rule would establish emission limits for mercury, dioxin, particulate matter, hydrogen chloride, and carbon monoxide

The Boiler MACT's requirement to conduct a tune-up of each oil and coal fired regulated boiler will improve efficiency, minimize fuel consumption, reduce hazardous air pollutants, and reduce GHG emissions. EPA claims there will be a one percent fuel savings due to these boiler tune-ups, which equates to an equivalent one percent reduction in GHG emissions.

Many of the facilities affected by the Boiler MACT rule are located in close proximity to neighborhoods and schools. EPA estimates that by reducing the facilities' toxic mercury emissions and other harmful pollutants, cases of premature death from the inhalation of pollutants, chronic bronchitis, aggravated asthma, and acute respiratory symptoms will also be reduced. Reducing the public health impacts of these boilers through implementation of the Boiler MACT rule should also provide a small economic benefit by reducing health care expenses for affected families.

Estimated GHG Emissions Reductions in 2020

Figure C-19. Low and High GHG Benefits for Energy-4

Initial Reductions	0.07 $MMtCO_2e$	MDE Quantification Below
Enhanced Reductions	0.07 $MMtCO_2e$	MDE Quantification Below

Estimates – MDE Quantification

Coal and oil fired boilers located in Maryland which will be affected by the Boiler MACT currently have the potential to emit approximately 9.7 million tons of carbon dioxide per year.[49] Actual emissions from this sector have been calculated as approximately 1.45 $MMtCO_2e$ per year if the affected boilers operate at average 15 percent capacity factor.[50] Using MDE's inventory of boilers that would be subject to the Boiler MACT, MDE has calculated that implementation of the Boiler MACT tune-up requirement could result in carbon dioxide reductions from 98,000 to 14,700 tons per year. This is based on the total carbon dioxide emissions for impacted boilers being reduced by 1 percent. To put this in perspective, 98,000 tons per year of carbon dioxide is comparable to the emissions from a 140 million BTU per hour boiler. Accounting for overlap, reductions are reduced to 0.07 MMtCO2e.

Other Environmental Benefits

The Boiler MACT rule was promulgated to specifically address emissions of particulate matter, mercury, hydrogen chloride, carbon monoxide, and dioxin/furans from boilers.

[49] Potential calculated based on 100 percent capacity factor for all solid and liquid fuel burning non-utility boilers greater than 10mmbtu. All solid fuel was assumed to be coal. All liquid fuel was assumed to be #2 fuel oil.

[50] A 15 percent capacity factor chosen to approximate typical boiler based on COMAR 26.11.09.08F.

The compliance requirements vary based on size, type of fuel, and the hazardous air pollutant emissions of the facility. The majority of effected boilers in Maryland will be oil burning boilers at area sources of hazardous air pollutants. These boilers will not be subject to specific emission limits but will be required to perform boiler tune ups. The reduced fuel consumption attributed to the boilers tune ups will result in a reduction in emissions. Using the same maximum 100 percent capacity factor and typical 15 percent capacity factor, a range of reductions from reduced fuel consumption has been calculated for the following pollutants.

Range of Potential nitrogen oxide reductions: 31 to 201 tons per year.
Range of Potential sulfur dioxide reductions: 38 to 255 tons per year
Range of Potential particulate matter reductions (oil only): 1 to 6 tons per year

Implementation

MDE will adopt the final federal requirements into State regulations to insure that these requirements are implemented and enforced.

D,1,B: GHG New Source Performance Standard

Lead Agency: MDE

Program Description

As part of a court settlement reached in December of 2010, EPA will promulgate new regulations to reduce GHG emissions from fossil fuel power plants and petroleum refineries; there are no petroleum refineries in Maryland. EPA will use the New Source Performance Standard authority under the federal Clean Air Act for these new rules.

Implemented in the 1970s, EPA establishes New Source Performance Standard to address a variety of industrial sources of air pollution that significantly endanger public health and welfare and the environment. Each New Source Performance Standard has to be reviewed every eight years by EPA and revised, if appropriate.

For fossil fuel electricity generators, the new rule would apply to new or modified electricity generating units and create GHG emission guidelines for existing electricity generating units. EPA is coordinating this action on GHGs with a number of other required regulatory actions for traditional pollutants. Together, electricity generating units will be able to develop strategies to reduce all pollutants in a more efficient and cost-effective way than addressing the pollutants separately.

There are currently few potential projects in Maryland for new or modified fossil fuel electricity generating units. However, other states in the PJM grid region, such as Virginia and Pennsylvania, are constructing new fossil fuel electricity generating units and moving forward with modifications to existing electricity generating units. Since Maryland imports 30 percent of its needed electricity from states like Pennsylvania and Virginia, reductions in GHG emissions from the new GHG New Source Performance

Standard are expected to be evident when evaluating the carbon emissions profile from imported electricity.

EPA will propose GHG standards based on existing technologies for power plants in July 2011 and refineries in December 2011. The agency will issue final standards in May 2012 and November 2012 respectively.

Estimated GHG Emissions Reductions

The amount of GHG reductions achieved will depend on the standards that EPA adopts. Presumably, the adopted standard will result in increased efficiencies in the production of electricity, which will in turn result in the reduction of GHG emissions. Fuel switching may also result in emissions savings. For now, the emissions reductions are included in D: Other Energy programs.

D.1.C: GHG Prevention of Significant Deterioration Permitting Program

Lead Agency: MDE

Program Description

The Prevention of Significant Deterioration program is a preconstruction review and permitting program applicable to new major stationary sources and major modifications at existing major stationary sources. A principal requirement of the Prevention of Significant Deterioration program is that a new major source or major modification must apply Best Available Control Technology, which is determined on a case-by-case basis taking into account, among other factors, the cost effectiveness of the control and energy and environmental impacts.

Generally, this analysis will involve (1) an assessment of existing air quality, which may include ambient monitoring data and air quality dispersion modeling results, and (2) predictions, using dispersion modeling, of ambient concentrations that will result from the applicant's proposed project and future growth associated with the project.

The Prevention of Significant Deterioration program’s increment is the amount of pollution an area is allowed to increase. The Prevention of Significant Deterioration program’s increments prevent the air quality in clean areas from deteriorating to the level set by the National Ambient Air Quality Standards. The National Ambient Air Quality Standards is a maximum allowable pollution amount. A Prevention of Significant Deterioration program increment, on the other hand, is the maximum allowable increase in concentration that can occur above a baseline concentration for a pollutant. The baseline concentration is defined for each pollutant and, in general, is the ambient concentration at the time that the first complete Prevention of Significant Deterioration permit application affecting the area is submitted. Significant deterioration is said to occur when the amount of new pollution would exceed the applicable Prevention of Significant Deterioration increment. It is important to note, however, that the air quality cannot deteriorate beyond the concentration allowed by the applicable National Ambient Air Quality Standards, even if not all of the Prevention of Significant Deterioration increment is consumed.

Estimated GHG Emission Reductions in 2020

Though no potential emissions reductions have been quantified at this time, this program will assist in further GHG reductions occurring in the future.

Implementation

Requirements for the Prevention of Significant Deterioration program are established by EPA's Greenhouse Gas Tailoring Rule. On January 2, 2011, the requirements applied to sources' GHG emissions only if the sources are subject to the Prevention of Significant Deterioration program anyway due to their non-GHG pollutants. Therefore, EPA will not require sources or modifications to evaluate whether they are subject to this program's requirements solely on account of their GHG emissions. The Prevention of Significant Deterioration program's Best Available Control Technology will apply to projects that increase net GHG emissions by at least 75,000 tons per year CO_2-equivalent but only if the project also significantly increases emissions of at least one non-GHG pollutant. Beginning July 1, 2011, the Prevention of Significant Deterioration program's Best Available Control Technology will apply to new sources that have the potential to emit 100,000 tons per year CO_2-equivalent or modifications to existing sources that increases net emission of CO_2-equivalent by at least 75,000 tons per year.

Information on GHG best available control technology determinations are required to be entered into EPA's clearinghouse. These determinations will include information on GHG emission reductions resulting from implementation of Prevention of Significant Deterioration program's best available control technology.

Beginning July 1, 2013, additional sources will be included under the Prevention of Significant Deterioration program requirements and a possible permanent exclusion from permitting will be determined for some source categories. Additional details will follow in supplemental rulemaking. EPA is also establishing an enforceable commitment that EPA will complete a streamlining study by April 30, 2015 to evaluate the status of Prevention of Significant Deterioration program permitting for GHG emitting sources. No sources with emissions below 50,000 tons per year CO_2-equivalent and no modification resulting in net GHG increases of less than 50,000 tons per year CO_2-equivalent will be subject to this program's permitting before at least 6 years from now to April 30, 2016.

D.2: Main Street Initiatives

Lead Agency: DHCD

Program Description

Buildings have a large impact on the natural environment. Energy use is the source of about 70 percent of GHG emissions and buildings represent up to 48 percent of total energy use.[51]

The American Recovery and Reinvestment Act of 2009 was an economic stimulus package enacted by the 111th U.S. Congress in February 2009. Of the economic stimulus package, $3.2 billion was given to the U.S. Department of Energy's Energy Efficiency and Conservation Block Grant program.[52] Approximately $2.7 billion was awarded through formula grants directly to local jurisdictions. Remaining amounts were allocated through competitive grants and with some funding for technical assistance tools to state, local, and tribal grantees. This program was intended to assist U.S. cities, counties, states, territories, and Indian tribes to develop, promote, implement, and manage energy efficiency and conservation projects and programs designed to reduce fossil fuel emissions; reduce the total energy use of the eligible entities; improve energy efficiency in the transportation, building, and other appropriate sectors; and create and retain jobs.

The ten largest Maryland counties and ten largest municipalities, based on population, were eligible to receive formula grants directly from the U.S. Department of Energy under the Energy Efficiency and Conservation Block Grant program. Maryland local and county governments ineligible for direct formula grants were eligible for competitive funds from MEA, which received approximately $9.6 million in Energy Efficiency and Conservation Block Grant program for local and county projects. Under the competitive portion of the Energy Efficiency and Conservation Block Grant program, now known as Better Buildings, DHCD was awarded $20 million in funding, which was in response to its winning application entitled "Investment in Main Street: Energy Efficiency for Economic Growth." DHCD's program, marketed as "Be SMART," is a holistic programmatic approach to target households, multifamily rental properties, and small commercial properties for energy-efficiency retrofits, primarily in certain targeted areas. Be SMART programs will provide increased comfort, safety and affordability to buildings in Maryland through energy efficiency improvements; the $20 million in Be SMART financing is available for the purchase and installation of equipment and materials for energy efficiency measures. Such items include, but are not limited to ENERGY STAR qualified: HVAC systems, insulation, windows, draft stopping and duct sealing, appliances and fixtures, and water heating equipment. These improvements are expected to result in energy savings of 15-30 percent. This translates to significantly lower energy bills for consumers, more comfortable buildings and reduced consumption of fossil fuels.

DHCD's Be SMART initiative is also providing training for the implementation of the latest International Energy Conservation Code that will lead to a recognized certification for plan reviewers, inspectors, developers, engineers, and architects and will assist local jurisdictions in active compliance and enforcement of the energy codes. Most of the

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[51] Kaplow, Stuart D. "Maryland is Poised to be the 1st State to adopt the International Green Construction Code." March, 2011. http://www.stuartkaplow.com/library3.cfm?article_id=185

[52] http://www.eecbg.energy.gov/

targeted areas are in Main Street Maryland program areas. Main Street Maryland is a comprehensive downtown revitalization program created in 1998 by DHCD.

DHCD also partnered with DNR to publish "Going Green Downtown: A Sustainability Guide for Maryland's Main Streets."

Estimated GHG Emission Reductions in 2020

Figure C-20. Low and High GHG Benefits for Energy-15

Initial Reductions	0.05 $MMtCO_2e$	MDE Quantification Below
Enhanced Reductions	0.14 $MMtCO_2e$	MDE Quantification Below

Low and High Estimates – MDE Quantification
A. Estimated GHG Reductions

On April 21, 2010, Maryland, through the competitive portion of the Energy Efficiency and Conservation Block Grant, within the American Recovery and Reinvestment Act of 2009, was awarded $20 million. The program, which is funded for a period of three years, is being managed by DHCD. The program was developed to target commercial, multi-family and single-family properties for energy-efficiency retrofits. Fifteen cities/counties ('communities') in Maryland were identified as being eligible for the awards.

The focus of the program is commercial, multi-family, single-family retrofits that will result in significant, measurable reductions in energy consumption. The program would also be expected to result in the establishment of a Statewide bulk purchasing program for energy efficient supplies and equipment, along with the development of a Statewide green work force of contractors developed through job training and certification. DHCD plans to develop partnerships with lending institutions to provide home and building owners with access to low interest loans; repayment of the loans would be expected to replenish the funds, allowing additional Marylanders to finance energy efficiency retrofits. The funding would be available for use on the following:

- Energy star appliances
- Improvements in insulation, lighting and heating
- Energy efficient HVAC systems
- Energy efficiency windows and doors
- Weatherization

During a conversation with DHCD in April 2011, details on how the funds would be spent were not available, and thus the associated reduction of GHG emissions are based on assumptions (detailed below). Many of the assumptions are derived from a presentation prepared by DHCD, dated November 10, 2010, which provided projections as to how the funds would be spent.

The lower boundary of the reduction of GHG emissions expected by 2020 is based on the program not being replenished through the low interest loans, and therefore only existing for a period of three years. The upper boundary is based on the program replenishing the available funds through the low interest loans, and therefore the program continuing indefinitely, or at least through 2020. Details regarding the cost of the equipment, the distribution of the funding within each focus (commercial, multi-family, and single-family properties), and the reduction of GHG emissions is provided below.

B. Detailed Explanation of Methodology

Lower Boundary

Per the conditions of American Recovery and Reinvestment Act, which has provided the funds for this program, the program will last for a period of three years. This assumption defines the lower boundary for the reduction in GHG emissions.

Upper Boundary

By partnering with lending institutions, DHCD hopes to establish a low interest loan program to finance the purchase of the equipment; if successful, this program could become self-sustaining and continue to operate indefinitely. This assumption defines the upper limit for the reduction in GHG emissions.

Two central conclusions regarding the longevity and implementation of the program were made. The first is the assumption that equal amounts of the funding, or $5.6 million (($6 + $6 + $4.8) over 3 years), will be spent each year for the duration of the program (either three years or indefinitely; see below). The second is the distribution of the funds between commercial, multi-family, single-family, and other programs funded through this program. Some limited details on the distribution of the funds were contained within the November 2010 presentation prepared by DHCD. Specifically:

- $6 million retrofit financing for commercial properties
- $6 million retrofit financing for multi-family properties
- $4.8 million retrofit financing for single-family properties
- $600,000 the development of an energy efficiency purchasing cooperative
- $600,000 training related to the adoption of new building and energy costs

The last two items, the purchasing cooperative and training related to the adoption of new building and energy costs, do not directly result in the reduction of GHG; it is the actual installation/upgrade of the equipment, which is funded through the retrofit financing, that would result in the reduction of GHG emissions.

C. Calculations

Overall, the calculations are very simple, and use the available funds as a basis. There are three major assumptions made in order to proceed with the calculations:

- The cost of the equipment,
- The annual distribution of how the funds are spent, and
- The percent reduction in GHG emissions for each energy efficiency upgrade.

All assumptions related to equipment costs are based on professional experience. A spreadsheet for each scenario has been set up, and allows for simple adjustments of the values; changes to assumed values (as currently entered) affect the reduction in GHG emissions.

The six scenarios are as follows:

- $6 million Retrofit Financing – Commercial
  - Lower boundary – financed for 3 years
  - Upper boundary – financed indefinitely
- $6 million Retrofit Financing – Multi-family
  - Lower boundary – financed for 3 years
  - Upper boundary – financed indefinitely
- $4.8 million Retrofit Financing – Single family
  - Lower boundary – financed for 3 years
  - Upper boundary – financed indefinitely

The same methodology and assumptions are consistent for all of the scenarios. An example for one of the scenarios is provided here:

Retrofit financing – commercial
Lower boundary – financed for 3 years

1. A total of $6 million is designated for retrofit financing – commercial. An equal amount will be spent each year that the program operates, or $2 million per year.
2. An annual value of 350 MMBtu per commercial property was estimated, based on energy use being four times that of a single family property.
3. Assumed 100 percent of the funds will be spent each year. It is assumed that 15 percent will be spent on HVAC, 40 percent on windows/doors, and 45 percent on insulation/lighting. This equation establishes how much of the annual fund will be allocated to each type of upgrade.
4. A price is assigned to each upgrade: $14,000 for HVAC, $450 for window/door, and $5,000 for insulation/lighting. As part of this, it is estimated that there is one HVAC upgrade per commercial property, 40 windows/doors per commercial property, and three insulation/lighting per commercial property. This equation establishes how many HVACs, windows/doors, and insulation/lighting will be installed.
   Note: The cost and number can also be adjusted based on the type of property. For instance, for a multi-family, each window is $400, and there are 10 windows for each multi-family unit.
5. The energy efficiency value is assigned to each upgrade: 15 percent reduction for HVAC, 20 percent for windows/doors, and 15 percent for insulation/lighting. This equation calculates the reduction in MMBtu use, which is converted to reduction in GHG emissions.
6. The reduction in MMBtu for each upgrade, is calculated as follows:

(Annual MMBtu/property)*(% reduction of upgrade type) = MMBtu reduction/upgrade

(350 MMBtu/commercial property)(15% reduction for HVAC) = 52.5 MMBtu/HVAC

7. The total reduction in MMBtu, for the type of upgrade (i.e., HVAC, windows/doors, or insulation/lighting), is calculated as follows:

(MMBtu reduction/upgrade)*(# of upgrades/year) = Total MMBtu reduction/
Year per upgrade type

(52.5 MMBtu/HVAC)(21 HVAC/year) = 1,125 MMBtu/year from HVAC upgrades

8. The total reduction in MMBtu emissions is the sum of the MMBtu reductions of the total of each type of upgrade, and is calculated as follows:

[MMBtu reduction/yr per upgrade type i] * [MMBtu reduction/yr per upgrade type ii] * [MMBtu reduction/yr per upgrade type iii] = Total reduction per year in MMBtu

1,125 MMBtu/year per HVAC * 3,111 MMBtu/year per windows/door * 3,150 MMBtu/year per insulation/lighting = 7,386

9. The MMBtu value is converted to million metric tons of CO_2e, with conversion factors provided by MDE, with the final values reported in the figure below.

These calculations are performed for each of the six scenarios. The results are presented in the summary figure below.

D. Results

Figure C-21. Energy-15 Low Estimate Summary

	MMtCO$_2$e		
Year	2012	2015	2020
GHG emissions commercial	0.0023	0.0034	0.0034
GHG emissions Multi-family	0.0006	0.0009	0.0009
GHG emissions Single-family	0.0014	0.0021	0.0021
TOTAL	0.0043	0.0064	**0.0064**

Figure C-27. Energy-15 High Estimate Summary

	MMtCO$_2$e		
Year	2012	2015	2020
GHG emissions commercial	0.0023	0.0057	0.0115
GHG emissions Multi-family	0.0006	0.0015	0.0029
GHG emissions Single-family	0.0014	0.0035	0.0070
TOTAL	0.0043	0.0107	**0.0214**

Implementation

DHCD received a $20 million competitive award from the U.S. Department of Energy in 2010 to promote energy efficiency through its Energy Efficiency and Conservation Block Grant retrofit program. Now known as Better Buildings, DHCD's award was titled "Investing in Main Street: Energy Efficiency for Economic Growth." DHCD's proposal was a holistic, community-based approach to target individual households, multifamily rental properties and commercial properties for energy efficiency retrofits that will result in significant, measurable reductions in energy consumption and accompanying savings.

The program includes an overall education and outreach component to provide stakeholders and community members with information for behavior changes that reduce energy consumption. Components of the program under development include: a Green Retrofit Improvement Program which targets small business owners; a Multifamily "Preservation and Energy Efficiency" program for renters; and an Efficient Home Program for homeowners.

The $20 million in federal funds is expected to leverage more than five times that amount in other funds. Efforts will be focused in target communities where the following outcomes for homeowners, renters, and small business owners are anticipated: An estimated 2,000 homeowners will benefit from energy efficiency retrofits of their homes in the first three years; twenty buildings comprising approximately 2,000 affordable rental units will benefit from energy efficiency retrofits; a projected 900 historical commercial properties will benefit from energy audits and low-interest retrofit financing in concert with DHCD's Neighborhood BusinessWorks program; the establishment of sustainable financing resources for homeowners, rental properties and commercial properties; the creation of a Statewide Energy Efficiency Purchasing Cooperative to maximize purchasing power for retrofits; and provide funding for affordable housing, energy retrofits and energy efficiency.[53]

The targeted communities were selected by weighing what would benefit the greatest number of Marylanders, taking into consideration those areas that have not received an allocation of federal funding. The selected areas are all in communities where there is significant leveraging and partnership activity. Each area is a Main Street Maryland community, has numerous multi-family developments and is a target area for other funds through DHCD. The targeted communities include: Berlin, Cambridge, Chestertown, Cumberland, Denton, Easton, Elkton, Frostburg, Oakland, Princess Anne, Dundalk, Westminster, Havre De Grace, Salisbury, and Takoma Park.[54]

D.3: Weatherization and Energy Efficiency for Affordable Housing

Lead Agency: DHCD

Program Description

Energy efficiency can be defined as using a particular technology that requires less energy to perform the same function. Energy efficiency is recognized as a cost effective way to achieve meaningful GHG reductions. The additional costs of efficiency upgrades are often offset by lower utility bills, making energy efficiency essential to affordable housing.

[53] "Maryland to Receive $20 Million as Part of U.S. Department of Energy's Retrofit Ramp-Up Initiative." April 21, 2010. http://www.gov.state.md.us/pressrealeases/100421.asp

[54] Ibid.

Through various programs, DHCD works with other government agencies to incorporate energy efficiency into affordable rental housing developments and eligible low-income households. DHCD supports education and training on the benefits of energy efficiency in affordable rental housing which in turn promotes energy efficiency improvements and rental housing preservation efforts. DHCD also assists eligible low-income households with the installation of energy conservation materials in their dwelling units and energy audits/studies to determine the appropriate energy efficiencies for a building.

DHCD provides outreach and public education, performance contracting/shared savings arrangements, technical support resources for implementation, incentives for energy tracking and benchmarking, and public recognition programs. DHCD works with other agencies to support energy audits and energy efficiency retrofits in residential and commercial buildings, develop and implement advanced building codes and inspections, and create financial incentive programs for energy efficiency improvements through funding sources such as the Energy Efficiency and Conservation Block Grant program of the American Recovery and Reinvestment Act of 2009.

Estimated GHG Emission Reductions in 2020

Figure C-22. Low and High GHG Benefits for Energy-16

Initial Reductions	0.01 $MMtCO_2e$	MDE Quantification Below
High Estimate	0.02 $MMtCO_2e$	MDE Quantification Below

The number above have been adjusted for overlap.

Low and High Estimates – MDE Quantification
The American Recovery and Reinvestment Act of 2009 appropriated funding for the U.S. Department of Energy to award grants under the Weatherization Assistance Program. The purpose of the program was to increase the energy efficiency of residences owned or occupied by low income persons; the priority population included persons who are particularly vulnerable such as the elderly, persons with disabilities, families with children, high residential energy users, and households with high-energy burden.

A total of $61.4 million was awarded to Maryland. Of this, approximately $10 million was allocated to training and technical assistance; $46.7 million for weatherization/retrofit efforts; and the remaining for supporting expenses such as software acquisition, weatherization tactics and auditor classes, and vehicle purchase. Overall, the grant was to be used to scale up existing weatherization efforts in Maryland, create jobs, reduce GHG emissions, and reduce expenses for Maryland's low income families; this program is not available to commercial properties. Based on U.S. Department of Energy projections, an estimated 6,850 residences would be weatherized, with an annual reduction in gas consumption of 32 percent.

Available information on the details of the Weatherization Assistance Program, including distribution of the grant money, is summarized in the figure below. Within the web page the amount spent to date by each recipient is tabulated; however, details on what has in fact been completed could not be located. Since there was limited detailed information on what weatherization/retrofit was in fact performed, but general statements regarding the cost per weatherization/retrofit, this value was chosen as the main variable within the calculations. Since limited details on how the money was being spent were identified, it was not possible to confirm the cost per property, the number of properties, and the reduction in natural gas usage. Therefore, the main assumptions are that the values that were identified in supporting documentation, and used in the calculations, are reflective of true conditions.

Figure C-23. Summary of Funding Available to Maryland from the Weatherization Assistance Program

Award Recipient	Award Amount	Training and Technical Assistance	Weatherization
Allegany County human resources	$1,879,175	$319,460	$1,559,715
Baltimore, City of	$15,713,551	$2,671,304	$13,042,247
Carroll County	$917,052	$155,899	$761,153
Cecil County	$810,808	$137,837	$672,971
Frederick, City of	$1,468,005	$249,561	$1,218,444
Community Assistance Network, Inc	$3,802,661	$646,452	$3,156,209
Diversified Housing Development, Inc.	$1,800,000	$306,000	$1,494,000
Dorchester County	$626,279	$106,467	$519,812
Garrett County	$1,276,403	$216,989	$1,059,414
Howard County	$1,140,723	$193,923	$946,800
Maryland Energy Conservation, Inc.	$7,804,227	$1,326,719	$6,477,508
Montgomery County	$5,479,944	$931,590	$4,548,354
Prince George's County	$2,100,000	$357,000	$1,743,000
Shore Up, Inc.	$3,042,015	$517,143	$2,524,872
Southern Maryland Tri-County Community	$2,258,223	$383,898	$1,874,325
Timothy Jerome Kenny	$3,831,986	$651,438	$3,180,548
Upper Shore Aging, Inc.	$1,582,776	$269,072	$1,313,704
Washington County	$733,968	$124,775	$609,193
TOTAL	$56,267,796	$9,565,525	**$46,702,271**

Overall, the calculations are very simple, and use as a basis the cost per retrofit per property. In the figure above, a total value of $46,702,271 was calculated to be available for weatherization/retrofit activities in Maryland. A review of available documentation from DHCD and U.S. Department of Energy provided two estimated costs for the weatherization of a single property, $5,268 per property and $6,500 per property respectively. Therefore, there are two scenarios:

- Total grant: $46,702,271
  - Lower boundary - $6,500 per property
  - Upper boundary - $5,268 per property

Applying these values, applicable standards, and appropriate conversation values, the reduction in GHG emissions can be calculated. Both scenarios utilize the same methodology. An example for one of the scenarios is provided here:

- Upper boundary - $5,268 per property

(Total grant) / (cost per property) = Number of properties retrofitted

($46,702,271) / ($5, 268 per property retrofit) = 8,865 retrofits

- The following values are given:
  - 32 percent reduction in natural gas usage
  - 87.1 MMBtu per property, average current residential usage, annual

(Number of retrofits)*(current energy use/property)*(% reduction) = energy savings

(8,865 retrofits)*(87.1 MMBtu/property)*(32% reduction) = 247,093 MMBtu savings

- The MMBtu value is converted to million metric tons of GHG using conversion factors provided by MDE. The calculations and the final values are summarized in Figure 30.

Figure C-24. Low and High GHG Benefit Estimate

LOW Estimate	
$6,500	cost per retrofit
7185	number of retrofits
0.0207	million metric ton GHG saved/not emitted, 2012
0.0311	million metric ton GHG saved/not emitted, 2015
0.0311	**million metric ton GHG saved/not emitted, 2020**

HIGH Estimate	
$5,268	cost per retrofit
8865	number of retrofits
0.0256	million metric ton GHG saved/not emitted, 2012
0.0383	million metric ton GHG saved/not emitted, 2015
0.0383	**million metric ton GHG saved/not emitted, 2020**

Implementation

The Green Grant Program is part of DHCD's larger affordable rental housing preservation initiative funded in part by the John D. and Catherine T. MacArthur Foundation, known as the Maryland Base Realignment and Closure Preservation Initiative. The MacArthur Foundation's support for this initiative is part of their Window of Opportunity campaign, a $150 million, 10-year effort to preserve affordable rental homes across the nation. [55] Maryland is one of twelve states and cities to have been awarded funding under Window of Opportunity.

Through the Green Grant Rental Housing Preservation Program, DHCD promotes energy efficiency in affordable rental housing developments in eight counties (Anne Arundel, Baltimore, Cecil, Frederick, Harford, Howard, Prince George's and St. Mary's) affected by the federal Base Realignment and Closure process. In partnership with MEA, the Green Grant program reimburses eligible applicants for costs associated with energy audits for multi-family rental housing or for the U.S. Green Building Council's LEED accreditation and training. The Green Grant funding comes in the form of a $75,000 grant from the MacArthur Foundation, and matching funds of $200,000 from MEA.[56] These are grant funds to reimburse applicants for costs incurred. Eligible applicants can receive funding for energy audits or LEED training. All property owners or individuals who receive funding are required to complete a survey at the completion of the energy audit or training, as appropriate.

The Green Grant Program is one of five programs established under the Maryland Base Realignment and Closure Preservation Initiative, with the other four including: 1) a revolving loan fund for preservation of affordable rental housing in eight Base Realignment and Closure counties ($4 million), 2) data analysis and assessment to better identify and target preservation activities ($250,000), 3) education and outreach efforts aimed at affordable rental property owners ($125,000), and 4) a preservation compact designed to streamline loan documents and underwriting procedures for affordable rental projects ($50,000).[57]

DHCD implements other programs that focus on energy efficiency improvements and affordable housing preservation efforts. DHCD operates the federally-funded Weatherization Assistance Program, which helps eligible low income households with the installation of energy conservation materials in their dwelling units. DHCD Multifamily Rental Housing programs provide incentives for sustainable development through its competitive awarding of federal Low Income Housing Tax Credits.

Funding from MEA supported the Multifamily Energy Efficiency and Housing Affordability program. MEA program funding of $9.5 million, originating from the American Reinvestment and Recovery Act of 2009 funding and the Strategic Energy Investment Fund, complements DHCD's Multifamily Energy Efficiency and Housing Affordability program and the Green Grant under the Maryland Base Realignment and Closure Preservation Initiative. The program provides grants for the purchase and installation of energy efficiency improvements, and/or renewable energy improvements in affordable multifamily rental housing developments. These grants may be used to pay

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[55] DHCD. "Rental Housing Preservation Program - MD-BRAC - Green Grant." http://www.mdhousing.org/Website/programs/RHPP/Default.aspx.
[56] Ibid.
[57] DHCD. "Maryland Announces Opening of "Green Grant" Energy Efficiency Program." September 2, 2009.
http://www.dhcd.maryland.gov/website/About/PublicInfo/NewsEvents/newsDetail.aspx?newsID=226

for energy efficiency items included in the DHCD Development Quality Standards, including, but not limited to: HVAC systems, insulation, windows, draft stopping and duct sealing, appliances and fixtures, and renewable energy generation, and water heating equipment. The maximum grant is $500,000 per project or $2,500 per rental housing unit, whichever is less. Priority in awarding grants is given to projects that have received or are in the pipeline to receive funding, with all funds needing to be expended by April, 2012.

Through the American Recovery and Reinvestment Act, Maryland received approximately $52 million in funding for the U.S. Department of Energy's Energy Efficiency and Conservation Block Grant program. The ten largest Maryland counties and ten largest municipalities, based on population, are eligible to receive Energy Efficiency and Conservation Block Grant grants directly from the federal government. MEA received approximately $9.6 million in Energy Efficiency and Conservation Block Grant funds for projects to be implemented in the remaining Maryland counties and municipalities not eligible to receive direct federal grants.

Energy Sector Overlap Analysis

Since the Draft Report has been published, SAIC and MEA has performed an overlap analysis for the energy sector. While the accounting methods for RGGI differed between the two efforts, the final results were within 4% of each other.

For the MEA analysis, emissions reductions for each program (RPS, EmPOWER, and market-based fuel switching) were determined separately. For the RPS, the quantity of RECs were determined based on the BAU forecast adjusted for net sales applicable to the RPS. Next, a projected 2020 REC mix was calculated using historic and projected information. Using this REC mix, the 2020 emissions intensity was calculated with and without the RPS. The difference, when applied to the 2020 sales, is the reduction attributed to the RPS.

For EmPOWER, a 13.7% per capita reduction was assumed to be met by 2020 based on historic and projected performance of the programs. This has a direct result of reducing electricity consumption. Since Maryland would still be a net electricity importer even with the 13.7% per capita reduction, MEA assumed that reductions would come from imported electricity. While it is technically impossible to determine where actual electrons are produced and consumed, it is a reasonable estimate to assume that electricity produced in state would mostly likely be consumed in state, and that imports would make up the balance of the energy need. The actual result in reality may differ, but that is not knowable.

For the fuel switching analysis, MEA estimated that market-based fuel switching in PJM would continue its recent trend. As recently as 2007, natural gas and coal accounted for 7.7% and 55.3%, respectively, of energy produced in PJM. Through the first 6 months of 2012, these figures have changed to 19.4% and 40.3% for natural gas and coal, respectively. Due to a number of factors, such as low natural gas prices, increased cost of environmental regulation, and economic retirement of coal units, the trend of increased natural gas production in PJM is likely to continue.

For the fuel switching analysis, MEA assumed that roughly 30% of electricity produced in 2020 would come from natural gas, that existing nuclear and hydro would remain constant, that new renewable energy would come online according to RGGI Inc's projections, and that coal would fill in the gap. The result is a roughly even split between natural gas, coal, and nuclear, with hydro and renewables filling in the balance.

MEA then performed a linear regression on generation and emission data from RGGI Inc's updated baseline projections to determine emission coefficients for different generating technologies. Using the coefficients from that analysis, a updated carbon intensity for imported electricity was calculated. Additionally, generation in Maryland was assumed to be impacted as well, with less coal production and increased natural gas production. On the balance, in-state coal generation went down more than in-state natural gas production increased, leading to an increase in imported electricity.

After applying the new carbon intensities for in-state and imported electricity, the fuel switching accounted for a reduction of 7.0 $MMtCO_2e$ by 2020.

These three policies interact with each other, meaning that a direct sum of the individual savings will overstate the emissions reductions if all three happen simultaneously. For example, EmPOWER will reduce the total energy used, which will reduce the number of RECs required for RPS compliance. Since the RECs contain lower carbon content on average than conventional energy, reducing the quantity of RECs will reduce the benefit of that policy. Additionally, reducing energy use through EmPOWER is assumed to reduce imported electricity. With the fuel mix changes, imported power will be much cleaner than in-state, but using less electricity means that fewer reductions are possible from that scenario.

To determine the projected reduction when all three policies are implemented at the same time, MEA reduced the total electricity use to the EmPOWER level, and then recalculated the RPS requirement based on the new level. Finally, the balance of imported electricity changed, and the fuel switching impact was based on the new mix. As a result, the simultaneous reductions achieved dropped from the individual sum of 24.9 $MMtCO_2e$ to 19.8 $MMtCO_2e$.

The following table summarizes the SAIC overlap analysis and the MEA overlap analysis. As mentioned before, SAIC used a different methodology to apply reductions to RGGI. However, the final net reductions from the energy policies are within 4% of each other.

Figure C-25. SAIC and MEA Overlap Analysis Summary

Reduction Potential - Current Policies	SAIC	MEA

Program Reductions		
RGGI	8.33	0.00
EmPOWER	3.65	10.58
RPS	3.40	7.36
Fuel Switching	0.00	6.97
Imported Power	1.53	0.00
GHG New Source	2.31	0.00
Other	0.14	0.00
Total Independent Reductions	0.00	24.91
Combined Scenario Reductions	**19.36**	**19.76**

Sub-Appendix C-2: Transportation Programs

E.1: Transportation Technology

Lead Agency: MDOT

Program Description

Transportation technology initiatives are significant contributors to mobile source emissions reductions and are an important element of the State's efforts to help reduce GHGs. Projects fall across many diverse categories including: intelligent transportation systems, traffic operational improvements, engine replacements, and clean vehicle technology including State and federal initiatives.

Traffic Flow Improvements

The Coordinated Highways Action Response Team program, operated by MDOT and the Maryland State Police focuses its operations on non-recurring congestion, such as backups caused by accidents. The Statewide Operations Center, and the three satellite operations centers in the region, survey the State's roadways to quickly identify incidents through the use of intelligent transportation system technology and direct emergency responders to the accident scenes. Quicker response helps save lives and restores normal roadway operation.

The Coordinated Highways Action Response Team program also includes traffic patrols, which have been operating during peak periods on many of the State highways in the region since the early 1990s. Based on collected data, it has been estimated that this program saved 37.3 million vehicle hours of delay Statewide (21.3 million hours of delay in the Baltimore region), 6.3 million gallons of fuel, and reduced overall mobile source emissions.

Maryland 511 is Maryland's official travel information service. Maryland 511 provides travelers with reliable, current traffic and weather information, as well as links to other transportation services. Maryland 511 helps motorists reach their destination in the most efficient manner when traveling in Maryland.

Truck Stop Electrification

Truck stop electrification allows truckers to shut down their engine and obtain electric power and "creature comforts" while resting. Truck stop electrification reduces diesel emissions and noise as well as wear and tear on the truck engine.

Maryland truck stops provide electricity (110 volts AC), cab heating/cooling, television and movies, telephone and internet access. The Maryland sites currently being pursued are located in Baltimore, Jessup and Cecil Counties.

Timing of Highway Construction Schedules
MDOT continues to evaluate new options to require non-emergency highway and airport construction be scheduled for off-peak hours that minimize delay in traffic flow.

Electronic Toll Collection
The Maryland Transportation Authority commenced operation of its electronic toll collection system, MTAG, at the authority's three harbor crossing facilities in 1999. By fall 2001, all toll facilities in the region were equipped with electronic toll collection equipment.

Traffic Signal Synchronization
The Maryland State Highway Administration has instituted a program to review and retime its 1,200 traffic signals in the Baltimore region. The timing of each traffic signal system is reviewed and updated every three years. In addition, systems in high profile corridors or corridors subject to significant traffic pattern change are evaluated on a more frequent schedule. This program results in smoother traffic flow as well as reduced emissions resulting from idling vehicles.

Synchro software is used to develop new timing plans and to calculate benefits from the new timing plans. This program has resulted in the following average annual benefits for the Baltimore region: 11.8 percent reduction in network delay; 8.5 percent reduction in arterial delay; 8.7 percent reduction in arterial stops; and 1.9 percent reduction in fuel consumption. Additional traffic signal control projects in the Baltimore region are planned for FY 2011 using federal funds.

Variable Message Sign
A variable message sign is an electronic traffic sign used on roadways to give travelers information about special events. Such signs warn of traffic congestion, accidents, incidents, roadwork zones, or speed limits on a specific highway segment. In urban areas, variable message signs are used within parking guidance and information systems to guide drivers to available car parking spaces. The signs may also ask vehicles to take alternative routes, limit travel speed, warn of duration and location of the incidents or just inform of the traffic conditions.

Telework Partnership with Employers
The Baltimore Metropolitan Council and the Metropolitan Washington Council of Governments participate in a bi-regional program to assist large and small employers to establish home-based telecommuting programs for their employees. This program, known as the "Telework Partnership with Employers," is funded by MDOT. In addition to the traffic and GHG reduction benefits, this program assists in perfecting marketing, outreach procedures, and administrative methods that may be used in other alternate commute programs. Since its kickoff in October 1999, over 25 large and small private sector employers as well as two nonprofit organizations have been recruited to participate in the bi-regional telework partnership program. In the Baltimore region, eight employers have taken advantage of this program and several others are currently considering the

program. Employers are recruited through outreach events. Employers that have signed up to participate in year-long pilot programs choose from a list of qualified regional and national telecommuting consultants whose services are paid for by MDOT.

Light-Emitting Diode Traffic Signals
MDOT continues to work with Baltimore City and other State jurisdictions to find opportunities to replace traditional traffic signal heads with light-emitting diode signal heads. The light-emitting diode signal heads would have an expected 90 percent power savings for the 39,000 traffic signals in Baltimore City.

Vehicle Technologies
Vehicle fuel economy standards are a key consideration in estimating future GHG emissions. By 2020, a number of State and federal initiatives that affect fuel economy standards will be in-place and significantly contribute to the 2020 transportation sector GHG reductions. Vehicle standards that have not been accounted for elsewhere in this document and would affect fuel economy and potential GHG emissions prior to 2020 include:

- <u>Corporate Average Fuel Economy Standards (Model Years 2008-2011)</u> – Vehicle model years through 2011 are covered under existing Maryland standards that will remain intact under the new national program.
- <u>National Program (Model Years 2012-2016)</u> – Fuel economy improvements begin in 2012 until an average 250 gram per mile carbon dioxide standard is met in the year 2016. This equates to an average fuel economy near 35 mpg.

Transportation Fuels
Accounting for increases in the availability of renewable fuels in 2020 is an important component of estimating potential GHG emission reductions from the Maryland transportation sector. EPA issued the Renewable Fuel Standard Program final rule in March 2010, which mandates the use of 36 billion gallons of renewable fuel annually by 2022.

Other Areas
Transportation technology initiatives also include projects at Baltimore Washington International Airport, such as aircraft taxi/idling/delay reduction strategies, vehicle fleet purchases, dedicated lanes, smart park facilities, auxiliary power units for ground service equipment, and facility electricity usage, and by the Maryland Port Administration, such as cargo handling equipment replacements and engine repowers, and truck replacements and engine repowers. Refer to Transportation-14: Airport Initiatives and Transportation-15: Port Initiatives for more GHG emission reduction strategies being implemented in these areas.

Estimated Greenhouse Gas Emission Reductions in 2020
The emission reductions from this measure have been combined with the Maryland Clean Cars Program described in Transportation-1. Mobile source emission reductions are calculated using a model which addresses all of the various control programs at once. Because of this, it is most appropriate to use the total emission reduction from all of the

measures combined, instead of trying to show emission reductions on a measure by measure basis. In some cases, the reductions from individual measures can actually change, based upon the order in which the modeler applied each individual control program in the model.

Figure C-26. Low and High GHG Benefits for Transportation-10

Initial Reductions	8.10 $MMtCO_2e$	MDOT Quantification Appendix D
Enhanced Reductions	8.61 $MMtCO_2e$	MDOT Quantification Appendix D

The emission reductions from this measure have been combined with the federal fuel efficiency (or Corporate Average Fuel Efficiency) standards and the other transportation technology programs included in Transportation-10: Transportation Technology Initiatives. Mobile source emission reductions are calculated using a model which addresses all of the various control programs at once. Because of this, it is most appropriate to use the total emission reduction from all of the measures combined, instead of trying to show emission reductions on a measure by measure basis. In some cases, the reductions from individual measures can actually change, based upon the order in which the modeler applied each individual control program in the model.

The following programs have significant overlap between them with respect to implementation and emission reductions:

E.1.A: Maryland Clean Cars Program
E.2: Transportation Technology Initiatives
E.1.D: Renewable Fuel Standard
E.1.B: Corporate Average Fuel Economy

For this reason, MDE has decided to combine the potential 2020 benefits from these programs under one emission benefit estimate.

Low and High Estimates – MDE Quantification
The Maryland Clean Cars Program contains all the benefits associated with the various Maryland and federal fuel economy programs initiated between 2008 through 2025. These would include the model year 2008 through 2011 federal fuel economy standards, the Maryland Clean Cars Program and the 2012 through 2016 model year federal fuel efficiency standards, and the upcoming proposed 2017 through 2025 model year federal fuel economy standards.

The 2008 federal fuel efficiency standards are discussed in more detail in Transportation-18: Corporate Average Fuel Economy Standards: Model Years 2008-2011.

By 2030, as the fleet continues to turn over, the combined benefits from Maryland and federal fuel efficiency standards could be approximately 14.11 $MMtCO_2e$.

Implementation

Projects that contribute to a change in VMT growth and/or improve system efficiency are a subset of the State's complete Consolidated Transportation Program. Current Consolidated Transportation Program projects applicable to transportation technology initiatives include Coordinated Highways Action Response Team program implementation, State and local programs for signal synchronization, transit system upgrades, and high speed tolling at I-95 Fort McHenry toll plaza.

Funded and planned transportation system investments 2006-2020, which are defined in the Maryland 2009 - 2014 Consolidated Transportation Program and in the metropolitan planning organizations, transportation improvement programs, and long-range plans through 2020 include:

- Installation, repair and replacement of variable message signs
- Congestion management programs including the employment of variable message signs, closed circuit television, signal coordination, the deployment of local information technology system projects (transit signal priority systems, automatic passenger counters, traffic signal control software, etc.), and the development of park and ride facilities
- Congestion Mitigation and Air Quality Improvement Program projects
- Clean Air Partners projects
- Advanced transportation management systems utilizing fiber optics

Additionally, the following strategies were identified for further analysis and possible implementation under this program area:

- *Active Traffic Management / Traffic Management Centers* – Provide real-time, variable-control of speed, lane movement, and traveler information (for drivers and transit users) within a corridor and conduct centralized data collection and analysis of the transportation system. System management decisions are based on inroad detectors, video monitoring, trend analysis, and incident detection (currently performed by Coordinated Highways Action Response Team program).
- *Traffic Signal Synchronization / Optimization* – Traffic signal operations are synchronized to provide an efficient flow or prioritization of traffic, increasing the efficient operations of the corridor and reducing unwarranted idling at intersections. The system can also provide priority for transit and emergency vehicles. Specific performance measure is "reliability." Traffic Signal Synchronization is currently performed by the Maryland State Highway Administration and local jurisdictions.
- *Timing of Highway Construction Schedules* – Consider requiring non-emergency, highway and airport construction be scheduled for off-peak hours that minimize the delay in traffic flow. Include incentives for completing projects ahead of schedule.
- *Green Port Strategy* – Develop and implement a "Green Port Strategy" consistent with industry trends and initiatives including EPA's Strategy for Sustainable seaports (note: also applies to Transportation-15: Port Initiatives).

- *Reduce Idling Times* – Reduce idling time in light duty vehicles, commercial vehicles (including the use of truck stop electrification), buses, locomotive, and construction equipment.
- *Marketing and Education Campaigns* – Initiate marketing and education campaigns to operators of on-and off-road vehicles (note: this strategy also applies to Trasnportation-11: Electric Vehicle Initiatives and Transportation-12: Low Emission Vehicle Initiatives).
- *Technology Improvements for On-highway Vehicles* – Promote and incentivize fuel efficiency technologies for medium and heavy-duty trucks (on-highway vehicles) (note: this strategy also applies to Trasnportation-11: Electric Vehicle Initiatives and Transportation-12: Low Emission Vehicle Initiatives).

E.1.A: Maryland Clean Cars Program

Lead Agency: MDE

Program Description

In Maryland, motor vehicles account for approximately 30 percent of all GHG emissions. Vehicles sold in the U.S. must be certified through one of two certification programs: the Tier 2 federal program or the California Clean Car Program. The California Clean Car Program was the first and only program in the country to regulate GHG emissions from motor vehicles. This program establishes a fleet-wide average GHG standard. Each vehicle manufacturer demonstrates compliance with the fleet-wide average by sales-weighting the specific emission levels to which each vehicle is certified. These fleet average GHG requirements apply to vehicles up to 10,000 pounds, including vehicles such as passenger cars, sport utility vehicles, and light duty trucks.

Section 177 of the federal Clean Air Act authorizes other provides states the ability to adopt the California Clean Car Program in lieu of the federal program. The Maryland Clean Cars Act of 2007 required MDE to adopt regulations implementing the California Clean Car Program. Implementation of the program began with model year 2011 vehicles. In addition to Maryland, thirteen other states (California, New York, Massachusetts, Maine, Rhode Island, Connecticut, Vermont, Pennsylvania, New Jersey, Arizona, New Mexico, Oregon, and Washington) have also adopted and implemented the California Clean Car Program.

On May 7, 2010, EPA and the National Highway Traffic Safety Administration finalized new national GHG and fuel economy standards for passenger vehicles and light-duty trucks. The standards were finalized on May 7, 2010. These new standards will be phased in beginning in model year 2012 and, when fully implemented in model year 2016, will attain the same fuel economy and GHG reductions as the California Clean Car Program. This action brings both the federal standards and California standards into harmony, effectively creating one national standard.

In 2010, California began working on its next generation clean car program which would become effective for model year 2014 through 2025 vehicles. On May 21, 2010, President Obama also directed the National Highway Transportation Safety Administration and EPA to begin a process for evaluating and setting standards to improve fuel efficiency and reduce GHG emissions for passenger cars and light duty trucks built in model years 2017 and later. The federal agencies will work closely with the California Air Resources Board in developing new standards.

The National Highway Transportation Safety Administration and EPA, working with the California Air Resources Board, are currently meeting with stakeholders to gather information necessary to set aggressive light-duty vehicle standards for model year 2017 and beyond. The September 1, 2010 Notice of Intent described key elements of the program that the National Highway Transportation Safety Administration and EPA intend to propose in a future joint rulemaking, and identified potential standards that could be practically implemented nationally for the 2017 through 2025 model years and a schedule for setting standards as expeditiously as possible to provide sufficient lead time. The National Highway Transportation Safety Administration, EPA, and the California Air Resources Board are expecting to release the proposal in the September 2011 timeframe.

This joint program will achieve substantial annual progress in reducing transportation sector GHG emissions and fossil fuel consumption. Additionally, the program will encourage continuous technological innovation through performance-based standards, and will stimulate increases in the use of electric, hybrid, and other vehicles utilizing cutting edge technologies.

Estimated Greenhouse Gas Emission Reductions in 2020

The following programs have significant overlap between them with respect to implementation and GHG emission reductions:

E.1.A: Maryland Clean Cars Program
E.2: Transportation Technology Initiatives
E.1.D: Renewable Fuel Standard
E.1.B: Corporate Average Fuel Economy

For this reason, MDE aggregated the potential 2020 benefits from these programs under one emission benefit estimate. Refer to E: Transportation Technology Initiatives for the description and data regarding the methodologies used to quantify these four programs.

Other Environmental Benefits

The Maryland Clean Cars Program is also designed to reduce emissions of the ozone precursor pollutants, nitrogen oxides and volatile organic carbons and to also reduce emission of air toxics.[58] To ensure that specific emission levels are achieved on a fleet-

[58] For purposes of this document and the Maryland Clean Cars Program, the terms volatile organic carbon and non-methane organic gases are used interchangeably. When referencing the California regulations or

wide basis, the Maryland Clean Cars Program also sets a fleet-wide average standard for these criteria pollutants. Compliance with this fleet-wide average standard is demonstrated by each vehicle manufacturer by sales-weighting the specific emissions levels to which each individual vehicle is certified. Additionally, the Maryland Clean Cars Program also has a zero emission vehicle component, which requires manufacturers to produce zero (or near zero) emission vehicles. This technology forcing component of the Maryland Clean Cars Program has facilitated the development of advanced technology vehicles such as hybrid and fuel cell vehicles.

Nitrogen oxide emission reductions will help Maryland meet air quality standards for ground level ozone and fine particulate matter. They will also significantly help Maryland reduce nitrogen pollution in the Chesapeake Bay. By 2030, nitrogen oxide emission is expected to reduce by 7.1 tons per day.

Volatile organic carbon emission reductions will help Maryland meet air quality standards for ground level ozone. By 2030, volatile organic carbon emission is expected to reduce by 4.8 tons per day.

The Maryland Clean Cars Program will also reduce emissions of air toxics like benzene, 1-3 butadiene, and acetaldehyde. By 2030, air toxics emissions could be reduced by 69.5, 8.9, and 15.7 tons per day, respectively.

Implementation

This program has been implemented through regulations adopted by MDE into the Code of Maryland Regulations through Incorporation by Reference. The requirements are fully enforceable, and MDE is enforcing these regulations just as it enforces all its regulations.

E.1.B: Corporate Average Fuel Economy (CAFÉ) Standards: Model Years 2008-2011

Lead Agency: MDOT

Program Description

The Energy Independence and Security Act of 2007 established a goal for increasing the national fuel economy to 35 miles per gallon by the year 2020. This marked the first new Corporate Average Fuel Economy standard since the creation of these standards in 1975, over 30 years ago. The fuel economy standard is the sales-weighted fuel economy average for a vehicle manufacturer for the current model year of vehicles with a gross vehicle weight rating of 8,500 lbs or less. This new standard included passenger vehicles as well as light duty trucks.

standards, non-methane organic gas is used since it is the terminology used in those regulations. When referencing benefits, volatile organic carbon is used for consistency with the MDE modeling.

Since introduction in 1975, Corporate Average Fuel Economy standards have increased very slowly from an initial 18 miles per gallon. Since 1990 the standard for passenger cars has been stable at 27.5 miles per gallon. Light duty trucks have experience a more gradual increase from 17.5 miles per gallon in 1982 increasing to just 22.2 miles per gallon in 2007. The Energy Independence and Security Act of 2007 requires the National Highway Traffic Safety Administration, the agency with the regulating authority on fuel economy, to gradually increase the fuel efficiency standard mpg until it achieves the 35 miles per gallon mark. Each year the National Highway Traffic Safety Administration must analyze the effect of its new proposed standard on the environment as well as employment. The new standard must be issued 18 months before the model year for a fleet. Manufacturers need this lead time in order make any changes to their vehicle lineup necessary to meet the new standard.

In passing the Energy Independence and Security Act of 2007, Congress instructed the National Highway Traffic Safety Administration to establish a credit trading and transferring system for manufacturer's to transfer credits between categories and to sell them to other manufacturers or non-manufacturers. This policy allowed greater opportunities for compliance with the increasing standards.

Since being passed and implemented, newer fuel efficiency and GHG standards have been adopted through a joint rulemaking between National Highway Traffic Safety Administration and EPA for model years 2012-2016. These new GHG standards along with a new, quicker, phase in of fuel economy standards will replace those adopted from the passage of the 2007 federal law. The 2008-2011 fuel efficiency standards will be enforced up to 2012 and will still provide GHG benefits into the future.

Estimated Greenhouse Gas Emission Reductions in 2020

The following programs have significant overlap between them with respect to implementation and GHG emission reductions:

E.1.A: Maryland Clean Cars Program
E.1: Transportation Technology Initiatives
E.1.D: Renewable Fuels Standard
E.1.B: Corporate Average Fuel Economy

For this reason, MDE aggregated the potential 2020 benefits from these programs under one emission benefit estimate. Refer to E: Transportation Technology Initiatives for the description and data regarding the methodologies used to quantify these four programs.

Implementation

This program has been implemented through regulations adopted by the National Highway Traffic Safety Administration. The requirements are fully enforceable, and this federal administration is enforcing these regulations just as it enforces all its regulations. Since its implementation, new national GHG and fuel economy standards have been adopted through a joint agency agreement between EPA and the National Highway Traffic Safety Administration. These new standards will improve upon the current standards set forth in this program and succeed this program as the enforceable fuel economy standards.

While these standards are applicable through model year 2011 vehicles, these vehicles will remain in the fleet and will still be producing benefits in 2020.

E.1.C: National Fuel Efficiency & Emission Standards for Medium- and Heavy- Duty Trucks

Lead Agency: MDE

Program Description

The National Fuel Efficiency & Emission Standards for Medium- and Heavy- Duty Trucks program is the first program ever designed to reduce GHG emissions and improve fuel efficiency for medium- and heavy-duty vehicles. The program represents collaboration between EPA and the National Highway Traffic Safety Administration in response to President Obama's Presidential Memorandum issued in May of 2010. Medium- and heavy-duty vehicles make up the transportation segment's second largest contributor to oil consumption and GHG emissions.

EPA and the U.S. Department of Transportation are each proposing complementary standards under their respective authority covering model years 2014-2018. EPA and the National Highway Transportation Safety Administration are proposing emission standards for carbon dioxide and fuel consumption standards, respectively, for the following regulatory categories: Combination tractors, heavy-duty pickup trucks and vans, and vocational vehicles. EPA will propose standards for air conditioning related emissions of hydrofluorocarbons from pickups, vans and tractors, as well as nitrous oxide and methane standards applicable to all heavy-duty engines, pickups and vans. EPA is also proposing to include recreational on-highway vehicles in its rulemaking while the National Highway Transportation Safety Administration is not including them. For this proposal the heavy-duty fleet includes all onroad vehicles rated at 8,500 lbs or more, except those covered by the current GHG emissions and federal Corporate Average Fuel Economy standards for model years 2012-2016.

The proposed standards cover not only engines but also the complete vehicle. In order to account for the fact that many of these vehicles carry payloads of goods and equipment, the regulations has proposed two types of standard metrics: payload-dependent gram per mile standards for pickups and vans, and gram per ton-mile standards for vocational vehicles and combination tractors.

The proposed regulations set phase in standards for vehicle manufacturers similar to the national GHG standards. This program takes a sales-weighted approach to averaging the emissions from each model in order to determine a manufacturer's fleet wide average. The program also provides flexibility to manufacturers to meet the standards. The primary flexibility provision is an engine and vehicle averaging, banking, and trading program. These programs would allow for emission and/or fuel consumption credits to be averaged, banked, or traded within each regulatory subcategory, but not across categories. EPA is also proposing to allow engine manufacturers to use carbon dioxide credits to offset methane or nitrous oxide emissions that exceed the applicable standards. In addition, the agencies are proposing three additional credit opportunities. The first is an early credit option for improvements in excess of a proposed standard prior to the model year it becomes effective. The second is a credit to promote implementation of advanced technologies, such as hybrids, and electric vehicles. The third credit applies to new and innovative technologies that reduce carbon dioxide emissions and fuel consumption, but for which the benefits are not captured over the test procedures used to determine compliance with the standards (i.e., off-cycle).

Estimated Greenhouse Gas Emission Reductions in 2020

Because this is a relatively recent initiative, and the full benefits of the effort depend on the turnover of the mobile fleet, significant additional reductions of GHGs are expected by 2030 and 2050. By 2030 and 2050, the GHG reductions increase to 1.13 and 1.6 $MMtCO_2e$ respectively.

Figure C-27. Low and High GHG Benefits for Transportation-2

Initial Reductions	0.88 $MMtCO_2e$	MDOT Quantification Appendix D
Initial Reductions	0.88 $MMtCO_2e$	MDOT Quantification Appendix D

E.1.D: Renewable Fuels Standard

Lead Agency: MDOT

Program Description

The Renewable Fuels Standard, regulated by EPA, was originally created under the federal Energy Policy Act of 2005. It established the first renewable fuel volume mandate in the U.S. Originally the program set a requirement that 7.5 billion gallons of renewable fuel be blended into gasoline in 2012. The Energy Independence and Security Act of 2007 greatly expanded the Renewable Fuel Standard in a number of ways. The new policy included diesel fuel as a medium for renewable fuel, along with gasoline. It also increased the volume of renewable fuels to be blended to 9 billion gallons in 2008 and 36 billion gallons in 2012. The federal law also developed new categories of renewable fuel and set limits on how much of the mandate could be met by certain fuels types, as well as required an application of lifecycle GHG performance threshold standards to ensure each category of renewable fuels emits fewer GHGs than the conventional fuel it replaces.

Biofuels must reduce lifecycle GHG emissions by at least 20 percent in order to qualify as a renewable fuel. The volume of ethanol included in the Renewable Fuels Standard is capped at 12 billion gallons in 2010 and increases to 15 billion gallons in 2015 where it is fixed thereafter. The new policy includes a mandate for advanced biofuels, which grow from 1 billion gallons in 2010 to 21 billion gallons in 2022. To qualify as an advanced biofuel the fuel must reduce lifecycle GHG emissions by 50 percent. Corn-starch ethanol is directly excluded from this category and cannot be used to meet this part of the mandate. Ethanol created from non-starch parts of the corn plant (such as the stalk and cob) can qualify if they meet the GHG lifecycle emission reductions. Included is also a cellulosic and agricultural waste-based biofuel mandate. This grows from 100 million gallons in 2010 to 16 billion gallons in 2022. Cellulosic biofuels must reduce lifecycle GHG emission by at least 60 percent. The final category, bio-mass based biodiesel, has a mandate that grows from .5 billion gallons in 2009 to 1 billion gallons in 2012. Any fuel made from biomass feedstock that has a 50 percent lifecycle GHG reduction satisfies this part of the mandate.

In order to ensure that the fuel supply sold in the U.S. meets the mandated volume of renewable fuels, EPA established a system of tradable Renewable Identification Numbers, which are unique identifiers issued by the biofuel producer or importer at the point of production or port of importation. A unique number is generated for every qualifying gallon of renewable fuel.

EPA uses estimates provided by the U.S. Department of Energy's Energy Information Agency, to determine the total volume of transportation fuel expected to be used in the U.S. during the next year. The mandate is computed and a preliminary standard is issued in the spring of the preceding year, with a final rulemaking in 2012, pending legal issues. Fuel blenders are required to include a quantity of biofuels equal to a percentage of their total annual sales. Each blender must show that it has enough Renewable Identification Numbers at the end of each year to meet its share for each of the four mandated standards.

The Renewable Fuels Standard is a federally-mandated program designed to reduce the nation's need of foreign oil, and encourage the development and expansion of our nation's renewable fuels sector. The program will also help reduce GHG emissions from transportation fuels through the use of renewable fuels.

Estimated Greenhouse Gas Emission Reductions in 2020

Figure C-28. Low and High GHG Benefits for Transportation-2

Initial Reductions	0.24 $MMtCO_2e$	MDOT Quantification Appendix D
Initial Reductions	0.24 $MMtCO_2e$	MDOT Quantification Appendix D

E.2.B: Airport Initiatives

Lead Agency: MDOT

Program Description

The following initiatives, supported by the Maryland Aviation Administration, are intended to reduce criteria pollutant emissions and will also serve to reduce GHG emissions. A 2011 energy audit is assisting the Maryland Aviation Administration in evaluating potential reductions in electricity consumption and conventional vehicle fuel use, which would result in less GHG emissions by using more energy efficient design and fuel conservation measures. Lower consumption and demand on electricity power plants would help to reduce GHGs. A future Air Quality Management Plan should also help in addressing future air quality requirements including GHG emissions reduction. More detail on these measures is provided below.

Compressed Natural Gas Buses

The Maryland Aviation Administration has a fleet of approximately 20 buses that transport passengers from the terminal to various off-campus facilities, such as the consolidated rental car facility and long-term parking lots. To reduce emissions associated with the buses, these diesel-powered buses were replaced with compressed natural gas vehicles. Compressed natural gas offers air quality benefits by producing fewer overall emissions than diesel-powered engines.

Air Emissions Reductions

To reduce air emissions, the Maryland Aviation Administration's Division of Maintenance uses alternative fuel or bi-fuel vehicles. Some of the vehicles use only compressed natural gas, while others use a combination of natural gas and fossil fuels. There are approximately 20 vehicles in the maintenance fleet that use alternative fuels, such as E-85 fuel, including vans, pick-up trucks and flat-bed trucks that are used daily. The Baltimore Washington International Thurgood Marshall Airport facilities also include an on-site quick-fill compressed natural gas fueling station.

BWI Energy Audit

The environmental stewardship section of MDOT's 2010 Attainment Report identified that the Maryland Aviation Administration will conduct an energy audit at BWI to establish a baseline for developing conservation goals. The draft Energy Audit is completed, and Administration is investigating those energy usage improvements that will help reduce criteria pollutant and GHG emissions at the airport.

BWI Utility Master Plan

The Maryland Aviation Administration has prepared a *Utility Master Plan for BWI Marshall Airport* to identify the many systems and utilities needed to operate the airport. The plan provides baseline energy consumption data and describes existing services used to operate BWI under current conditions, such as: water and sanitary services, glycol collection, natural gas consumption, electrical power, heating and air conditioning systems, fuel use and communication networks.

BWI Energy Efficiency

The Maryland Aviation Administration is promoting efficient energy use in the terminal area by replacing the lighting with more energy efficient fixtures. Switching from T-12 fluorescent lights to T-8 lights with electronic ballasts is expected to reduce the electricity required to illuminate the airport by 30 percent.

Another program to reduce energy consumption has focused on BWI's heating, ventilation and cooling systems. Such systems have been upgraded as the airport expanded during the last decade. The new systems provide for a five to ten percent reduction in fuel use.

Enhanced Access to BWI by Other Travel Modes

As aviation demand at BWI grows, surveys indicate that many passengers choose private vehicles and other gasoline-powered vehicles to access the airport. The Maryland Aviation Administration will continue to look for ways to encourage access to BWI using other modes that reduce criteria pollutants and GHG's.

BWI's Periodic Air Quality Assessments

The Maryland Aviation Administration conducts periodic studies to assess air quality on, and in the vicinity of, BWI Marshall. Most recent studies for air quality include the *Air Quality Assessment Update 2006* (a study that is updated every five to 10 years to support the Maryland State Implementation Plan), and a *Final Draft, 2006 Greenhouse Gas Baseline Emissions Inventory (completed in 2008)*.

Estimated GHG Emission Reductions in 2020

In order to account for similarities across programs, all emission benefits and costs associated with this program has been aggregated under E.2: Transportation Technologies.

Implementation

The Maryland Aviation Administration supports a wide range of initiatives geared towards reducing GHG's, and improving the airport environment's air quality. There are many advances being made by the aviation industry to address GHG reduction, including testing and use of bio-fuels for aircraft use, and changing the fleet of airline ground support equipment, such as aircraft tugs and baggage belt loaders, to non-gasoline technologies (electric and/or natural gas). Many of these programs are part of the Environmental Impact Statements created for Maryland's State-owned airports. This process is part of the environmental permitting process required for project approval Air quality analysis and general conformity considerations are part of the required evaluation in the federal Environmental Impact Statements process as well as comparable State processes. It is critical to note that Maryland Aviation Administration does not have the legal authority to prohibit airlines from using existing aircraft engine technologies that operate within the existing federal and State regulatory environment. Below is a listing of various efforts being discussed and/or implemented by the aviation industry to reduce criteria pollutants and GHG's, and an indication of whether Maryland Aviation Administration can control the implementation schedule of some of these efforts:

Airline Controlled Activities (Federally regulated)

- Aircraft taxi/idling/delay reduction strategies
- Aircraft engine modifications

Maryland Aviation Administration Controlled Activities (State initiatives)

- State Vehicle fleet purchases
- Lower Roadway Dedicated Lanes for commercial, curbside activities (already exists)
- Expanded Smart Park facilities (all parking facilities contain such facilities—no additional expansion of parking facilities are planned)
- Promote preferential airport parking for hybrids and low-emitting vehicles—have installed eight electric charging areas within the Hourly and Daily Garages
- Lower airport facility electricity usage through energy audit reduction strategies
- Promote reforestation and afforestation at BWI

Activities Not within Control of Maryland Aviation Administration and/or Airlines, Requiring Regional Planning Coordination and/or Business Partnership Efforts

- Promote hybrid car rentals and hybrid satellite lot shuttle vehicles
- Promote transit including MARC, Light Rail, and AMTRAK connections to BWI
- Promote sustainable lodging (hotels with energy efficient lighting, recycling, and conservation practices) around BWI
- Enhance Light Rail access to BWI
- Maryland Transit Administration's Yellow Line from Baltimore to BWI and Columbia
- Evaluate incentives for EPA SmartWay carriers in cargo activities at BWI

Consider low carbon footprint air travel incentives (carbon offsets) to passengers and airlines using BWI

E.2.C: Port Initiatives

Lead Agency: MDOT

Program Description

The Maryland Port Administration's Environmental Management System and other initiatives to reduce the environmental footprint from activities related to Maryland's deepwater seaport include emission reduction strategies consistent with the State's efforts to help reduce air emissions, including GHGs. Specific actions currently part of the Maryland Port Administration's emission reduction program include, but are not limited to, use of cleaner diesel fuel port fleet vehicles, use of diesel operated equipment, reduced truck emissions through turn time efficiency improvements, and idle reductions. Initiatives to encourage lower emissions and introduce cleaner technologies at the port are described in more detail below.

Port of Baltimore Initiatives

In 2002, the Maryland Port Administration began developing assessments of relative mobile and off-road emission contributions from vessels and cargo handling activities at port facilities.

In 2006, the Maryland Port Administration partnered with Port stakeholders to oversee various physical and operational improvements to terminal gates at the Dundalk and Seagirt Marine Terminals. The purpose of the improvements was to expedite inbound and outbound vehicle traffic. A net benefit of these projects was overall reductions in idling time for heavy-duty diesel trucks and other vehicles visiting the terminals, resulting in reduced emissions.

Since 2006, the Maryland Port Administration has used ultra-low sulfur diesel fuel blended with bio-diesel in all of its "on road" as well as "off road" diesel engines. This included Administration owned vehicles such as gantry cranes, ship-to-shore cranes, mobile cranes, terminal service vehicles, stationary generators, fire pumps, off-road, and other cargo handling-equipment. The Maryland Port Administration annually exceeds EPA's 75 percent fleet vehicle alternative fuel purchasing requirements. To do so, the port administration purchases flex-fuel (ethanol/gas) fleet vehicles. The Maryland Port Administration also purchased four hybrid (electric/gas) fleet vehicles, one electric vehicle, and a hybrid aerial lift. Additionally, the Administration performs outreach to employees on "ozone alert days" in order to reduce activities which contribute to ozone pollution, such as vehicle fueling and combustion engine usage.

Beginning in the fall of 2006 and continuing through 2010, Maryland Port Administration applied for and received a series of EPA and U.S. Department of Energy grants to retrofit ship-to-shore crane and rubber tire gantry cranes with Diesel Oxidation Catalysts. Several grant awards from EPA and U.S. Department of Energy have allowed expansion of these efforts to a port-wide initiative involving private sector port operators, including railroad, harborcraft, dray truck and cargo handling equipment upgrades throughout the Port of Baltimore. Ongoing educational and outreach efforts regarding emission reductions and environmental stewardship take place through the Baltimore Port Alliance Environmental Committee.

Recent improvements in truck turn times have come through investment in technology improvements at the Seagirt Marine Terminal. This investment is a result of the 2010 partnership between the Maryland Port Administration and Ports America Chesapeake to operate the Seagirt Marine Terminal.

Current 2011 initiatives include development of a port-wide Dray Truck Replacement Program, energy efficiency improvements through energy performance contracts and alternative energy projects, and development of a strategy for further reducing carbon emissions.

A major initiative aimed at voluntarily reducing particulate matter and nitrogen emissions on a port-wide basis did not receive EPA funding in the most recent competitive round of grants. Funding assistance remains a critical element of successful programs and the resulting achievement of intended GHG and other emission reductions.

Estimated GHG Emission Reductions in 2020

In order to account for similarities across programs all emission benefits and costs associated with this program has been aggregated under E.2: Transportation Technologies.

Implementation

Ongoing or planned administrative, management, maintenance, and operations strategies by the Maryland Port Administration that will result in voluntary reductions in energy consumption from the transportation sector are listed below. These strategies reduce GHG emissions through helping to decrease rates of energy consumption from transportation infrastructure and support facilities.

- *Green Port Strategy* will be developed consistent with industry trends and initiatives including EPA's Strategy for Sustainable Seaports.
- Applied for and received EPA grants for demonstration emission reduction projects on Maryland Port Administration fleet vehicles, cargo handling equipment at port terminals, and on construction equipment at Hart Miller Island and Poplar Island.
- Applied for and received EPA grant for a Port-wide assessment of technologies that can effectively reduce emissions related to cargo movement.
- Retrofit and repowered tugs with anti-idling technology and new engines.
- Flex-fuel vehicles, alternative fuel vehicle, and hybrid vehicles have been introduced into the Maryland Port Administration fleet.
- Plans to install a fuel tank capable of storing E-85 will be included in the new fuel island configuration at Dundalk Marine Terminal.
- Comply with national laws and regulations that increase environmental protection and maintain competitiveness
- Emission controls for ocean going vessels

E.2.D: Freight and Freight Rail Strategies

Lead Agency: MDOT

Program Description

The initiative to improve efficiency of freight transportation is part of the State's efforts to reduce the transportation sector's air emissions including GHGs. This program enhances connectivity and reliability of multimodal freight through infrastructure and technology investments, such as expansion and bottleneck relief on priority truck and rail corridors and enhanced intermodal freight connections at Maryland's intermodal terminals and ports. The following are a variety of initiatives to encourage and improve rail and freight transport.

Auxiliary Power Units for Existing Locomotives

Auxiliary power units have been installed on diesel locomotives to reduce the need for long idling periods. An auxiliary power unit eliminates emissions and conserves fuel by shutting down the main engine at idle regardless of weather conditions or operating location. It also protects the main locomotive engine during shut-down times by monitoring and maintaining the lube oil and water temperatures. Auxiliary power units are part of the locomotive emissions control strategies certified to meet the EPA Locomotive Rule.

Technology Advances for Non-highway Vehicles
MDOT will continue to analyze and identify opportunities to incentivize retrofits or promote replacement of old, diesel-powered non-highway engines, like switch-yard locomotives, with new hybrid locomotives. Targeted engines could include State-owned switchers, like MARC. MDOT should also provide outreach to private operators, such as Amtrak, CSX, Norfolk Southern, and Canton Railroad.

Estimated GHG Emission Reductions in 2020

In order to account for similarities across programs, all emission benefits and costs associated with this program has been aggregated under either E.2: Transportation Technologies.

Implementation

No specific freight strategies are currently recommended in addition to projects identified in implemented and adopted transportation plans and programs, as identified below, for consideration before 2020. Recent developments and Maryland strategic involvement in the CSX Transportation National Gateway initiative will result in implementation of freight rail projects in Maryland and the mid-Atlantic region that will help reduce truck VMT in Maryland by 2020. Funding for the National Gateway is a public-private partnership between the federal government, six states and the District of Columbia, and CSX. The benefit of the National Gateway is assessed in this report.

The benefits of Norfolk Southern's Crescent Corridor initiative are not assessed in this report as direct GHG emission reduction benefits to Maryland are unknown, and a level of support and funding commitment from Maryland has not been recommended to date.

Projects that contribute to a change in VMT growth and/or improve system efficiency are a subset of the State's complete Consolidated Transportation Program. Currently funded and planned transportation system investments 2006-2020, which are defined in the Maryland 2009 - 2014 Consolidated Transportation Program and in the metropolitan planning organizations, transportation improvement programs, and long-range plans through 2020 include:

- Major roadway capacity projects impacting truck freight movement in Maryland planned for opening by 2020, such as:
    - I-695 from I-95 South to MD 122
    - I-695 from I-83 to I-95 North
    - MD 32 grade separation and interchange at I-795
    - MD 4 upgrade in Prince Georges County

    - US 50 access control improvements in Wicomico County
- Long range projects associated with the Maryland Statewide Freight Plan to provide rail freight capacity improvements on railroads owned by Maryland

The State will continue to implement and look for areas to expand this ongoing effort while seeking funding sources at the State and federal level and continuing to work with State and federal lawmakers on legislation. Examples of initiatives that may be added or enhanced include (this list should not be considered exclusive):

- Providing climate change adaptation and mitigation for rail lines at risk from rising sea levels- The Amtrak North East Corridor lines in Harford County are a prime example.
- Advancing the construction timetable for high speed rail projects in the North East Corridor. For example, Maryland recently received $22 Million from the High Speed Intercity Passenger Rail Program to begin Preliminary Engineering and National Environmental Policy Act analysis toward the replacement of the Susquehanna River Bridge on the Amtrak North East Corridor. This would provide additional tracks which would alleviate the chokepoint created by the current double tracked bridge and allow for expanded capacity for Amtrak, MARC and Norfolk Southern freight trains, as well as increased times. This would help alleviate current train idling and allow for the expansion of passenger and freight service that would alleviate road congestion for commuters and freight.
- Building the proposed CSX intermodal container facility, to be located south of CSX's Howard Street tunnel. This will remove a major freight bottleneck and enhance competitiveness of rail freight transport by allowing CSX to double stack containers, which will divert marginal long haul trucking and improve emissions by diverting cargo to rail.
- Replacing long haul truck freight hauling with rail hauling by 2020 (Norfolk Southern Crescent Corridor, CSX National Gateway)

E.3: Electric Vehicle Initiatives

Lead Agency: MDOT

Program Description

Initiatives to encourage use of electronic vehicles are part of efforts by the State to help reduce air emissions, including GHGs, by providing viable alternatives to internal combustion engine vehicles. Electric vehicles can help to reduce mobile emissions because they are a clean vehicle technology, using battery power for propulsion rather than an internal combustion engine. The following are a variety of initiatives to encourage electric vehicle usage.

Electric Vehicles
MDOT has been working closely with MDE, MEA, Baltimore City and the Baltimore Electric Vehicle Initiative to select appropriate locations for 65 electric vehicle re-charging stations around the State. Several of the re-charging stations will be located at MDOT and modal facilities such as the MDOT Headquarters in Hanover, the Baltimore Washington International Airport MARC/AMTRAK station, the BWI parking garage and park-and-ride lots maintained by MDOT modal agencies. MDOT's continued involvement in expanding the availability of electric vehicle recharging stations throughout the State will contribute to Statewide GHG emission reductions and complement the efforts of the 2010 Maryland General Assembly, which has passed legislation approving electric vehicle tax credits and electric vehicle use of high-occupancy vehicle lanes, and the 2011 Maryland General Assembly, which has passed legislation to create an Electric Vehicle Infrastructure Council, and establish a State income tax credit of 20 percent of the cost of electric vehicle charging equipment for individuals and businesses.

MDOT is working to form an Electric Vehicle Infrastructure Council comprised of State, local and private sector representative to develop a plan to implement electric vehicle infrastructure throughout the State. It is MDOT's goal to make the availability of electric vehicle rechargers as convenient as current conventional fueling systems.

MDOT is also working with the Transportation and Climate Initiative, a consortium of transportation, air and energy agencies in the North East and Mid-Atlantic, to develop a process and guidelines for incorporating electric vehicle rechargers in and near the I-95 corridor.

Non-MDOT Initiatives Underway

Maryland Electric Vehicle Initiative
In March 2010, MEA launched a new program to promote the use of electric vehicles in Maryland. The Electric Vehicle Infrastructure Program initiative will provide aid in the installation of electric vehicle recharging units and truck stop electrification. The program, run by MEA and the Maryland Clean Cities Coalition, will provide $1 million during the FY11 in grants to State and local governments as well as nonprofits and private entities.

Several plug-in electric vehicles are expected to be commercially available later this year, including the Chevy Volt and the Nissan Leaf. These vehicles will reduce the amount of gasoline utilized in the State while also reducing carbon emissions and promoting energy independence.

MDOT has been working with other State agencies to expand the availability of electric vehicle recharging systems. An initial 65 public electric charging stations are being installed in the Baltimore region. Almost a third are being installed on MDOT property, particularly at passenger transfer points such as BWI parking garages, train station parking facilities and near I-95. MDOT installed 2 public recharging stations at MDOT headquarters for public usage.

Maryland Transit Administration Support for Howard County Electric Bus Project

- Replace three diesel buses with electric buses to operate on Howard Transit's Green Route (serving downtown locations including the Columbia Mall, the Village of Wilde Lake, Howard Community College, and Howard County General Hospital)
- Install an inductive charger at Howard County Community College to provide energy to the bus batteries through electromagnetic induction
- Build a transit shelter and an "Energy Information Station" to provide real-time information on the charging process including the recording of emission reductions and cost savings
- This project is fully funded by TIGGER II Discretionary Grant Funds and is ready to proceed so has been added as an amendment to the FY 2011-2014 transportation implementation program.

Clean and Efficient Strategies

MDE is supporting the installation of two “Quick Charge” recharging units in Baltimore City. These chargers allow the recharge of electric vehicles in under an hour as compared to the previous time of six hours. This increase in efficiency could encourage Baltimore City to purchase more electric vehicles for its downtown fleet.

MDE also worked with Johns Hopkins University to install a “Quick Charger” unit at its main campus.

Baltimore City Electric Vehicle Infrastructure

This is a Baltimore Regional Transportation Board Congestion Mitigation and Air Quality *S*ubcommittee recommendation for FY11 funding to install 8 electric vehicle charging units in public garages in Baltimore.

MDOT, MEA and MDE continue to analyze and consider other options to promote electric vehicles such as:

- Plug-in spaces at workplaces, hotels, toll plazas, etc
- Preferential parking for electric and low emitting vehicles

Estimated GHG Emission Reductions in 2020

In order to account for similarities across programs, all emission benefits and costs associated with this program has been aggregated under E.2: Transportation Technologies.

Implementation

The following strategies were identified for further analysis and possible implementation under this program area:

- *Incentives for Low-Carbon Fuels and Infrastructure* – Incentivize the demand for clean low-carbon fuels and the development of infrastructure to provide for increased availability/accessibility of alternative fuels and plug-in locations for electric vehicles (note: this strategy also applies to Transportation-12: Low Emitting Vehicle Initiatives).
- *Marketing and Education Campaigns* – Initiate marketing and education campaigns to operators of on-and off-road vehicles (note: this strategy also applies to Transportation-11: Electric Vehicle Initiatives and Transportation-12: Low Emission Vehicle Initiatives).
- *Technology Improvements for On-highway Vehicles* – Promote and incentivize fuel efficiency technologies for medium and heavy-duty trucks (on-highway vehicles) (note: this strategy also applies to Transportation-11: Electric Vehicle Initiatives and Transportation-12: Low Emission Vehicle Initiatives).

Additionally, there is discussion on creating smart outlets and the required communication between electrical distribution company and the vehicle. This type of technology may provide a solution in the future, but is not currently part of the initial electric vehicle and plug-in hybrid electric vehicle production. In the longer term, the enhanced electricity storage capacity of vehicle to grid systems may provide a significant share of the grid's total electricity load. But in the short run, electric vehicles and plug in hybrid electric vehicles, which only draw from the grid, may place more demand on the grid than it can currently meet. New electricity generation sources might be needed and there might be pressure to build more peak hour plants unless sufficient electricity generation sources are available and deployed in advance of the surge of potential demand from electric vehicles.

The biggest challenge with electric vehicles has been the battery that stores the energy needed to drive the vehicle, with challenges of cost, lifetime, and lifecycle emissions. There has been significant research to improve these variables and it is anticipated that if adequate public policy is implemented, costs may become competitive within four to seven years

The State will aggressively seek funding sources at the State and federal level and legislation to promote and develop the following projects (this list should not be considered exclusive):

- Plug-in and vehicle to grid requirements in zoning for parking lots for stores, offices, hotels/motels, schools, and government buildings
- Seek funding to enable low and moderate income drivers to buy electric vehicles, which are currently expensive to purchase
- Work with MEA and the Comptroller's Office to create tax incentives for purchasers of electric vehicles
- Requirements for photo-voltaic cells in parking lots as a power source for electric vehicles and plug-in hybrid electric vehicles.
- Require reserved parking at State agency and State university parking lots for electric vehicles and plug-in hybrid electric vehicles.

- Promote reserved parking at local and federal government and business facilities for electric vehicles and plug-in hybrid electric vehicles.
- Push for increased funding for electric vehicles and plug-in hybrid electric vehicles and vehicle to grid enhancement projects in Maryland through MEA or the U.S. Department of Energy grants
- Work with the University of Maryland to develop a vehicle to grid pilot program

E.3: Low Emitting Vehicle Initiatives

Lead Agency: MDOT

Program Description

Initiatives to encourage use of low emitting vehicles are part of efforts by the State to help reduce air emissions, including GHGs, by providing lower emitting alternatives to internal combustion engine vehicles. Along with encouraging the use of low emitting vehicles, such as hybrids, programs such as car-sharing can help to reduce the number of personal cars by allowing rentals at locations like commuter rail stations so that people can travel by transit and then extend their trips by car for errands or recreation. The following are a variety of initiatives to encourage electric vehicle usage.

Howard Transit Para-transit Fleet Replacement Vehicles

This is a Baltimore Regional Transit Board Congestion Mitigation and Air Quality Subcommittee recommendation for FY11 funding for incremental cost to replace diesel vehicles with 4 hybrid electric sedans and 1 hybrid bus.

Clean and Efficient Strategies

Through both the use of State and federal funds, MEA has worked with several local governments to introduce new technologies designed to reduce GHG emissions of their in-use fleet as follows:

- Baltimore City - retrofit 108 trash haulers, 23 dump trucks and 49 fire-trucks with diesel oxidation catalysts and closed crankcase ventilation filtration systems; these systems also help reduce particulate matter emissions from both the exhaust systems and from the engine.
- Johns Hopkins University - retrofit its fleet of 10 diesel vehicles with diesel oxidation catalysts and closed crankcase ventilation filtration systems
- Howard County - retrofit 25 of their transit buses with diesel oxidation catalysts, closed crankcase ventilation filtration systems, and International Clean diesel kits. This project will reduce both particulate matter and nitrogen dioxide emissions.
- Anne Arundel County Public Schools - retrofit its fleet of fifty-one diesel-powered school buses with diesel oxidation catalysts and closed crankcase ventilation filtration systems.

MEA is in the process of retrofitting ten fire trucks for the City of Annapolis. These vehicles will be retrofitted with diesel oxidation catalysts and closed crankcase ventilation filtration systems.

Estimated GHG Emission Reductions in 2020

In order to account for similarities across programs, all emission benefits and costs associated with this program has been aggregated under E.2: Transportation Technologies.

Implementation

Projects that contribute to a change in VMT growth and/or improve system efficiency are a subset of the State's complete Consolidated Transportation Program. Current Consolidated Transportation Program projects applicable to transportation technology initiatives include Maryland Transit Administration diesel-hybrid electric bus purchases.

The following strategies were identified for further analysis and possible implementation under this program area:

- *Incentives for Low-GHG Vehicles* – Provide incentives to increase purchases of fuel-efficient or low-GHG vehicles / fleets.
- *Technology Advances for Non-highway Vehicles* – Encourage or incentivize retrofits and/or replacement of old, diesel-powered non-highway engines, such as switchyard locomotives, with new hybrid locomotives.
- *Incentives for Low-Carbon Fuels and Infrastructure* – Incentivize the demand for clean low-carbon fuels and the development of infrastructure to provide for increased availability/accessibility of alternative fuels and plug-in locations for electric vehicles (note: this strategy also applies to Transportation-11: Electric Vehicle Initiatives).

Maryland will continue to analyze many different strategies to promote lower emitting vehicles and seek funding sources at the State and federal level and to purchase low emitting buses and vehicles. Several of the examples listed below would also require legislation to implement. This list should not be considered exclusive:

- Incentivize hybrid vehicle use through tax discounts, dedicated lanes, and reserved parking spaces
- Support Expansion of hybrid vehicle and electric vehicle use in State, federal, and local government fleets
- Promote use of clean vehicles in business and rental car fleets
- Expansion of the Coordinated Highways Action Response Team program in Maryland
- Transit information system upgrades
- Traffic signal priority systems
- Increase smart park technology
- Enhance driver information technology
- Encourage retrofits and repowering of on and off road vehicles including addition of "add-on" emission control strategy.

Public Transportation

F.1: Public Transportation Initiatives

Lead Agency: MDOT

Program Description

For several decades, VMT has been rising faster than the population has been increasing in Maryland and nationwide. Land use development over the past 40 to 50 years has put more people beyond the reach of easy access to transit facilities. The initiative to enhance public transit is part of MDOT's efforts to help make transit more viable for more people thereby reducing mobile emissions, including GHGs.

This program identifies strategies regarding land use planning and policy, pricing disincentives to auto use, and bike and pedestrian access improvements which aim to reduce GHG emissions produced by public transportation services by encouraging the use of public transportation. As such, this program directly supports another State program, specifically Transportation-6: Double Transit Ridership. The following are current and potential measures to encourage transit use in Maryland.

Charm City Circulator and Hampden Neighborhood Shuttle

Three downtown routes, 7 days a week service, free, uses hybrid buses, air quality benefit calculations from this service started in 2009.

The Transit Vehicle Purchases Project will add hybrid-electric buses to the Charm City Circulator and extend service to Fort McHenry National Monument and Historic Shrine.

Locally Operated Transit Systems

The Maryland Transit Administration provides funding to local jurisdictions and rural area transit systems around the State.

Smart Card Implementation

The Maryland Transit Administration is implementing Smart Card Technology and fare collection equipment for the Baltimore Metro. Smart card will allow for quicker and seamless travel between different transit systems. Passengers will be able to pay for travel throughout the State with the swipe of a card, making transit travel more convenient.

Transit Oriented Development

Transit Oriented Development is an important tool to help leverage future growth, public investments, and achieve Smart Growth and sustainable communities. Maryland has great transit oriented development potential, with more than 75 existing rail, light rail, and subway stations, and dozens more proposed in the next 20 years. People living within a half mile of a transit station drive 47 percent less than those living elsewhere and are up to five times more likely to use transit.

Legislation signed by Governor O'Malley in 2008 facilitates the development of transit oriented development in Maryland by authorizing MDOT to use its resources to support "designated" projects. Designated projects are those that are good models of transit oriented development, have strong local support, represent a good return on public investment, demonstrate strong partnerships, and can succeed with a reasonable amount of State assistance but not without State support.

Due to limited State and local resources, not all transit oriented development projects that represent good sustainable development can be "designated" under this program. Instead, projects are prioritized that meet the criteria above and cannot succeed without public sector support. Designated projects could benefit from several potential tools, depending on the needs of the particular project at the particular stage of development. Among the benefits are prioritization for transportation funds and resources, financing assistance, tax credits, prioritization for the location of State offices and support from the State Highway Administration on access needs. As of June 2010, Maryland has designated 14 projects for priority State support.

Transit oriented development is consistent with Governor O'Malley's Smart, Green and Growing initiative that brings together State agencies, local governments, businesses and citizens to: create more livable communities, improve transportation options, reduce the State's carbon footprint, support resource based industry, invest in green technologies, preserve valuable resource lands, and restore the health of the Chesapeake Bay.

Maryland Commuter Tax Credit

As of January 2000, a tax credit has been in effect Statewide that allows employers to claim a 50 percent State tax credit for providing transit benefits to an employee of up to $52.50 per month, which an employer may provide to an employee without tax consequences under the Federal tax law. The State tax credit has been more attractive to employers as a benefit to offer employees than the Federal law, which is a direct tax credit as opposed to an allowable business expense. This Maryland law encourages increased transit use by low and moderate-income employees. Under provisions of both the 1999 and 2000 Maryland laws, private non-profit organizations may also participate in the program.

Employers claim tax credits for providing transit passes and vouchers, guaranteed ride home, and parking cash-out programs. Similar to the federal benefits, the Maryland Commuter Tax Benefit program does not provide financial assistance to carpoolers. Information is available online and employers are able to register to participate in the program over the internet.

Guaranteed Ride Home

Metropolitan Washington Council of Governments Commuter Connections operates a Guaranteed Ride Home program for the DC metropolitan region. The Guaranteed Ride Home program has recently been expanded to Cecil County, the Baltimore region and Southern Maryland.

College Pass
The Maryland Transit Authority manages a reduced transit pass program for Baltimore area college students.

Ride Share
The Baltimore region's original rideshare program began in 1974 as a joint effort of Baltimore City, the Regional Planning Council (now the Baltimore Metropolitan Council), and MDOT. Efforts to encourage ridesharing were expanded to cover the entire State in 1978 when the Maryland Ridesharing Office of the Maryland Transit Administration was established. Since it was formed, the Maryland Transit Administration has enhanced and expanded its activities to include both commuters and their employers. One such program provides funding support to local rideshare coordinators in order to strengthen ride matching and rideshare-support services at the jurisdictional level.

Commuter Connections- Washington DC/Baltimore Region
Commuter Connections provides complimentary information on a host of commuter programs. The Ridesharing Program facilitates persons interested in carpooling and/or vanpooling to and from work. Over 20,000 commuters rely on Commuter Connections to provide free up-to-the-minute ridesharing information at no cost. Telework, bicycling, and walking information is also available through the Commuter Connections web site. If people carpool, vanpool, use public transportation, or bicycle or walk to work two or more days a week, Commuter Connections will get them home in the event of an emergency as part of the Guaranteed Ride Home program.

Non-MDOT Initiatives Underway:

Baltimore Collegetown Network
The Baltimore Collegetown Network operates a free bus service available to students registered at Goucher, Towson, Notre Dame, Loyola, Johns Hopkins, Maryland Institute College of Art, and the University of Maryland Baltimore County. This service is paid for by those institutions.

Hunt Valley Shuttle
The Baltimore County Chamber of Commerce and the Hunt Valley Business Community are working to establish a bus shuttle between Hunt Valley and southern York County, PA, including the City of York.

Kent Street Transit Plaza
The Kent Street Transit Plaza and Pedestrian Corridor Project will expand bus ridership and safe access to the existing light rail system through design and construction of the Kent Street Plaza and Pedestrian Corridor from the Westport Light Rail Station to Annapolis Road.

University of Maryland College Park Carpool Program and Shuttle Bus Service

The University of Maryland College Park's shuttle bus operation has undertaken many steps to improve fuel efficiency and support campus sustainability efforts. The focus has been to reduce the use of diesel fuel and bus engine emissions. All buses in the fleet run on a mixture of bio diesel fuel.

The Smart Park Carpool Program is a service offered by the University of Maryland's Department of Transportation Services to connect commuter students who have similar commuting schedules. Not only do participants in carpools reduce vehicle emissions, but they also save money by benefiting from lower parking permit fees.

The University of Maryland's carpool program includes an internet-based tool that makes it easier for individuals to find others interested in carpooling.

PlanMaryland

PlanMaryland, the State's first comprehensive plan for sustainable growth and development, presents an opportunity to address climate change mitigation and adaptation issues in Maryland, in the context of many related quality-of-life, economic, social and environmental goals. The strategies identified for land use and location efficiency, in the 2008 Climate Action Plan, are directly tied to the objectives of PlanMaryland and are overall consistent with Maryland's Smart, Green and Growing policies. MDP is working with MDOT and MDE with a focus on policies and programs implemented by 2020 to reduce dependence on motor vehicle travel (especially single-occupant vehicles). These policies and programs may include incentives and requirements for projects and regional land use patterns that shorten trip length and greatly facilitate the use of alternative transportation mode choices to reach employment, shopping, recreation, education, religious and other destinations. The benefits of PlanMaryland are documented separately from this document through MDP's role. There are VMT related benefits associated with PlanMaryland that will accrue to the transportation sector.

Estimated GHG Emission Reductions in 2020

Figure C-29. Low and High GHG Benefits for Transportation-5

Initial Reductions	2.00 $MMtCO_2e$	MDOT Quantification Appendix D
High Estimate	2.89 $MMtCO_2e$	MDOT Quantification Appendix D

Implementation

The State has identified additional strategies to address the expected gap in meeting the transit ridership goal defined in the 2008 Climate Action Plan (e.g. a doubling of 2000 transit ridership by 2020). The intent is for these strategies to complement and support funded the Maryland Transit Administration's and the Washington Metropolitan Area Transit Authority plans and programs identified for implementation by 2020 in the 2011-2016 Consolidated Transportation Program and metropolitan planning organization's transportation implementation plans and long-range plans.

- Implement Bicycle and Pedestrian Improvements to Support Transit
- Reduce GHG Emissions from Transit Vehicles
- Bus Priority Improvements
- Plan Transit in Conjunction with Land Use

This initiative is included and funded through the current Maryland Consolidated Transportation Program, metropolitan planning organization's transportation implementation plans and land restoration programs. MDOT is the lead implementing agency. Progress is discussed at metropolitan planning organization meetings and conformity is discussed at interagency consultation groups. MDOT will seek funding sources at the State and federal level and legislation to promote and develop the following projects (this list should not be considered exclusive):

- Expand transit oriented development
- Expanded Transportation Management Associations
- Promote Live Near Your Work
- Increased security at park and ride lots and on transit vehicles
- High Efficiency / Low Rolling Resistance Tires: Evaluate further the use and efficiency of low rolling resistance tires for heavy duty diesel vehicles (includes transit vehicles) where appropriate
- Improved transit access to large and critical employers including hospitals, colleges and universities
- Other entities will look at:
    - Expanding Zipcar service to Baltimore (MARC, AMTRAK, Light Rail), BWI Airport, and Frederick (MARC)
    - Increasing public/private commuter shuttles to transit stops

F.2: Intercity Transportation Initiatives

Lead Agency: MDOT

Program Description

Traffic congestion along the Interstate 95 corridor has been steadily increasing over the past decades. The State is implementing strategies to help reduce mobile emissions, including GHGs, by providing viable alternatives to single occupant vehicle use as well as improvements to the transportation system. These strategies enhance connectivity and reliability of non-automobile intercity passenger modes through infrastructure and technology investments, such as expansion of intercity passenger rail and bus services as well as improved connections between air, rail, intercity bus and regional or local transit systems. The following are some examples of ongoing programs designed to enhance Maryland's commuter and intercity rail systems to give travelers viable alternatives to driving their personal vehicles to work, pleasure or errands.

MARC Station Parking Enhancements

Maryland Area Regional Commuter (MARC) rail services have been enhanced through construction of additional parking at stations throughout the Baltimore region.

A feasibility study is underway for structured parking (garage or parking deck) at the Odenton Station for 2,500 spaces on State-owned property.

Phase I of the Halethorpe MARC Station park-and-ride lot expansion is complete, providing 428 additional parking spaces. The scope of the work included high level platforms, new shelters, and improved accessibility for persons with disabilities, lighting and streetscaping. Phase II, which includes a pedestrian bridge and high level platforms, is in the project initiation stage.

National Gateway
The National Gateway Project is a package of rail infrastructure and intermodal terminal projects that will enhance transportation service options along three major freight rail corridors owned and operated by CSX through the Midwest and along the Atlantic coast. The improvements will allow trains to carry double-stacked containers, increase freight capacity and make the corridor more marketable to major East coast ports and shippers.

Refurbishing MARC and other rail vehicles
In order to insure the reliability, safety and comfort of MARC equipment the rolling stock is periodically overhauled. Twenty-six MARC cars were refurbished between FY05 and FY08.

Between FY05 and FY12, twenty-three locomotives are scheduled to be overhauled and retrofitted to cleaner federally required standards in force at the time of the improvement.

Update on Maryland High Speed Rail
In September 2010, MDOT signed an agreement with the Federal Railroad Administration that obligated $9.4 million in high-speed stimulus funds to complete environmental and engineering work to replace the BWI Station, which serves Baltimore/Washington International Airport. As of March 2011, MDOT is advancing preliminary work on BWI station improvements.

MDOT is also awaiting a grant agreement with the Federal Railroad Administration to complete engineering and environmental studies for a Baltimore and Potomac tunnel replacement in Baltimore.

Estimated GHG Emission Reductions in 2020
In order to account for similarities across programs, all emission benefits and costs associated with this program has been aggregated under F: Public Transportation.

Implementation
Improving passenger convenience for intermodal connections at airports, rail stations, and major bus terminals have been identified as the primary pre-2020 unfunded intercity

transportation strategies. Primary strategies for intercity passenger transportation in Maryland by 2020 include improving:

- Passenger access, convenience, and information across all modes at BWI Airport
- Travel time, reliability and overall level of service improvements on the MARC Penn Line and Amtrak NorthEast Corridor (consistent with the MARC Growth and Investment Plan and Northeast Corridor Infrastructure Master Plan)

Projects that contribute to a change in VMT growth and/or improve system efficiency are a subset of the State's complete Consolidated Transportation Program. Currently funded and planned transportation system investments 2006 - 2020, which are defined in the Maryland 2009 - 2014 Consolidated Transportation Program and in the metropolitan planning organizations transportation improvement programs, and Long-Range Plans through 2020 include:

- Long range projects associated with the MARC Growth and Investment Plan, such as:
    - Baltimore intercity bus terminal
    - MARC infrastructure and operations improvements
    - Planning and engineering for BWI MARC/Amtrak Station improvements and the Baltimore and Potomac tunnel

The GHG reduction benefit from full implementation of the National Gateway and Northeast Corridor Infrastructure Master Plan are included in the unfunded GHG reduction program assessment.

G: Pricing Initiatives

Lead Agency: MDOT

Program Description

This program addresses transportation pricing and travel demand management incentive programs. It also tests the associated potential GHG emission reduction benefits of alternate funding sources for GHG beneficial programs. Projects are tied to commute alternative and incentive programs including specific projects such as ridesharing (Commuter Connections), guaranteed ride home, transportation demand program management and marketing, outreach and education programs (Clean Air Partners), parking cash-out subsidies, transportation information kiosks, local car-sharing programs, telework partnerships, parking impact fees, and vanpool programs.

The following are a variety of pricing initiatives to reduce GHGs.

Electronic Toll Collection

The Maryland Transportation Authority commenced operation of its electronic toll collection system, MTAG, at the authority's three harbor crossing facilities in 1999. By fall 2001, all toll facilities in the region were equipped with electronic toll collection equipment. As of January 2004, 45 percent of vehicles using the Maryland Transportation Authority facilities used electronic toll tags. The Maryland Transportation Authority is a member of the E-Z Pass Inter-Agency Group, a coalition of Northeast Toll Authorities. Reciprocity with the E-Z Pass system in was established in 2001, enabling travelers in Maryland, as well as at most toll facilities in New York, New Jersey, Delaware, Pennsylvania, Massachusetts, Virginia, and West Virginia, to pay tolls using one electronic device.

At present high speed toll lanes, such as Fort McHenry Tunnel, are under study.

Programs Under Consideration

The State continues to work with metropolitan planning organizations, the Maryland General Assembly, and stakeholders to identify additional pricing initiatives to consider. Several of these efforts are described below.

High Occupancy Toll Lanes

High occupancy toll lanes continue to be evaluated in Maryland for reducing peak hour congestion, but they have to be coupled with strategies that reduce their potential negative impacts. Care must be taken to ensure that these lanes do not adversely affect drivers with no transit options, extreme commutes, lower incomes, and jobs with inflexible hours.

VMT Fees

Maryland is working with the I-95 corridor coalition to evaluate efforts in other areas to establish GHG emission-based road user fees Statewide to complement or replace motor fuel taxes.

Congestion Pricing and Managed Lanes

Maryland continues to work with the metropolitan planning organizations to evaluate local pricing options in urban areas, charges to local motorists to use a roadway, bridge, or tunnel during peak periods, with revenues used to fund transportation improvements and systems operations meeting State goals.

Parking Impact Fees

Maryland continues to analyze parking pricing policies that ensure effective use of urban street space. Provision of off-street parking should be regulated and managed with appropriate impact fees, taxes, incentives, and regulations.

Employer Commute Incentives

Maryland continues to look for opportunities to strengthen employer commute incentive programs by increasing marketing and financial and/or tax based incentives for employers, schools, and universities to encourage walking, biking, public transportation usage, carpooling, and teleworking.

Estimated GHG Emission Reductions in 2020

Figure C-30. Low and High GHG Benefits for Transportation-9

Initial Reductions	0.41 $MMtCO_2e$	MDOT Quantification

		Appendix D
Enhanced Reductions	2.30 $MMtCO_2e$	MDOT Quantification Appendix D

Implementation

Projects that contribute to a change in VMT growth and/or improve system efficiency are a subset of the State's complete Consolidated Transportation Program. Currently funded and planned transportation system investments 2006 - 2020, which are defined in the Maryland 2009 - 2014 Consolidated Transportation Program and in the metropolitan planning organizations, transportation improvement programs, and long-range plans through 2020 include implementation of Baltimore regional ride share and guaranteed ride home programs and Metropolitan Washington Council of Government's Commuter Connections program. Additional Consolidated Transportation Program projects related to pricing incentives include Maryland Transportation Authority projects, primarily the Inter-county Connector and I-95 Express Toll Lanes. Also included are State funded commute alternative incentive programs in the Baltimore and Washington regions.

Strategies that amplify GHG emission reductions from other strategies by supporting Smart Growth, transit, and bike and pedestrian investments have also been considered. Detailed definitions of these strategies, outlined in four strategy areas, are as follows:

- *Maryland Motor Fuel Taxes or VMT Fees* – There are two primary options for consideration, both of which would create additional revenue that could be used to fund transportation improvements and systems operations to help meet Maryland GHG reduction goals; they are:
  (1) Increase the per gallon motor fuel tax consistent with alternatives under consideration by the Blue Ribbon Commission on Maryland Transportation Funding, and
  (2) Establish a GHG emission-based road user fee (or VMT fee) Statewide by 2020 in to replace or in addition to existing motor fuel taxes.
- *Congestion Pricing and Managed Lanes* – Establish as a local pricing option in urban areas that will charge motorists more to use a roadway, bridge or tunnel during peak periods, with revenues used to fund transportation improvements and systems operations to help meet Maryland GHG reduction goals.
- *Parking Impact Fees and Parking Management* – Establish parking pricing policies that ensure effective use of urban street space. Provision of off-street parking should be regulated and managed with appropriate impact fees, taxes, incentives, and regulations.
- *Employer Commute Incentives* – Strengthen employer commute incentive programs by increasing marketing and financial and/or tax based incentives for employers, schools, and universities to encourage walking, biking, public transportation usage, carpooling, and teleworking.

Other Innovative Transportation Strategies & Programs

H.1: Evaluate the GHG Emissions Impacts from Major New Projects and Plans

Lead Agency: MDOT

Program Description

This proposal focuses on the process of evaluating GHG emissions of all State and local major projects. The goals of this program are to understand the impacts of new, major projects on the Governor's GHG reduction commitment; and to develop guidance for the State and other major project sponsors to use. MDOT identified three potential strategies under this program:

- Actively Participate in Framing National GHG Emissions Evaluation Policy;
- Evaluation of GHG Emissions through the National Environmental Policy Act Process; and
- Evaluation of GHG Emissions of selected projects through Statewide/regional planning at the discretion of the metropolitan planning organization.

A process for addressing GHGs is currently being considered along with other options on a national level. MDOT is of the position that before the State establishes a formal evaluation process for transportation GHGs, Maryland should wait and see what is proposed on a national level.

Estimated GHG Emission Reductions in 2020

The implementation strategies under this program are assumed to contribute to the overall goal of reducing GHG emissions from the transportation sector; however, the GHG emissions impact of implementing this program was not quantified.

Implementation

MDOT will continue to analyze and develop implementation strategies to evaluate the GHG emission impacts of major projects and plans. MDOT is currently working with the American Association of State Highway and Transportation Officials and the Northeast Association of State Transportation Officials on a national level to develop a unified procedure for measuring and determining the effects of projects on GHG emissions. Potential implementation strategies for this program have been identified as follows:

Actively Participate in Framing National GHG Emissions Evaluation Policy – Given the recent EPA proposed ruling that carbon emissions endanger Americans' health and well-being, Maryland should actively participate in framing national policy rather than implementing specific, state guidance requiring GHG emissions evaluation of all major projects on both the National Environmental Policy Act and statewide/regional planning level.

Evaluation of GHG Emissions through the National Environmental Policy Act Process – The impact of GHGs on major capital projects through the current National Environmental Policy Act decision-making process should be encouraged. GHGs should be considered during the impact assessment phase when conducting alternatives analyses for all major capital projects. Where appropriate, the alternatives analysis should be accompanied by analysis of potential alternatives, such as transit-oriented land use and investment; adding toll lanes and express bus; express toll lanes; a hybrid transit-oriented express toll lane; or a rail and express bus scenario. Where the proposed projects may lead to increased GHG emissions, mitigation measures should be considered. The GHG analysis should be included as part of the Air Quality Technical Report and should allow for the demonstration of GHG benefits as well as impacts through both quantitative and qualitative components with the understanding that appropriate and/or approved emissions models and methodologies may not be available. The GHG analysis would be required:

- If there is an Environmental Impact Statement, Categorical Exclusions will be screened out.
- For any roadway capacity enhancement project which is identified for analysis through interagency consultation.
- For active projects that have yet to receive federal sign-off on draft National Environmental Policy Act documents. It is recommended that any project with approved draft documents would be "grandfathered" through the process.

Evaluation of GHG Emissions through Statewide/Regional Planning – The impact of GHGs should be addressed in the Statewide and/or regional planning processes. The process would be similar to the current conformity process for ozone and particulate matter; however, instead of setting a budget, a mechanism for tracking GHG emissions reductions would be established. Regional level analyses (determining the GHG impacts on a larger scale than just the project level) account for control strategies that are in place such as fleet make up, analysis years, VMT increases, etc.

H.2: Bike and Pedestrian Initiatives

Lead Agency: MDOT

Program Description

This initiative is part of the State's efforts to help reduce mobile emissions, including GHGs, by providing viable alternatives to single occupant vehicle use. Building appropriate infrastructure for additional bicycle and pedestrian travel in urban areas provides viable alternatives to traveling by car. Increased use of bicycles and sidewalks can help reduce the number of short trips currently taken in motor vehicles, thereby reducing mobile emissions of air pollution and GHGs. The following are some current and potential measures to help Maryland's bicyclists and pedestrians to travel efficiently and safely to their destinations.

Bicycle/Pedestrian Enhancements

Through MDOT, the Maryland State Highway Administration has worked to engineer, implement, and promote new and improved bicycle and pedestrian facilities. They have also developed the *Maryland State Highway Administration Bicycle and Pedestrian Guidelines* to provide general guidance on design. The State has a policy of considering sidewalks to reinforce pedestrian safety and promote pedestrian access adjacent to roadway projects being constructed or reconstructed. Special efforts are made to facilitate pedestrian travel near schools.

In addition, bicycle safety and travel are being accommodated by construction of wider shoulders and curb lanes to separate motor vehicles from cyclists. In regard to bicycle or pedestrian travel in controlled access roadway corridors, there is almost always a separation between these modes and motor vehicles. Only along roadways where speeds or mix of the travel modes could result in serious accidents are sidewalks and bicycle travel not promoted.

Improvements to existing sidewalks or new sidewalk construction have taken place along many roadways in the Baltimore region. These roads include MD 2, MD 435, MD 26, MD 134, MD 140, MD 7, MD 150, MD 542 and MD 648. Cyclist and pedestrian multi-use travel routes in the Baltimore region include: the Maryland and Pennsylvania Heritage trail extension, Broken Land Parkway Pathway, Centennial Access Trail, Wakefield Community Trail, Broad neck Peninsula Trail, and the South Shore Trail.

Maryland Trails Plan

Maryland Trails: A Greener Way to Go is Maryland's coordinated approach to developing a comprehensive and connected statewide, shared-use trail network. This plan focuses on creating a state-wide transportation trails network. The Maryland Trails plan identifies approximately 820 miles of existing transportation trails and 770 miles of priority missing links (160 trail segments) that, when completed will result in a statewide trails network providing travelers a non-motorized option for making trips to and from work, transit, shopping, schools and other destinations.

Bike Racks on Buses, MARC, Subway, Light Rail

In Maryland, public transportation accommodates bicycles to facilitate longer trips. The Maryland Transit Administration allows bicycles to be attached to the front of commuter buses so that cyclists can add to their trip range. Public transportation and bicycles provide more mobility options to everyone, helps improve air quality, and reduces traffic congestion.

In addition, the Maryland Transit Administration allows riders to bring bicycles onto Light Rail, Metro Subway, and, in some cases, MARC trains.

Construction of Bike Lanes and Bike Paths

Additional bicycle paths being considered include, but are not limited to, the Capital Crescent Trail, Patuxent Branch, Rock Creek, B & A, BWI, North Central Rail, and Fair Hill Trails. The State and regional goal is to have many of these trails link to form a bicycling network connecting the metro areas and beyond and the East Coast Greenway.

East Coast Greenway

The East Coast Greenway is the planned backbone of an emerging network of trails along the eastern seaboard from Maine to Florida that could contribute, both actually and symbolically, to priorities such as:

- Increasing transportation options
- Reducing roadway congestion
- Enhancing local economic development
- Connecting people and communities
- Helping to create new and inviting public spaces
- Improving community walking and cycling environments, vital for smart growth initiatives
- Mitigating climate change through zero GHG emission travel

Bike Stations

Bike stations are currently located at major transit modal connector stations such as Camden Yards, Hunt Valley, Shady Grove METRO, and Glen Burnie.

Bike Rentals

Many jurisdictions are promoting bike rentals. The City of Annapolis has a system in place for bike rentals and a promotional website. This encourages locals and tourists to travel around downtown by bike. Bike rentals could be expanded to other areas in Maryland.

Bike Racks

There has been a big push to expand provision of bike racks at transit stations and elsewhere, such as downtown areas. Accordingly, the City of Annapolis is installing bicycle racks outside of downtown businesses.

Estimated GHG Emission Reductions in 2020

In order to account for similarities across programs, all emission benefits and costs associated with this program has been aggregated under F: Public Transportation

Implementation

Bike and pedestrian initiatives include infrastructure design and construction policies; funding, regulatory, and land use strategies; and education and marketing measures. These strategies result in improved bike and pedestrian amenities, resulting in an increase in the number of trips made on foot or bicycle, particularly in urban areas and adjacent to Maryland's trail networks. These initiatives recognize that local governments are responsible for the design and maintenance of approximately 80 percent of roads in Maryland. Land use and location efficiency strategies addressing density, mix of uses, and urban design represents a very strong predictor of bike and pedestrian travel.

Potential implementation strategies are as follows:

- Promote use and regular review/updates to existing manuals and design standards;

- Improve bike/pedestrian access through corridor retrofits and new roadway construction projects (e.g. Complete Streets);
- Update existing land use policy guidance and zoning/development standards to include provisions for bike and pedestrian supportive infrastructure;
- Place bike facilities and supportive infrastructure at strategic locations, including transit stations and government facilities;
- Provide funds for low-cost safety solutions;
- Encourage bicycle travel through education, safety, and marketing programs

Projects that contribute to a change in VMT growth and/or improve system efficiency are a subset of the State's complete Consolidated Transportation Program. Currently funded and planned transportation system investments 2006 - 2020, which are defined in the Maryland 2009 - 2014 Consolidated Transportation Program and in the metropolitan planning organizations transportation improvement programs, and long-range plans through 2020 include:

- Complete Streets implementation
- Projects supporting completion of the Statewide transportation trails network
- Improved bicycle and pedestrian access to transit facilities
- Implementation of a number of local and regional sidewalk, trail, recreation and enhancement programs.
- Maryland State Highway Administration's Sidewalk Program and Community Safety and Enhancement Program

Metropolitan planning organizations and state departments of transportation are required by the Clean Air Act Amendments of 1990 and the Safe, Accountable, Efficient, Flexible, Transportation Efficiency Act to identify Transportation Emissions Reduction Measures that provide criteria pollutant emission-reduction benefits. Applicable measures in this implementation plan include: sidewalk and street rehabilitation, bicycle and pedestrian facilities improvements, acquisition of scenic easements, streetscapes, and functional/safety improvements.

The State will continue to implement and look for areas to expand this ongoing effort. Examples of additional initiatives that may be added or enhanced by others include (this list should not be considered exclusive):

- Advance timetable for multi-use trails from 2020/30 to 2015 for trails such as:
  - Cromwell Valley, Red Line Trail and Southwest Area Park Trail in Baltimore County
  - Little Pipe Creek and Westminster Community Trail in Carroll County
- Expand local bicycle enhancement policies such as:
  - Separate cycling facilities along heavily traveled roads and at intersections
  - Provide extensive bike parking, integration with transit, training and promotional events
  - Use land use policies to foster compact, mixed use developments that generate shorter trips
  - Coordinate implementation of this multi-faceted, self-reinforcing set of policies

- o Expand bike share systems

Sub-Appendix C-3: Agriculture and Forestry

I: Forestry and Sequestration

I.1: Managing Forests to Capture Carbon

Lead Agency: DNR

Program Description

Healthy and vigorous forests provide both direct benefits to GHG reductions and also serve as the preferred land-use strategy for avoiding emissions and capturing airborne GHGs. The State will promote sustainable forestry management practices in existing Maryland forests on public and private lands to capture carbon. The enhanced productivity resulting from enrolling unmanaged forests into management regimes will yield increased rates of carbon dioxide sequestration in forest biomass, increased amounts of carbon stored in harvested, durable wood products which will result in economic benefits, and increased availability of renewable biomass for energy production.

DNR will work with the General Assembly and various State agencies (MDE, MDA, and the Maryland State Highway Administration), as well as local and county governments, conservation organizations, private landowners, sawmills, arboreal industries and others to implement this program. By 2020, the implementation goal is to improve sustainable forest management on 30,000 acres of private land annually; improve sustainable forest management on 100 percent of State-owned resource lands. Additionally, 50 percent of State-owned forest lands will be third-party certified as sustainably managed. DNR will continue to support the Forestry for the Bay program, which reaches forest owners with management messages and will partner with the Pinchot Institute with support from Center for AgroEcology to develop best management protocols for forest harvests associated with expected biomass markets.[59]

Cooperation between State agencies and landowners is essential in forest management and carbon sequestration. DNR and MDA will work together on controlling invasive, destructive insects and diseases that threaten the health and vigor of forests, and DNR will work with the National Resource Conservation Service State Technical Committee, Forestry Sub-committee to increase landowner assistance for forest improvements. DNR will also continue to explore potential of establishing a carbon credit market aggregation

[59] See existing biomass guidelines established for North East U.S. http://www.forestguild.org/publications/research/2010/FG_Biomass_Guidelines_NE.pdf

service with private entities as well as draft legislation to amend the Woodland Incentive Program to allow use with federal cost-share programs. This will be accomplished through the development and adoption of the Statewide Forest Assessment and Response plan, which is a 5-year strategic planning document enabling access to federal funds, as mandated by the 2008 Farm Bill.

Estimated GHG Emission Reductions

Figure C-31. Low and High GHG Benefits for Ag and Forestry-1

Initial Reductions	1.80 $MMtCO_2e$	MDE Quantification Below
Enhanced Reductions	1.80 $MMtCO_2e$	MDE Quantification Below

Estimate – MDE Quantification
Forest management practices can provide carbon sequestration in the State. The enhanced productivity resulting from enrolling unmanaged forests into management regimes will yield increased rates of carbon sequestration in forest biomass; increased amounts of carbon stored in harvested, durable wood products; and, increased availability of renewable biomass for energy production. Maryland will promote sustainable forest management practices in existing Maryland forests on public and private lands. By 2020, the implementation goal is to improve sustainable forest management on 30,000 acres of private land annually; improve sustainable forest management on 100 percent of State-owned resource lands; and third-party certify 50 percent of State-owned forest lands as sustainably managed. Using the assumptions above, the total managed forest area is multiplied by an applicable sequestration rate to obtain the yearly CO_2-equivalent for the practices. The result is 2.70 $MMtCO_2e$ estimated to be sequestered in 2020. This result is adjusted for overlap resulting in 1.80 MMtCO2e.

B. Detailed Explanation of Methodology

To obtain a 2020 carbon sequestration amount for the forest management of private land and State owned land, a data table was created to calculate the acres of managed forest land times the applicable rate of carbon sequestration per acre.

Carbon is sequestered, or captured out of the air by living plants and trees. By employing forest management practices a forest can actively capture carbon at a higher rate than if a forest was left alone and dead trees and overgrowth can choke out the living trees. The goal is to improve sustainable forest management on 30,000 acres of private land annually; improve sustainable forest management on 100 percent of State-owned resource lands; and third-party certify 50 percent of State-owned forest lands as sustainably managed to capture the most carbon.

The total 2020 year carbon sequestration or credit is 2.70 $MMtCO_2e$; this is calculated by adding the Private Forest Stewardship Impact 2.15 $MMtCO_2e$ to the State Forest 0.55 $MMtCO_2e$. For data and assumptions see the figure below.

Calculations for 2020 involve, the private lands of 30,000 acres multiplied times the carbon rate of 4.43 tonnes CO_2-equivalent per acre and divided 1,000,000 conversion factor to get 0.13 annual $MMtCO_2e$, then added to the previous 20 years of private land improvements sequestration to get 2.15 $MMtCO_2e$ sequestration credit plus adding the State lands of 62,500 acres multiplied times the carbon rate of 0.98 tonnes CO_2-equivalent per acre and divided 1,000,000 conversion factor to get 0.06 annual $MMtCO_2e$, then added to the previous 20 years of State land improvements sequestration to get 0.55 $MMtCO_2e$ sequestration credit, for a total of 2.70 $MMtCO_2e$ sequestration credit.

C. Calculations

Total $MMtCO_2e$ = Private + State

The Yearly Private FS Impact $MMtCO_2e$ = (FS acres * 4.43 tonnes CO_2-equivalent per acre / 1,000,000) + previous years credit (up to 20 years prior)

The Yearly State Forest $MMTCO_2e$ = (State acres * 0.98 tonnes CO_2-equivalent per acre per 1,000,000) + previous years credit (up to 20 years prior)

Also, see data figure below.

D. Data and Data Sources

Explanation of Figure Columns

[1] Private Forest Service Impact – Private lands data from 2006-2010 is actual acres recorded by DNR, and then assume average of 30,000 acres from 2011 – 2020. Forest Service Impacts include forest management planning, timber stand improvements, habitat work, and area of timber harvest planning.

[2] Carbon Rate Source = 6.9 tonnes CO_2-equivalent per acre from – 1.5 tonnes CO_2-equivalent per acre for unmanaged forest vs. 8.4 tonnes CO_2-equivalent per acre for managed forest, therefore a total of 6.9 tonnes CO_2-equivalent per acre sequestration rate for forest management. (R. Birdsey, USFS-NRS, March 11, 2011). Predictions for carbon response rate to forest management were based on the Carbon On-Line Estimator model developed jointly by National Council for Air and Stream Improvement, Inc. and the USFS http://www.ncasi2.org/ . Rate used was 4.43 tonnes CO_2-equivalent per acre for each acre improved in a year. This is the average between DNR 6.9 tonnes CO_2-equivalent per acre and 1.96 tonnes CO_2-equivalent per acre from the Maryland D-GORCAM model report for public forest improvements.

[3] Annual $MMtCO_2e$ = Private Forest Service Impact acres times carbon rate

[4] Yearly $MMtCO_2e$ = Annual sequestration plus all annual sequestration from previous 20 years. Assume after 20 years sequestration acres drop out of credit as land management activities rotate and age of trees are less active.

[5] State management and third party certification, assume 62,500 acres per year.

[6] Carbon Rate Source = From the Maryland-GORCAM report, Valuing Timber and Carbon Sequestration in Maryland, April 24, 2007: Page 14 – Expected pounds of carbon sequestration for four forest management scenarios.

Using scenario # 4, un-managed and comparing to scenario #1, most management actions; calculated as follows:

- For Loblolly Pine 2.47 tonnes CO_2-equivalent per acre vs. 4.46 tonnes CO_2-equivalent per acre = 1.99 tonnes CO_2-equivalent per acre
- For Red Maple 1.47 tonnes CO_2-equivalent per acre vs. 3.40 tonnes CO_2-equivalent per acre = 1.93 tonnes CO_2-equivalent per acre
- Average of the two tree types was assumed =1.96 tonnes CO_2-equivalent per acre

The Rate used was 0.98 tonnes CO_2-equivalent per acre for each acre improved in a year. Maryland already has an aggressive forest maintenance program so the rate used is 50 percent of the MD-GORMAC report of 1.96 tonnes CO_2-equivalent per acre.

[7] Annual $MMtCO_2e$ = State Forest acres times carbon rate

[8] Yearly $MMtCO_2e$ = Annual sequestration plus all annual sequestration from previous 20 years. Assume after 20 years sequestration acres drop out of credit as land management activities rotate and age of trees are less active.

Figure C-32. Carbon Sequestration Potential for State and Private Lands

Year	Private Forest Service Impact Acres[1]	Carbon Rate tons CO_2-equivalent per acre [2]	Annual $MMtCO_2e$ [3]	Yearly $MMtCO_2e$ (Stack credit from previous year) [4]	State Forest dual-certified 500,000 acres [5]	Carbon Rate tons CO_2-equivalent per acre [6]	Annual $MMtCO_2e$ [7]	Yearly $MMtCO_2e$ (Stack credit from previous year) [8]
2006	34,914	4.43	0.15	0.15		0.98	0.00	0.00
2007	29,407	4.43	0.13	0.28		0.98	0.00	0.00
2008	46,218	4.43	0.20	0.49		0.98	0.00	0.00
2009	40,008	4.43	0.18	0.67		0.98	0.00	0.00
2010	33,845	4.43	0.15	0.82		0.98	0.00	0.00
2011	30,000	4.43	0.13	0.95		0.98	0.00	0.00
2012	30,000	4.43	0.13	1.08	62,500	0.98	0.06	0.06
2013	30,000	4.43	0.13	1.22	62,500	0.98	0.06	0.12
2014	30,000	4.43	0.13	1.35	62,500	0.98	0.06	0.18
2015	30,000	4.43	0.13	1.48	62,500	0.98	0.06	0.25
2016	30,000	4.43	0.13	1.61	62,500	0.98	0.06	0.31

2017	30,000	4.43	0.13	1.75	62,500	0.98	0.06	0.37
2018	30,000	4.43	0.13	1.88	62,500	0.98	0.06	0.43
2019	30,000	4.43	0.13	2.01	62,500	0.98	0.06	0.49
2020	**30,000**	4.43	**0.13**	**2.15**	**62,500**	0.98	**0.06**	**0.55**
	484,392		2.15		562,500		0.55	

TOTAL 2.70 MMtCO_2e

E. Assumptions

- Baseline is existing forest unmanaged.
- Acreage of forest lost or gained is ignored.
- DNR assumption for private land improvement of 30,000 acres managed annually.
- Private land management enacted through education, incentives and public support.
- Forest Service impact rate – use the average between DNR 6.9 tonnes CO_2-equivalent per acre and 1.96 tonnes CO_2-equivalent per acre from Maryland-GORCAM report = 4.43 tonnes CO_2-equivalent per acre.
- Assume 562,500 acres of State forest management.
- Public land management ensured through policy.
- State forest rate – third party certification process, plus overall State forest maintenance, but Maryland already has an aggressive forest maintenance program so the rate used is 50 percent of the Maryland GORMAC report 1.96 tonnes CO_2-equivalent per acre.
- Forest management improvements yield a uniform and constant carbon response regardless of geographic location, type, age, pre-treatment growth rate, intensity of activity, post-treatment growth rate, soils, hydrologic regime, and absence of biotic disturbances during the management period (Note: this is not an exhaustive list of factors affecting forest carbon rates).
- Stacking credit of CO_2-equivalent sequestration from previous years for 20 years prior only.
- US Forest Service – FIDO 2.45 million acres of forest in Maryland. Approximately 26 percent State, fed or local owned = 647,170 acres. Approximately 74 percent private owned = 1,806,753 acres. Therefore, 484,392 total acres of private land is 27 percent with forest management and 562,500 acres of State land is 87 percent- with forest management and third party certified as sustainably managed.

Implementation

Since 2006, DNR has implemented 60,000 acres of forest stand improvements; prepared 125,000 acres of new private forest management plans. DNR has successfully retained third-party certification for 200,000 acres of sustainably managed publicly owned forests; over 1,300 private landowners retain 142,000 acres of forest certified by American Tree Farm System.. In 2009, DNR implemented a Carbon Sequestration Pilot project to assess forest planting and management techniques for approximately 174 acres of Maryland forests. The Woodland Incentive Program statute, Natural Resources Article §5-304, was amended in 2010 and a State-wide Forest Assessment was completed.

The impact of the Emerald Ash Borer (*Agrilus planipennis)* is not under control within Maryland forests. Gypsy moth (*Lymantria dispar*) spraying occurs annually. DNR continues to support the Forestry for the Bay program, which reaches forest owners with management messages, and will soon release the best management protocol manual for forest harvest associated with expected biomass markets. The Woodland Incentive Program statute was amended in 2010 and a Statewide Forest Assessment was completed. The potential of establishing a carbon credit aggregation service with private entities, however, continues to be explored. The current productivity of these programs cannot be attained if there is a future reduction in staff and funding.

DNR will promote sustainable forestry management practices in existing Maryland forests on public and private through a suite of efforts, policies and programs, including:

Public Lands/State Forest System:
- Dual Third Party Certification for Forest Sustainability
- Continuous Forest Inventory
- State Forest Annual Workplans

Private Lands:
- Technical Assistance
- Forest Stewardship Plan Implementation
- Financial Assistance
  - State and Federal Cost Sharing
    - Woodland Incentive Program
    - Environmental Quality Incentive Program
    - Conservation Reserve Enhancement Program

I.2: Planting Forests in Maryland

Lead Agency: DNR

Program Description

Increasing forest and tree cover provides additional benefits for mitigation of GHGs in addition to sequestration. This program promotes forest cover and associated carbon stocks by regenerating or establishing healthy, functional forests through afforestation (on lands that have not, in recent history, been forested, including agricultural lands) and reforestation (on lands with little or no present forest cover) where current beneficial practices are not displaced. Successful establishment requires commitment for as long as twenty years. Forest patches should be sufficient in size to function as a community of trees and related species.

This program also promotes the implementation of practices, such as soil preparation, erosion control, supplemental planting, to ensure optimum conditions to support forest growth. Included in this is identification of areas, including wetlands, in need of physical intervention to return forest habitats to full vigor. Additional areas of concern are linking islands of fragmented forests to restore function, recovering severely disturbed lands, and reversing the effects of continued toxicity on those disturbed lands.

DNR will work with the General Assembly and various State agencies (MDE, MDA, and the Maryland State Highway Administration), as well as local governments, conservation organizations, private landowners, sawmills, arboreal industries and others to implement this program. By 2020, the implementation goal is to achieve afforestation and/or reforestation of 43,030 acres for Years 2011-2020. Planted acreage for Years 2006 – 2010 was intentionally not included here since this planting has already been accomplished. Private landowner subscription to planting programs can be highly variable due to a myriad of factors – mostly economic – and thus the goal focuses on future efforts and to utilize prior gains as a "hedge" against potential disinterest from private landowners.

DNR will continue to support the Forestry for the Bay program, which reaches forest owners with management messages. DNR will also partner with the Pinchot Institute with support from Center for AgroEcology to develop best management protocols for forest harvests associated with anticipated biomass markets. DNR will continue participating in the development of the BayBank and Landserver programs utilizing the U.S. Forest Service grant awarded to the Pinchot Institute for Conservation, and will draft regulations pursuant to the passage of No-Net-Loss legislation and the Sustainable Forestry Act of 2009. Beginning in 2009, afforestation and buffer planting on public land accomplishments will be reported, and DNR will work with federal and State partners, local governments, and non-profits to create, restore, and enhance forests.

Estimated GHG Emission Reductions in 2020

Figure C-33. Low and High GHG Benefits for Ag and Forestry-6

Initial Reductions	1.79 $MMtCO_2e$	
Enhanced Reductions	1.79 $MMtCO_2e$	DNR Quantification

Estimate – DNR Quantification

The Maryland Forest Service is working with forest carbon scientists from the U.S. Forest Service-Northern Research Station to refine methodologies, protocols and metrics for properly measuring CO_2-equivalent attenuation benefits resulting from forestry activities. To provide a generally reliable starting point for understanding the contribution of forests, and as importantly, forest management, the best available carbon accounting tools were employed utilizing metrics historically collected. Using data that has been collected systematically for the past decade or more will help to establish a better understanding of trends in forests, which require very long-term planning horizons when implementing changes in management goals. As forest carbon accounting protocols become more refined, the underlying assumptions will undoubtedly change as well.

Figure C-34. Potential Carbon Sequestration from Reforestation

MMtCO$_2$e **Reforestation**						
	Private Lands		**Public Lands**			
	Loblolly	Mixed Upland	Loblolly	Mixed Upland		
	Pine[60,61,62,634]	Hardwood[133,134,136,64]	Pine[133,134,135,136]	Hardwood[133,134,136,65]	Total	
Year	(Acres)	(Acres)	(Acres)	(Acres)	(MMTCO$_2$e)	
2006	1,887	210	685	893	0.17	
2007	1,791	199	94	485	0.12	
2008	2,148	239	196	719	0.15	
2009	6,785	754	106	663	0.38	
2010	1,798	200	128	588	0.11	
2011	1,887	210	128	663	0.12	*est.
2012	1,887	210	128	663	0.11	*est.
2013	1,887	210	128	663	0.11	*est.
2014	1,887	210	128	663	0.11	*est.
2015	1,887	210	128	663	0.10	*est.
2016	1,887	210	128	663	0.10	*est.
2017	1,887	210	128	663	0.10	*est.
2018	1,887	210	128	663	0.09	*est.
2019	1,887	210	128	663	0.09	*est.
2020	1,887	210	128	663	0.09	*est.
Total	33,283	3,698	2,489	9,978	**1.95**	**MMtCO$_2$e**

Figure C-35 Potential Carbon Sequestration from Afforestation

MMtCO$_2$e Afforestation				
	Loblolly	Mixed Upland		
	Pine[66,67,68,69]	Hardwood[70,140,142,71]	Total	
Year	(tons CO$_2$-equivalent)	(tons CO$_2$-equivalent)	(tons CO$_2$-equivalent)	
2006	11,345	45,382	0.06	
2007	4,761	19,044	0.02	
2008	17,171	68,685	0.09	
2009	17,166	68,665	0.09	
2010	10,263	41,053	0.05	

60 Includes soil carbon estimate of 34.51 tonnes per acre
61 Assumes constant rate of reforestation annually, based on median acreage planted years 2006-2010.
62 From Carbon On Line Estimator report for Maryland
63 U.S. Dept of Agriculture Forest Service-NRS GTR NE-343
64 Assumes 90 percent reforestation post-harvest is pine. See Figure above
65 Assumes 90 percent reforestation post-harvest is pine. See Figure above
66 Includes soil carbon average of 26.17 tonnes per acre per year.
67 Assumes constant rate of afforestation annually, as based on median acreage planted years 2006-2010
68 From Table 4, Carbon On Line Estimator report for Maryland. Based on U.S. Dept of Agriculture Forest Service-NRS GTR NE-343
69 Assumes 80 percent of all afforestation is mixed hardwood.
70 Includes soil carbon average of 17.93 tonnes per acre per year.
71 From Figure above.

2011	9,910	39,641	0.05	*est.
2012	9,557	38,229	0.05	*est.
2013	9,204	36,816	0.05	*est.
2014	8,851	35,404	0.04	*est.
2015	8,498	33,992	0.04	*est.
2016	8,145	32,580	0.04	*est.
2017	7,792	31,168	0.04	*est.
2018	7,439	29,755	0.04	*est.
2019	7,086	28,343	0.04	*est.
2020	6,733	26,931	0.03	*est.
Total	143,922	575,688	**0.72**	**$MMtCO_2e$**

Implementation

By 2020, the implementation goal for this program is to achieve afforestation and/or reforestation of 43,030 acres for Years 2011-2020. To accomplish this, DNR will work with federal and state partners, local governments, and non-profits to create, restore, and enhance forests. As of June 2011, the Forest Brigade has met its goal of planting one million trees. Since 2006, DNR has achieved 3,894 acres of afforestation and reforested 6,469 acres. The current productivity of this program cannot be attained if there is a future reduction in staff and funding.

DNR will implement this program through a suite of efforts, policies and programs, including:

Public Lands

- State Forest System Annual Workplan Implementation
- Natural Filters

Private Lands:

- Technical Assistance
  - Forest Stewardship Plan Implementation
- Financial Assistance
  - State and Federal Cost Sharing
    - Woodland Incentive Program (WIP –MD Forest Service)
    - Environmental Quality Incentive Program (EQIP – Federal/NRCS)
    - Conservation Reserve Enhancement (CREP – Federal/NRCS)

I.3: Creating and Protecting Wetlands and Waterway Borders to Capture Carbon

Lead Agency: DNR

Program Description

Wetlands and marshlands provide one of the best ways to prevent property damage and maintain healthy environments in coastal areas. To ensure that wetland buffers will be available for Maryland, current wetlands need to be able to move inland as sea level rises. Without inland areas to which these wetlands can migrate, the Chesapeake Bay's coastal wetlands could simply be drowned by rising Bay waters. Acquisition of lands adjacent to existing tidal marsh in fee simple or by conservation easements is essential for wetlands to migrate landward as sea level rises.

Wetlands with long periods of inundation or surface saturation during the growing season are especially effective at storing carbon in the form of peat. Salt marsh and forested wetlands tend to release less methane than freshwater marsh. Riparian wetlands can also capture carbon washed downstream in litter, branches, and sediment. Because they accumulate sediment and bury organic matter, floodplain and tidal wetlands are especially effective as carbon sinks. These lands also reduce nutrient, sediment, and other pollution into the Chesapeake Bay and other bodies of water.

DNR will work with the General Assembly and various State agencies (MDE, MDA, and the Maryland State Highway Administration), as well as local governments, conservation organizations, private landowners, sawmills, arboreal industries and others to implement this program. Meetings will be held with local governments to refine local policies toward establishment, expansion and protection of riparian zones and wetlands. DNR will continue to support the Forestry for the Bay program, which reaches forest owners with management messages.

Targets for forested buffers and on the ground wetland restoration, as established under Maryland's Phase II Watershed Implementation Plan (WIP) for the Chesapeake Bay TMDL, include the restoration of 1,142 acres of wetlands on state and public land and planting 645 acres of streamside forest buffers on state and public lands.

DNR and MDE are working together to promote wetland carbon sequestration. Estuarine wetlands are known to be very efficient at sequestering carbon[72]. There are three potential components to this program: the Blackwater National Wildlife Refuge, a Power Plant Research Project study located in Dorchester County, and the Sea Level Affecting Marshes Model.

The Blackwater National Wildlife Refuge contains a large estuarine wetland system that is threatened by subsidence and sea level rise. The Power Plant Research Program entered into a memorandum of understanding with the University of Maryland to study carbon sequestration processes in selected marsh segments in the Blackwater National Wildlife Refuge. Sequestration in a natural marsh and a manmade marsh, which is a restored area of inundated marsh, were compared with a view to understanding how marsh restoration may be used as a climate change mitigation technique through offsetting emissions of carbon dioxide. The aim of this project is to develop a terrestrial carbon sequestration protocol that is generally applicable to estuarine wetlands and tidal

[72]US Climate Change Science Program, 2007. The First State of the Carbon Cycle Report: The North American Carbon Budget and Implications for the Global Carbon Cycle. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [King, A.W., L. Dilling, G.P. Zimmerman, D.M. Fairman, R.A. Houghton, G. Marland, A.Z. Rose, and T.J. Wilbanks (eds.)]. National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, NC, USA, 242 pp.

marshes and which will lead to projects that produce carbon offsets that can be used to compensate for GHG emissions.

The protection and restoration of wetlands can offer significant opportunities for carbon sequestration. A DNR Power Plant Research Project study[73] of wetlands in Dorchester County demonstrates this potential. Dorchester County was chosen as it contains extensive coastal marshes. Areas for potential restoration were identified in DNR's Green Infrastructure data set. Satellite derived net primary productivity is used to estimate gross sequestration and net accumulation was estimated based on the current understanding of carbon dynamics in coastal wetlands.

In 2011, DNR completed a study using the Sea Level Affecting Marshes Model to identify areas projected to convert into new wetlands under future sea level rise conditions. Using this modeling the State is able to target lands that may support coastal wetland establishment. These areas are otherwise known as wetland migration areas. The modeling will be used to target wetland restoration and land conservation in areas identified as potential wetland migration areas. Targeting these areas may help maintain coastal wetlands into the future. Future carbon sequestration can be achieved through wetland establishment and restoration activities that enhance these targeting areas for wetland migration. Modeling results are accessible on DNR's *Coastal Atlas* (http://www.dnr.state.md.us/ccp/coastalatlas/index.asp).

Estimated GHG Emission Reductions in 2020

Figure C-36. Low and High GHG Benefits for Ag and Forestry-4

Low Estimate	0.43 $MMtCO_2e$	DNR Quantification Below
High Estimate	0.43 $MMtCO_2e$	DNR Quantification Below

Estimate – DNR Quantification
#1: Research to date has shown that restored marshes are effective at sequestering carbon and may initially be more productive than natural, extant, marsh. Important research is ongoing on the fate of the sequestered carbon, particularly the potential for these systems to reemit carbon in the form of methane, itself a potent GHG.

Based on observed sequestration rates, it was estimated (Needelman, 2007) that fully restoring the Blackwater marsh system could sequester as much as 15 percent of carbon dioxide cap set for Maryland in the RGGI program – up to 0.15 $MMtCO_2e$ (150,000 milligrams carbon dioxide per year.)

There are a number of groups around the country working on similar projects. At the national level, these programs are being coordinated under the leadership of Restore America's Estuaries. The output of this coordination is to be a protocol for creating GHG offsets through marsh/wetland restoration. The protocol would be managed by the Climate Action Reserve, a group that manages offset projects. Maryland is an active

[73] D. Strebel, "Wetland Restoration Potential for Carbon Sequestration", report to PPRP (2010)

participant in the protocol development and it is anticipated that protocol demonstration projects will occur in the State.

#2: Estimates of carbon sequestration for the potential wetland restoration projects in Dorchester County are shown in the Figure C-56.

Figure C-37. Estimated Carbon Sequestration from Dorchester County wetland restoration projects.

Project Type	Total Area (Hectares)	Sequestration Rate (milligrams carbon per hectare per year)	Estimated Sequestration ($MMtCO_2e$ per year)
Green Infrastructure to herbaceous wetland	7600	5.9	0.17
Green Infrastructure to forested wetland	7700	4.7	0.13
Agricultural lands to herbaceous wetlands	97000	5.7	0.20

#3: Estimates of the potential for carbon sequestration in future wetlands created by sea level rise has yet to be determined.

Implementation

This program is being implemented through a suite of programs and strategies. DNR is planting forested stream buffers and pursuing the creation, protection and restoration of wetlands to promote carbon sequestration through several means, including undertaking on-the-ground wetland restoration projects through its Coastal Wetlands Initiative, the development of a terrestrial carbon sequestration protocol; a DNR Power Plant Research Project wetland study in Dorchester County, and the Sea Level Affecting Marshes Model. Targets for forested buffers and on the ground wetland restoration, as established under Maryland's Phase II Watershed Implementation Plan (WIP) for the Chesapeake Bay TMDL, include the restoration of 1,142 acres of wetlands on state and public land and planting 645 acres of streamside forest buffers on state and public lands.

There are a number of groups around the country working on similar projects. At the national level, these programs are being coordinated under the leadership of the non-governmental organization, Restore America's Estuaries. The output of this coordination is to be a protocol for creating GHG offsets through marsh/wetland restoration. The protocol would be managed by the Verified Carbon Standard, (http://v-c-s.org/) a non-governmental organization that manages offset projects. Maryland is an active participant in the protocol development and it is anticipated that protocol demonstration projects will occur in the State.

Currently there are no financial or regulatory drivers to implement this program. DNR continues to evaluate the need for financial or regulatory drivers to implement this program. This program could ultimately be implemented through a suite of strategies including green infrastructure planning, offsets under RGGI or other offset trading mechanisms, tax incentives, fee-in-lieu payments, and acquisition of landward properties to allow migration of coastal wetlands at risk of inundation from sea level rise.

I.4: Biomass for Energy Production

Lead Agency: DNR

Program Description

Maryland is working to promote the use of locally produced woody biomass for generation of thermal energy and electricity. Energy from forest by-products can be used to offset fossil fuel-based energy production and associated GHG emissions. There are many end users that could potentially benefit from such a program, including Maryland's public schools which could enjoy wood heating and cooling; hospitals which could utilize wood as primary heating/cooling source; municipalities which could utilize local fuel markets as key component of their urban tree management programs; and all rural landowners which would have access to a wood fuel market..

Woody biomass is a feedstock that can be used in a number of energy applications. Wood chips, forest thinning remnants, and urban wood waste are all examples of woody biomass that can be used to generate thermal power (heat and cooling), electric power, or liquid fuels. Advanced technology supports the generation of energy through clean, efficient methods that address particulate matter generation as well as GHG emissions.

The Maryland Wood Energy Coalition is composed of representatives of State agencies, university extension, non-profits, and business committed to increasing the adoption of high efficiency, low emission wood energy technologies that meets Maryland air quality standards. The Pinchot Institute for Conservation released a comprehensive analytical study in September 2010 of the distribution of Maryland's diverse woody biomass resources and the opportunity to develop optimal scale projects. Utilizing this report and other sources, the Maryland Wood Energy Coalition determined that the efficient use of woody biomass in Maryland can best be achieved through small to medium-sized commercial and institutional applications for government, schools, and businesses as well as residential thermal applications.

Debates continue within the scientific community on the effects of atmospheric carbon resulting from wood combustion. However, consensus is converging on the concept that wood combustion should be regarded as carbon neutral. The assumption that wood combustion is in fact carbon neutral was bolstered by EPA research that indicates that carbon neutrality is highly probable. If a determination is made that wood combustion is not a contributory agent towards overall atmospheric carbon, then substituting wood for fossil fuels is clearly a net reduction in carbon emissions.

The following hypothetical example illustrates the potential opportunity for reducing GHG emissions if Maryland would pursue the development of wood energy. The factors utilized in the example are verifiable and taken from published reports documenting the metrics involved.

Thousands of potential sites exist within Maryland, such as schools, hospitals, and college campuses, which would be prime candidates for wood-fired combined-heat-and-power systems. These systems provide the heating and cooling needs for the facilities they serve and utilize excess thermal capacity to generate electricity. Thousands of additional sites exist, such as residential communities, businesses, and institutions, throughout Maryland ideally suited for simple thermal-only systems, which are designed to provide only the heating and cooling needs of the facility.

Estimated GHG Emission Reductions in 2020

Figure C-37. Low and High GHG Benefits for Ag and Forestry-7

Initial Reductions	0.33 $MMtCO_2e$	DNR Quantification Below
Enhanced Reductions	0.33 $MMtCO_2e$	DNR Quantification Below

Estimate – DNR Quantification

The amalgam of State policies affecting energy development currently presents numerous barriers to the development of potential wood energy systems; therefore, our estimate of carbon reductions must necessarily be 0 $MMtCO_2e$. However, presuming adjustments to policy, installing a very modest number of wood energy systems (18 appropriately sized boiler units) Maryland could avoid 4.47 $MMtCO_2e$ of fossil fuel emissions by 2020.

Debates continue within the scientific community on the effects of atmospheric carbon resulting from wood combustion. However, consensus is converging on the concept that wood combustion should be regarded as carbon neutral. We assume that wood combustion is in fact carbon neutral. Accepting that assumption is bolstered by EPA's recent announcement that their research indicates neutrality is highly probable. Therefore, if wood combustion is not a contributory agent towards overall atmospheric carbon, then substituting wood for fossil fuels is clearly a net reduction in carbon emissions.

The following hypothetical example illustrates the potential opportunity for reducing GHG emissions if Maryland would pursue the development of wood energy. The factors utilized in the example are verifiable and taken from published reports documenting the metrics involved.

Literally thousands of potential sites exist within Maryland (e. g. schools, hospitals, college campuses, etc.) which would be prime candidates for wood-fired combined-heat-and-power systems. These systems provide the heating and cooling needs for the facilities they serve and utilize excess thermal capacity to generate electricity. Thousands of additional sites exist (e. g. residential communities, businesses, institutions, etc.) throughout Maryland ideally suited for simple thermal-only systems (i.e., designed to provide only the heating and cooling needs of the facility). For purposes of this exercise, we assumed that Maryland aggressively address the political and financial barriers immediately, and would thus enable the first systems to come "on-line" in 2015. We further assumed the annual installation of 3 systems per year, which would be a very reasonable estimate.

Example scenario:

Wood-fired heating and cooling system of 4 mmbtu (120 horsepower) operating for 7,000 hours per year would require 3,000 tons of wood chips annually.

Conservatively, 1 ton of wood displaces 60 gallons of #2 heating oil. Each 1,000 gallons of oil emits 22,300 pounds of carbon dioxide (11.15 tons).

Therefore, if 3,000 tons of wood chips displace 180,000 gallons of heating oil, there is a displacement of 1,882 tons of CO_2-equivalent.

Assuming three systems installed per year beginning in 2015, the potential displacement of CO_2-equivalent is displayed in Figure C-61.

Figure C-38. Potential CO_2-equivalent displacement from 3 wood-firing systems.

	Total No.	Annual	Cumulative	
	Systems	Displacement	Displacement	
Year	Installed	(tonnes carbon dioxide per year)	(tonnes carbon dioxide per year)	
2015	3	5,474	5,474	
2016	6	10,947	21,895	
2017	9	16,421	76,631	
2018	12	21,895	262,735	
2019	15	27,368	897,676	
2020	18	32,842	3,065,236	
	18	114,946	4,329,646	
		4.33	**$MMtCO_2e$**	

Other Environmental Benefits

Sustainable and renewable forestry practices underscore the benefits of utilizing the available wood supplies for an alternative energy source. Incorporating Maryland's annually renewed stocks of unutilized wood as fuel presents Maryland with multiple opportunities:

- Improving the energy situation,

- Extracting greater value from urban and rural forests,
- Maintaining a healthy and clean environment, and
- Improving stewardship abilities through enhanced management opportunities.

An estimated 800,000 tons of wood waste is generated annually in Maryland from urban activities such as tree maintenance, land clearing and waste collection centers and is grossly underutilized due to lack of markets.

The fact remains the bulk of Maryland's total energy portfolio (40 percent) is simple thermal demands. This presents a significant market opportunity for wood-based energy. Thermal applications represent a two-fold opportunity to improve forest conditions:

1. Enhanced management capabilities resulting from entirely new market opportunities for urban wood.
2. Clearly demonstrating the enhanced benefits that communities receive from their local forests through proper management. (Ex: reduction in carbon footprint, clean energy, boost to local economy, reduced energy costs, energy independence, improved health of local trees and forests, reduction in waste, and an obvious linkage between local trees and public facilities.)
3. Our strategy is geared toward sizing systems strictly to the available fuel supply – a key concept of sustainability often overlooked within the architectural and engineer designs of energy systems.

Implementation

Key actions to support this program include the development of policies that recognize wood as preferable renewable resources and the largest source of energy consumption in Maryland. DNR will also be working to offer incentives for the utilization of locally produced wood to meet thermal energy needs. The goal of this program is to foster the development of 18 wood energy projects by the 2020.

Numerous barriers exist to advancing wood energy in Maryland: awareness of wood as a viable, and preferred, energy source; State procurement systems that currently do not recognize wood energy systems as option for consideration in HVAC design; lack of emission standards reflecting the state-of-art emission controls, etc.

The favorable economic structure of wood energy systems would likely lead to the development of wood energy market in Maryland, if not for the many barriers currently existing hindering facilities from taking advantage of these systems.

Removing, or at least reducing, these barriers would enable residential and commercial stakeholders to pursue adopting wood energy systems. Leveling the playing field within State government to recognize that wood energy is comparable to wind and solar as a viable and desirable form of renewable energy would be a logical first step. Some other measures that would accelerate the advancement of wood energy include:

- Educating State agency leadership of the numerous benefits of wood energy and catalog solutions for removing barriers to implementation.

- Developing policy recognizing thermal energy (i.e., heating/cooling) as the single largest source of energy consumption in Maryland, and offer incentives for utilizing locally produced wood in meeting these thermal energy needs.
- Modifying State energy policies to specifically recognize wood as a preferred renewable energy source on par with solar, geothermal, and wind.
- Expanding existing financial incentive programs for renewable energy development to also include wood.

Various grants, loans, and cost-share programs offered by MEA, MDE, and other agencies will support implementation. Amendments to a number of existing laws and regulations would offer additional implementation assistance, including:

- Amending Renewable Fuels Standard to accommodate renewable thermal energy.
- Recognizing modern emission control technologies utilized by wood energy systems in air quality permitting regulation.
- Specifically including wood energy systems as option for HVAC design in State buildings.

Additionally, DNR is working with several outside groups to promote and advance implementation, including:

- U.S. Forest Service -- Woody Biomass Utilization Program http://www.fs.fed.us/woodybiomass/index.shtml
- Fuels for Schools -- a venture between public schools, State foresters, and Regional Foresters of the Forest Service to helps public schools retrofit their current fuel or gas heating system to small-scale biomass heating systems. http://www.fuelsforschools.info/
- Biomass Energy Resource Center -- assists communities, colleges and universities, State and local governments, businesses, utilities, schools, and others in making the most of their local energy resources. http://www.biomasscenter.org/
- Alliance for Green Heat -- promotes high-efficiency wood combustion as a low-carbon, sustainable, local and affordable heating solution. http://www.forgreenheat.org/

The current productivity of this program cannot be attained if there is a future reduction in staff and funding.

Early Action(s):

- Pinchot Institute for Conservation authored 200-page report investigating opportunities and challenges for wood energy in Maryland, released in September 2010. Key findings include: smaller scale systems are best suited for Maryland; modifying existing energy policies to address thermal energy applications would remove a lot of barriers.
- Ancillary to the published report described above, a suite of science-based guidelines establishing forest biomass harvesting Best Management Practices were developed and released in September 2010 in collaboration with Pinchot Institute for

Conservation, Maryland Center for Agro-Ecology, and the DNR Forest Service. These were vetted extensively with private landowners and forest industry.

I.5: Conservation of Ag Land for GHG Benefits

Lead Agency: MDA

Program Description

Land conservation offers an important mechanism for mitigating and adapting to climate change. Healthy and vigorous forests and grass lands provide both direct benefits to GHG reductions and also serve as the preferred land-use for avoiding emissions and capturing GHGs. Wetlands and marshlands provide one of the best ways to prevent property damage and maintain healthy environments in coastal areas as well as reduce nutrient, sediment, and other pollution into the Chesapeake Bay and other bodies of water. Deforestation and other land-use changes account for as much as 25 percent of global GHG emissions. In addition, the increasing rate of sea level rise and associated erosion threaten Maryland's shoreline and associated coastal wetlands, removing another natural sink for GHGs. For these reasons and more, MDA is working to safeguard Maryland's network of natural areas, agricultural lands and coastal lands through MDA's established conservation programs and practices.

MDA will decrease the conversion and development of agricultural lands through the protection of productive farmland and will continue to pursue policies and programs that complement those of DNR and MDP by preserving existing forested, grassed, and wetland areas on agricultural land. Policies and programs promoting the installation of forest and grass buffers and wetlands on agricultural land will also be pursued. MDA and its partners will also collaborate to implement policies, programs, and strategies to sequester additional carbon and avoid or reduce GHG emissions associated with growth and development.

Estimated GHG Emission Reductions in 2020

Figure C-39. Low and High GHG Benefits for Ag and Forestry-8

Initial Reductions	0.18 $MMtCO_2e$	2008 Climate Action Plan, Appendix D [74] Pg. 31 of 341)
Enhanced Reductions	0.18 $MMtCO_2e$	2008 Climate Action Plan, Appendix D [75] Pg. 31 of 341)

74 http://www.mde.state.md.us/programs/Air/ClimateChange/Documents/www.mde.state.md.us/assets/document/Air/ClimateChange/Appendix_D_Mitigation.pdf

75 http://www.mde.state.md.us/programs/Air/ClimateChange/Documents/www.mde.state.md.us/assets/document/Air/ClimateChange/Appendix_D_Mitigation.pdf

Other Environmental Benefits

Many of the policies and programs sponsored by MDA not only preserve farmland and protect natural resources, but also provide other environmental benefits. Besides maintaining prime farmland and woodland as a viable local base of food and fiber production in the State, the preservation of agricultural land curbs the expansion of random urban development, safeguards wildlife habitat, and enhances the ecology of the Chesapeake Bay and its tributaries. Other environmental benefits continue to be under assessment.

The preservation and protection of agricultural land limits the expansion of random urban development, safeguards agricultural and forest lands as both open space and wildlife habitat, and enhances the environmental quality of the Chesapeake Bay and its tributaries by reducing sediment and nutrient loss. By the close of the 2010 fiscal year, the Maryland Agricultural Land Preservation Foundation had helped to permanently protect from development more than 280,000 acres on approximately 2,100 farms in all of Maryland's 23 counties. Although participation levels vary year to year, when fully implemented at its authorized 100,000 acres, the Conservation Reserve Enhancement Program will have planted up to 16,000 acres of marginal land into grass, shrubs, and trees, established 77,000 acres of riparian buffers and 5,000 acres of water and wetland habitat, and restored 2,000 acres for declining, threatened, or endangered species

Implementation

Established in 1977 and one of the first programs of its kind in the country, the Maryland Agricultural Land Preservation Foundation retains prime farmland and woodland as a viable local base of food and fiber production in the State through the purchase of permanent preservation easements. The Maryland Agricultural Land Preservation Foundation has become one of the nation's leaders in agricultural land preservation and is a central element of Maryland's "Smart, Green and Growing" initiative. Combining the Foundation's program with county and other State land preservation programs, Maryland has preserved more agricultural land for future production than any other state in the Union. By the end of the 2010 fiscal year, more than 280,000 acres on approximately 2,100 farms have been permanently protected from development. Farmland has been successfully preserved in all of Maryland's 23 counties. Today, the Maryland Agricultural Land Preservation Foundation manages a public investment of over $600 million in permanently preserved land.

Since 1997, Maryland has partnered with the U.S. Department of Agriculture in the Conservation Reserve Enhancement Program to offer rental payments for long-term, leased easements, along with other cash incentives, to encourage agricultural producers to protect environmentally sensitive lands and improve wildlife habitat. When fully implemented at its authorized 100,000 acres, the Conservation Reserve Enhancement Program will have planted up to 16,000 acres of marginal land into grass, shrubs, and trees, established 77,000 acres of riparian buffers and 5,000 acres of water and wetland habitat, and restored 2,000 acres for declining, threatened, or endangered species.

Although participation in both programs is voluntary, the financial incentives provided by the purchase of easements through the Maryland Agricultural Land Preservation Foundation guarantees that the land will be permanently preserved for agricultural use and helps to keep Maryland's agricultural base intact. Similarly, Maryland landowners participating in the Conservation Reserve Enhancement Program can receive five types of payments that incentivize the installation and maintenance of eligible conservation practices.

MDA continues to work independently as well as with its climate change partners at DNR, MDE, and MDP to not only protect existing agricultural lands, forests, and wetlands, but also promote the adoption and installation of beneficial conservations practices. MDA and its partners will collaborate with the General Assembly, federal and local governments, conservation/environmental organizations and foundations, as well as private property owners in implementing policies, programs, and strategies to sequester additional carbon and avoid or reduce GHG emissions associated with development. MDA will protect 962,000 acres of productive farmland from development by 2020

I.6: Increasing Urban Trees to Capture Carbon

Lead Agency: DNR

Program Description

DNR is currently working to maintain and improve the health and longevity of trees in urban areas and increase the urban tree canopy cover throughout Maryland. Trees in urban areas help absorb GHG emissions from power production, vehicles and the operation and maintenance of the built environment. Urban trees shield buildings from cold winds and lower ambient summertime temperatures, reducing heating and cooling costs and the demand for energy production. Reduced heat slows the formation of ground level ozone as well as the evaporation of fuel from motor vehicles.

Figure C-40. Urban Tree Assessments

County (total census designated places)	Assessment status	Assessment Date Completed	Current Urban Tree Canopy %	Goal Set	Urban Tree Canopy Goal	Achieve by date
Allegany (total 8 places)				N		
-- Cumberland	Complete	10/1/2008	48%	TBD		
Anne Arundel (total 32 places)	Complete	2/19/2010	58%	TBD		
-- Annapolis	Complete	6/1/2006	41%	Y	50%	2036
Baltimore (total 30 places)	Complete	4/1/2009	49%	TBD		
Baltimore City	Complete	1/1/2006	20%	Y	46%	2036
Dorchester (total 11 places)				N		
-- Vienna	None	n/a		Y	TBD	
-- Cambridge	None	n/a		Y	TBD	
Frederick (total 22 places)				N		

-- Frederick County Board of Education	Complete		12%	Y	20%	2038
-- Brunswick	Complete		38%	Y	48%	
-- City of Frederick	Complete	10/1/2009	14%	Y	40%	2035
-- Lake Linganore Watershed	Underway					
Howard (total 5 places)	Complete	12/1/2009	50%	TBD		
Kent (total 5 places)				N		
-- Rock Hall	Underway					
-- Millington	Underway					
-- Chestertown	Complete	4/1/2009	25%	Y	40%	2020
-- Betterton	Underway			TBD		
Montgomery (total 48 places)	Complete			TBD	TBD	
-- Rockville	Complete	5/1/2009	44%	N		
-- Takoma Park	Complete	12/3/2010	59%			
Prince George's (total 27 places)	Complete		44%	TBD	TBD	
-- Bowie	Complete	3/1/2009	46%	N		
-- Edmonston	Complete	3/1/2009	32%	N		
-- Greenbelt	Complete	2/1/2009	62%	Y	Hold at 62%	
-- Hyattsville	Complete	8/1/2008	41%	TBD		
-- Forest Heights	Complete	6/22/2010	34%	TBD		
Washington (total 25 places)				N		
-- Williamsport	Complete		TBD	TBD		

The Urban Tree Canopy Initiative is a component of the Maryland Commission on Climate Change, as well as is a goal of the Chesapeake Executive Council Riparian Forest Buffer Directive No. 03-01. The Urban Tree Canopy Initiative continues to be an overarching program for the Maryland Forest Service Urban & Community Forestry program.

The original concept was to target incorporated municipalities for participation in the Urban Tree Canopy Initiative. The thirty-seven municipalities, which are participating in the Urban Tree Canopy Initiative, include Annapolis, Baltimore, Bowie, Cumberland, Edmonston, Greenbelt, Hyattsville, and Rockville as well as Baltimore County's 29 communities. All of these communities have received tree canopy assessments performed by the University of Vermont and funded by the Chesapeake Bay Trust's Urban Greening Initiative grant program and DNR's Maryland Forest Service. Of these communities, three have developed goals: Annapolis 50 percent, City of Baltimore 40 percent and Frederick County Board of Education 20 percent. The remaining communities have experienced difficulty in developing and adopting goals. However, some communities (such as Greenbelt with 62 percent canopy coverage) are moving ahead with planting plans to maintain their tree cover. Others continue evaluating how to proceed.

In 2010, the Maryland Forest Service changed the direction of the Urban Tree Canopy Initiative. Instead of targeting individual communities, the emphasis has been redirected toward counties -particularly counties with significant urban areas. With this re-focus, those highly urban communities can benefit. These communities are census designated communities and typically have no staff or budget for such an initiative. Assessments have been completed for Anne Arundel (thirty-one communities) and Howard (five communities). Urban Tree Canopy assessments were completed in FY11 by the University of Vermont for Montgomery (forty-seven communities) and Prince George's (twenty-two communities) Counties', and the town of Williamsport. With this change in direction, the goal of the Chesapeake Executive Council Riparian Forest Buffer Directive No. 03-01 can be accomplished. The directive requires the following: "Establish urban tree canopy goals for 50 percent (74 communities) of the area developed primarily before stormwater management regulations (pre-1984) by 2020".

One method to increase urban tree canopy coverage is the Marylanders Plant Trees program. In the summer of 2008, the Maryland Forest Service was tasked with developing a citizen component of the Urban Tree Canopy Initiative. This new program would assist citizens with planting trees in their neighborhoods and ultimately increase the canopy coverage of the State.

On Arbor Day 2009, Governor O'Malley launched the Marylanders Plant Trees Initiative http://www.trees.maryland.gov/ to encourage Marylanders to plant 50,000 trees by the end of 2010 with a grand total of 600,000 trees by 2020 to promote a more sustainable future for generations to come. This program is part of the Smart, Green & Growing Statewide initiative. Similar to Baltimore County's "Growing Home" campaign, Marylanders Plant Trees Initiative utilizes a coupon to entice citizens to plant trees. The $25 coupon can be used to purchase a native tree with a net value of $50. A website was developed to provide technical assistance on tree planting such as right tree-right place and other tree planting tips. The website also contains the list of acceptable native trees for coupon use, a list of participating nurseries and lastly a page in which citizens can report the number and location of their tree plantings. This information is automatically tallied into a registry dial on the website and the Maryland BayStat website. In this manner the citizens can track the Initiative's progress on a weekly basis. The most interesting aspect of the website is the Tree Benefits Calculator designed by Davey with funding from the U.S. Forest Service. The Benefits Calculator was updated to allow multiple trees to be inputted and will allow the State to obtain Statewide benefits based on the trees registered. Since 2008, 82,700 trees have been planted and registered.

The Urban Tree Canopy Initiative targets Maryland counties, particularly counties with significant urban areas. Through this program, DNR is currently working to establish urban canopy goals for 50% (74 communities) of the area developed primarily before 1984. By 2020, the overall goal is to plant 12,500,000 trees through the FCA Marylanders Plant Trees and Tree-Mendous and 5-103 planting programs. For measurement purposes, trees include 450 container grown seedlings per acre.

Estimated GHG Emission Reductions in 2020

Figure C-41. Low and High GHG Benefits for Ag and Forestry-3

Initial Reductions	0.02 $MMtCO_2e$	DNR Quantification Below
Enhanced Reductions	0.02 $MMtCO_2e$	DNR Quantification Below

Estimate – DNR Quantification

Figure C-42. Urban Forest Carbon Calculation

	Forest Conservation Act and NRA 5-103(h) Tree Planting	TreeMendous Maryland & Marylanders Plant Trees Programs	
Year	Number of Trees Planted	Number of Trees Planted	$MMtCO_2e$
2006	929,110	8,178	0.0004
2007	1,094,310	6,057	0.0010
2008	812,420	2,160	0.0013
2009	512,440	39,020	0.0016
2010	837,070	11,643	0.0027
2011	837,070	11,643	0.0040
2012	837,070	11,643	0.0050
2013	837,070	11,643	0.0058
2014	837,070	11,643	0.0069
2015	837,070	11,643	0.0111
2016	837,070	11,643	0.0158
2017	837,070	11,643	0.0195
2018	837,070	11,643	0.0223
2019	837,070	11,643	0.0262
2020*	837,070	11,643	0.0339
	12,556,050	**317,058**	**0.16 $MMtCO_2e$**

Note: 2020 estimates reflect values for trees planted in 2020 (if grown to 2021), so trees planted in 2019 will collect 0.0262 $MMtCO_2e$ in 2020.

The original Urban Tree Policy (Policy AFW-2) from the 2008 Climate Action Plan was designed to increase urban tree canopy from 28 percent to 38 percent by 2020, enhancing green infrastructure, and improving urban wood recovery. The urban tree canopy policy reduces GHG emissions directly from new carbon sequestration resulting from the new trees and indirectly from the reduction in electricity used for cooling due to the shade and local climate effects of the trees. The GHG reductions are listed in Figure C-52.

Figure C-43: GHG Emission Reductions Resulting from 2008 Climate Action Plan Policy AFW-2.

Emissions Category	GHG Reductions ($MMtCO_2e$)		
	2012	2015	2020
Cumulative Carbon Sequestration by Planted Trees	0.016	0.0398	0.16
Annual Carbon Sequestration by Planted Trees	0.00399	0.00691	0.0261

Reduced Electricity Demand for Cooling and Heating	*De minimis*

Detailed Explanation of Methodology

The MD Forest Service estimated carbon sequestration using software developed by the U.S. Forest Service. The iTree program was released in 2006 and is peer-reviewed by urban forestry experts and continues to be expanded and improved upon. The program is used to report on urban forests and the services they provide, from the individual tree scale to an entire State.

An analysis tool of the iTree program, iTree-Eco, was developed to use air pollution and meteorological data and whole inventories of trees or random samples to quantify ecosystem services provided by urban trees. It is an adaptation of the Urban Forest Effects model which was co-developed by the U.S. Forest Service Northern Research Station, the U.S. Department of Agriculture State and Private Forestry's Urban and Community Forestry Program and Northeastern Area, the Davey Tree Expert Company, and State University of New York College of Environmental Science and Forestry. This tool was utilized to develop parameters for individual tree species commonly planted by contractors in Maryland to estimate the amount of carbon that could potentially be captured in the next 10 years.

iTree-Eco depends on field data to develop estimates of the ecosystem services produced by urban trees. In the case of a whole inventory, specific details of each tree are collected by field crews; details such as crown shape, crown die-back, bole diameter, etc. Thus a fairly accurate assumption can be made about how ecosystem services are produced in a city or other area for trees of varying size and health.

Calculations

The following Steps describe the quantification approach summarized above:

<u>Step 1: Identify a Representative Sample of Maryland Trees:</u>

To create an estimate of the potential for planted trees to sequester carbon between 2006 and 2020, parameters were developed for six tree species commonly used for planting.

These species, Eastern White Pine (*Pinus strobes*), Northern Red Oak (*Quercus rubra*), Pin Oak (*Quercus palustris*), American Sycamore (*Platanus occidentalis*), Dogwood (*Cornus spp.*), and Sweetgum (*Liquidamber styraciflua*), were assumed to be planted at a rate of 25 percent White Pine for the total tree species planted in a year and 15 percent of the total for the other tree species.

<u>Step 2: Determine Carbon Sequestration Per Calendar Year:</u>

The calculations for the total goal were started in 2006 with 929,110 trees planted. This reflects the number of trees planted for Forest Conservation Act mitigation, Reforestation Law [NRA 5-103{h)] plantings, and from the Marylander's Plant Trees program. They assumed that trees were two year, bare root stock from local nurseries of approximately 0.5 inches in diameter, the industry standard, and was the default for subsequent years' newly planted trees. Following years were estimated using assumptions about the trees' size and health. For example, a tree planted in 2006 used the same carbon sequestration estimate until 2011, at which point the rate changed to reflect trees growth, assuming the trees grew nominally with an 80 percent survival rate. The parameters were entered into iTree-Eco, which provided a pound/year estimate of the carbon sequestered by each tree.

To determine how much carbon could potentially be captured by trees planted by 2020, carbon uptake estimates were produced for each tree type at 5 year increments; 2006, 2011, 2016, and 2021. The parameters for each year were estimates of how the average tree of one of the selected species would look in each of those years (see figure below). Five year increments were used because growth conditions vary widely across the State and from site to site. Soil conditions, rainfall amounts, competition from other plants, damage from insects, deer, voles, etc. and other stresses can inhibit growth in any planting. So, it was felt that 5 year increments would require fewer model runs and still provides an accurate estimate of what carbon could be sequestered by the trees planted during the 15 year time period using current levels of funding and staffing.

Once estimates were acquired for the carbon each tree could capture at five year increments from iTree-Eco, estimates of carbon captured for every year between 2006 and 2020 were computed. A simple spreadsheet combined the carbon rates for each tree, which were multiplied by the number of actual trees planted (2006 to 2010) or assumed to be planted (2010 to 2020). This provided a yearly estimate of carbon captured for all trees planted and for each cohort (for example all the trees planted in 2006). So, as the trees were "grown" in the spreadsheet, and reached 5 years of age, the rate of carbon sequestration changed, and every five years until the cohort reached 2021. Thus, the 2006 cohort had 15 years of growth and the 2020 cohort had 1 year of growth. The output can be seen in the figure below. Future years used the average number of trees planted between 2006 and 2010, or 837,070 trees.

<u>Step 3: Determine Annual Number of Trees to be Planted</u>

Figure C-44. Carbon Benefits from Planted Trees

	Forest Conservation Act and NRA 5-103(h) Tree Planting	**TreeMendous Maryland & Marylanders Plant Trees Programs**		
Planted Year	Number of Trees Planted	Number of Trees Planted	$MMtCO_2e$/Year	
2006	929,110	8,178	0.0004	
2007	1,094,310	6,057	0.0010	
2008	812,420	2,160	0.0013	

2009	512,440	39,020	0.0016	
2010	837,070	11,643	0.0027	
2011	837,070	11,643	0.0040	* est
2012	837,070	11,643	0.0050	*
2013	837,070	11,643	0.0058	*
2014	837,070	11,643	0.0069	*
2015	837,070	11,643	0.0111	*
2016	837,070	11,643	0.0158	*
2017	837,070	11,643	0.0195	*
2018	837,070	11,643	0.0223	*
2019	837,070	11,643	0.0262	*
2020	837,070	11,643	0.0339	*
	12,556,050	**317,058**	**0.16**	

Step 4: Determine Total GHG Reductions from Sequestration:

Figure C-45. Forest Conservation Act and NRA 5-103(h) Trees Planting Carbon Calculations; Tree-Mendous and Marylanders Planting Trees Tree Planting Carbon Calculations.

FCA and NRA 5-103(h) Tree Planting Carbon Calculations

Year	Trees Planted 2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	TOTAL lbs. C	Convert to Metric Tonne	TOTAL MTCO2e	TOTAL MMTCO2e
2006	981,610	264,642	264,642	264,642	264,642	712,649	712,649	712,649	712,649	712,649	2,580,064	2,580,064	2,580,064	2,580,064	2,580,064	4,865,644	22,387,776	10,155	37,212	0.037
2007		1,136,310	306,349	306,349	306,349	306,349	824,961	824,961	824,961	824,961	824,961	2,986,677	2,986,677	2,986,677	2,986,677	2,986,677	20,283,588	9,200	33,715	0.034
2008			827,953	223,216	223,216	223,216	223,216	601,094	601,094	601,094	601,094	601,094	2,176,192	2,176,192	2,176,192	2,176,192	12,603,101	5,717	20,948	0.021
2009				533,895	143,938	143,938	143,938	143,938	387,608	387,608	387,608	387,608	387,608	1,403,290	1,403,290	1,403,290	6,723,660	3,050	11,176	0.011
2010					837,070	234,536	234,536	234,536	234,536	631,578	631,578	631,578	631,578	631,578	2,286,556	2,286,556	8,669,146	3,932	14,410	0.014
2011						837,070	234,536	234,536	234,536	234,536	631,578	631,578	631,578	631,578	631,578	2,286,556	6,382,590	2,895	10,609	0.011
2012							837,070	234,536	234,536	234,536	234,536	631,578	631,578	631,578	631,578	631,578	4,096,035	1,858	6,808	0.007
2013								837,070	234,536	234,536	234,536	234,536	631,578	631,578	631,578	631,578	3,464,457	1,571	5,759	0.006
2014									837,070	234,536	234,536	234,536	234,536	631,578	631,578	631,578	2,832,879	1,285	4,709	0.005
2015										837,070	234,536	234,536	234,536	234,536	631,578	631,578	2,201,301	998	3,659	0.004
2016											837,070	234,536	234,536	234,536	234,536	631,578	1,569,723	712	2,609	0.003
2017												837,070	234,536	234,536	234,536	234,536	938,145	426	1,559	0.002
2018													837,070	234,536	234,536	234,536	703,609	319	1,170	0.001
2019														837,070	234,536	234,536	469,073	213	780	0.001
2020															837,070	234,536	234,536	106	390	0.000
2021	Total lbs. Carbon/yr	264,642	570,991	794,207	938,145	1,620,689	2,373,837	2,986,251	3,464,457	4,096,035	6,595,028	9,388,322	11,594,997	13,242,257	15,528,813	20,100,949	**93,559,620**		**155,512**	

Tree Mendous and Marylanders Plant Trees Tree Planting Carbon Calculations

Year	Trees Planted 2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	TOTAL lbs. C	Convert to Metric Tonne	TOTAL $MTCO_2e$	TOTAL $MMTCO_2e$
2006	8,178	2,205	2,205	2,205	2,205	5,937	5,937	5,937	5,937	5,937	21,495	21,495	21,495	21,495	21,495	40,537	186,517	85	310	0.00031
2007		6,057	1,633	1,633	1,633	1,633	4,397	4,397	4,397	4,397	4,397	15,920	15,920	15,920	15,920	15,920	108,120	49	180	0.00018
2008			2,160	582	582	582	582	1,568	1,568	1,568	1,568	1,568	5,677	5,677	5,677	5,677	32,880	15	55	0.00005
2009				39,020	10,520	10,520	10,520	10,520	28,329	28,329	28,329	28,329	28,329	102,560	102,560	102,560	491,402	223	817	0.00082
2010					11,643	3,139	3,139	3,139	3,139	8,453	8,453	8,453	8,453	8,453	30,602	30,602	116,025	53	193	0.00019
2011						12,538	3,380	3,380	3,380	3,380	9,103	9,103	9,103	9,103	9,103	32,955	91,989	42	153	0.00015
2012							11,643	3,139	3,139	3,139	3,139	8,453	8,453	8,453	8,453	8,453	54,820	25	91	0.00009
2013								11,643	3,139	3,139	3,139	3,139	8,453	8,453	8,453	8,453	46,367	21	77	0.00008
2014									11,643	3,139	3,139	3,139	3,139	8,453	8,453	8,453	37,914	17	63	0.00006
2015										11,643	3,139	3,139	3,139	3,139	8,453	8,453	29,461	13	49	0.00005
2016											11,643	3,139	3,139	3,139	3,139	8,453	21,009	10	35	0.00003
2017												11,643	3,139	3,139	3,139	3,139	12,556	6	21	0.00002
2018													11,643	3,139	3,139	3,139	9,417	4	16	0.00002
2019														11,643	3,139	3,139	6,278	3	10	0.00001
2020															11,643	3,139	3,139	1	5	0.00001
2021	Total Carbon/yr	2,205	3,838	4,420	14,940	21,811	27,956	32,081	53,028	61,481	85,900	105,876	118,438	201,122	231,725	283,072	**1,247,893**		2,074.2	
	Metric Tonnes C/y	1	2	2	7	10	13	15	24	28	39	48	54	91	105	128		566		
	MMTCO2e/yr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0003	0.0004	0.0005				0.002

Implementation

DNR is working with the General Assembly and various State agencies (MDE, MDA, and the Maryland State Highway Administration), as well as local governments, conservation organizations, private landowners, arboreal industries and others to implement this program. DNR will be working overtime with local communities to secure funding for conducting urban tree canopy assessments and encourage the adoption and implementation of urban tree canopy goals by local communities will continue.

Additionally, DNR will provide outreach and education on the significance of trees and their role in the built environment and control methods for invasive species as well as develop incentives for diverting wood from waste-stream to value-stream. And finally, from an adaptation perspective, DNR is working to encourage policies requiring tree canopy around at risk populations such as schools (green schools program), nursing homes, shelters and public buildings. The current productivity of this program cannot be attained if there is a future reduction in staff and funding.

To date, seventy-nine communities have received urban tree canopy assessments, seventy-five communities are awaiting completion of their urban tree canopy assessments, and eight communities have established goals. The Marylanders Plant Trees program's tree registry states that 182,000 trees have been planted and registered as of August 2012. DNR has received a grant from the U.S. Forest Service which has enabled the Chesapeake Bay Trust to award funding to help communities in Maryland implement "greening" plans that increase forest canopy, reduce stormwater runoff, improve air quality, and enhance the quality of life in urban areas.

The Maryland DNR Forest Service assists local jurisdictions through the implementation of the below statutes and regulations and also via requests for assistance from the locals. Tree planting assistance for local governments and citizens is also provided through the TreeMendous Maryland and Marylanders Plant Trees programs.

Funding to implement the urban canopy implementation plan's tree plantings can be obtained from the local jurisdiction's Forest Conservation ordinance fee-in-lieu fund.

J.1: Creating Ecosystem Markets to Encourage GHG Emissions Reductions

Lead Agency: DNR

Program Description

Increased attention to the benefits and cost efficiencies that ecosystem markets could provide has spurred DNR to evaluate the potential its programs and policies may have for fostering market development, as DNR is the lead regulatory or administrative agency for several ecosystem markets that provide carbon sequestration benefits. Maryland's Forest Conservation Act and Critical Area Act require mitigation for natural resource impacts generated through land development, and mitigation banking is an option to address these mitigation requirements. DNR works with landowners to conduct forest management, reforestation and afforestation projects. Although not developed at the State level, species habitat banking may be another market arena that has future potential for DNR's involvement. Beyond these programmatic linkages, DNR also owns and manages lands and purchases easements from willing landowners. These lands can potentially provide a supply of ecosystem market credits.

In fall 2010, DNR convened the Ecosystem Services Working Group, which consisted of representatives from State agencies, the private sector, and a non-profit organization. The Working Group assessed existing programs to determine which practices and programs could play a role in promoting private sector involvement in developing ecosystem markets. Ecosystem services programs, policies, and current or potential markets assessed by the Ecosystem Services Working Group include wetlands, streams and waterways, forests, critical areas, species and habitats, nutrients, carbon and biomass.

The Ecosystem Services Workgroup released its final report in October 2011 with recommendations identified for expanding the role of ecosystem markets in Maryland. As the next step in this process, Governor O'Malley has directed his Chesapeake Bay cabinet agencies to work together to review the recommendations and propose an action plan and timeline for expanding ecosystem markets in Maryland.

If it is ultimately determined that certain markets should be fostered and that this would advance our natural resource goals, mitigation benefits could begin to be calculated. Benefits would fall into two categories: 1) Avoidance / minimization benefits and 2) Net environmental enhancements. Avoidance / minimization benefits would be achieved when the costs to replace ecosystem services become a disincentive to a development project. Net environmental enhancements would be those benefits achieved when replacement ratios exceed 1:1 or if economic efficiencies derived through the market place allow more restoration and conservation projects to be conducted at lower costs.

The following is a list of ecosystem services program, policies, and current or potential markets that were analyzed and assessed by the Ecosystem Services Working Group.

Wetlands

Once receiving authorization to permanently impact a wetland, an applicant can propose mitigation, purchase credit from an approved wetland mitigation bank, or payment in the MDE In-Lieu Fee Program. If an approved wetland mitigation bank is within an approved service area and has available credits, the applicant must purchase credit from this bank rather than paying into the In-Lieu Fee Program. MDE's Wetland & Waterways Program is well established as the lead authority at the State level. Interjurisdictional cooperation, however, is paramount to the Program's successful implementation and pursuing banking opportunities, specifically with how it relates to the U.S. Army Corps of Engineers based in Baltimore.

Streams and Waterways

Stream and waterway markets and mitigation activities require great cooperation at all levels of government, especially between Maryland and the U.S. Army Corps of Engineers. This process, coupled with the process of creating stream mitigation banks, fosters high transaction costs and market uncertainty, thereby reducing market options. A major challenge is that there is no developed, accepted protocol for assessing and characterizing impacted streams. Therefore, there is no empirical or objective method of calculating the ecological impacts that need to be mitigated.

Forests

Maryland's Forest Conservation Act requires that a certain amount of forests be retained or replanted in response to land use changes of one acre or greater. This is not intended as a no-net-loss program; rather, it seeks to reduce the rate of forest loss resulting from development. The preferred order of mitigation is onsite retention or planting; offsite retention or planting; retention and creation banks; and, lastly, fee-in-lieu payments. Administration of the Forest Conservation Act programs occurs at the local government level with very little inter-jurisdictional consistency on mitigation rules, creating a barrier for markets implemented at the watershed or State level. Further, almost all counties collect fee-in-lieu payments, but it is unknown exactly how funds are expended. While the Forest Conservation Act has been very successful in slowing the rate of forest loss, there continues to be great concern over losing any forest at all because of the critical ecosystem services they provide. In 2009, Governor O'Malley appointed a Sustainable Forestry Council to develop a definition and implementation plan for a No Net Loss policy recommendation for Maryland forests. Current fee-in-lieu pricing is well below the actual costs of developing banks, and the low fees may potentially block out the market for Forest Conservation Act banks.

Critical Areas

Maryland's Critical Area Program for the Chesapeake and Atlantic Coastal Bays was established in 1984 by the Critical Area Protection Act. The law identifies the Critical Area as all tidal waters and wetlands and all land within 1,000 feet of these resources. A basic premise of this program is that land use and development in the Critical Area, because of the physical proximity of this land to Maryland's ecologically sensitive aquatic resources, must be carefully managed, and in some areas, limited by certain density and use restrictions. Generally, impacts to resources located within the Critical Area must also be mitigated within the Critical Area. Successful implementation of this program requires a high level of intergovernmental cooperation since local governments implement these Statewide laws and regulations.

Specific to ecosystem markets, four market opportunities within the Critical Area Program have been identified: Forest Clearing; Forest Interior Dependent Species

Habitat; Forest Buffer Impacts; and, Stormwater Pollutant Removal. However, mitigation banks are underdeveloped thus far in Maryland.

Species and Habitats

Habitat banks, or conservation banks, are parcels of land that are conserved and managed to protect specified federal and State rare, threatened, and endangered species and their critical habitat. The banks are used to offset development impacts occurring elsewhere to the same resources and must be approved by the U.S. Fish and Wildlife Service and DNR. Currently, Maryland has no formal bank program for federal and State listed endangered species. Development of a new program may require additional administrative budget and staff, or partnership with a non-profit organization, such as the Bay Bank, to help facilitate. At this time, a few conservation banks are in early stages of development, including Tiger Beetle habitat (U.S. Fish and Wildlife Service, DNR) and Brook trout habitat (The Bay Bank). The potential benefits of a market approach for certain appropriate species and habitats need to be explored.

Nutrients

Maryland's Nutrient Trading Program is a public, voluntary marketplace for the buying and selling of nutrient credits. The program, administered by MDA, establishes economic incentives for the use of existing and/or additional agricultural practices and structures to offset new or increased nutrient loads and maintain reductions from all sources within a watershed. The requirements and procedures for point-to-nonpoint agricultural trading, which were issued in April 2008, provide the mechanism for generating credits from agricultural sources and describe how credits will be exchanged between buyers and sellers. The program is operational and accessible, however, no transactions have occurred, and large-scale trading is not expected until new statewide growth offset policies are finalized. More information about the nutrient trading program can be found in this plan under Ag and Forestry-10: Nutrient Trading for GHG Benefits.

Carbon: RGGI and Maryland CO_2 Budget Trading Program Offsets

Started in 2009, the Maryland CO_2 Budget Trading Program is the regulatory subtitle for Maryland's participation in RGGI. The RGGI Model Rule, from which Maryland adopted its regulations, contains a voluntary carbon offsets chapter that outlines a process for submitting and approving voluntary offsets projects that eventually generate CO_2 offset allowances. CO_2 offset allowances are traded through a public access website called the CO_2 Allowance Tracking System located on RGGI's website. At this point, the regulations for the offsets program under the Maryland CO_2 Budget Trading Program restrict most Maryland-based offsets projects.

Carbon: Greenhouse Gas Emissions Reduction Act of 2009 - Offsets and Early Reductions

GGRA requires the 2012 Plan to provide for the use of offsets and early voluntary action credits to achieve compliance with the GHG reduction goal. Based on GGRA, offset credits would be generated by alternative compliance mechanisms executed within the State, including carbon sequestration projects. The legislation also contains language for providing 'credit' to GHG sources for voluntarily reducing GHG emissions in advance of implementing GGRA.

Carbon: Greenhouse Gas Emissions Reduction Act of 2009 - Nutrient Trading with Carbon Co-Benefits

One GGRA program under development to assist in achieving the GHG reduction goal is Nutrient Trading with Carbon Co-benefits. Since many of the agronomic, land use, and structural practices promoted by the Maryland Nutrient Trading Program administered by MDA also store carbon and lower other GHG emissions, the existing nutrient marketplace provides a platform for the addition or “stacking” of a voluntary carbon component.

A public and private stakeholder advisory process, started in November 2009, has begun assessing mitigation activities, determining a menu of eligible practices, and developing draft policies and guidelines that could be used to implement a complementary carbon trading program.

Biomass

Markets for woody biomass may contribute to the sustainable management and conservation of Maryland’s forests by expanding the range of forest management opportunities available to landowners and resource managers. The State will promote the use of locally produced woody biomass for generation of thermal energy and electricity. Energy from forest by-products would offset fossil fuel-based energy production and associated GHG emissions.

Maryland has up to 3,000 opportunities to produce both usable heat and electricity in the most fuel-efficient manner available, and biomass may be an ideal fuel for a number of combined heat and power facilities. State agency leadership will be briefed on the numerous benefits of wood energy and catalog solutions for removing barriers to developing this technology. Furthermore, State agency leadership should begin developing policy that recognizes thermal energy (i.e., heating/cooling) as the largest source of energy consumption in Maryland. Additionally, incentives to utilize locally produced wood should be offered to meet thermal energy needs. State energy policies should be modified to specifically recognize wood as a preferred renewable energy source on par with solar, geothermal, and wind. Financial incentive programs should be established that encourage wood energy development.

Estimated GHG Emission Reductions in 2020

With the exception of the GHG reduction benefits for nutrient trading, under Maryland’s Nutrient Trading Program, potential reductions from ecosystem markets cannot be quantified until an active set of markets has been established and protocols to assess GHG benefits have been developed. In order to account for similarities across programs, all emission benefits and costs associated with the Nutrient Trading program are discussed and aggregated under J.2: Nutrient Trading for GHG Benefits.

Implementation

The formation of the Ecosystem Services Workgroup originated from the 2010 Green Jobs and Industry Task Force Recommendations prepared for Governor O'Malley, under the leadership of DBED. The Green Jobs and Industry Task Force was convened to determine how Maryland can promote green, environmentally-friendly jobs and work toward a more sustainable economy. Formed in fall 2010, the Ecosystem Services Workgroup is an interagency and private sector group that was charged to evaluate the potential of existing and future ecosystem service markets in Maryland to advance conservation and restoration goals, including the State's GHG reduction goal, generate new jobs and improve the efficiency of government spending. Workgroup tasks addressed the following five elements:

1. Identify & compile Maryland's ecosystem markets and trading programs
2. Review other states' ecosystem markets & policies
3. Assess current status in term of market impacts
4. Address ecosystem services valuation
5. Develop policy recommendations to foster and take advantage of market opportunities

The Ecosystem Services Workgroup produced an interim report in December 2010 that evaluates the status of potential or existing forest, nutrient, wetland, species habitat, carbon, stream and Critical Area resource markets in the Maryland. The report also highlights success stories of ecosystem service markets in other jurisdictions, provides observation by workgroup members and provides a list of recommended future actions to Executive Branch on the next steps that should be taken to foster and take advantage of market opportunities. This report constitutes a workplan for the continuance of the Ecosystem Services Workgroup, in preparation for the final report released in October 2011. Governor O'Malley has directed his Bay cabinet agencies to work together to review the recommendations and propose an action plan and timeline for expanding ecosystem markets in Maryland.

This program is still under development. If determined to be feasible, the program will be implemented through new legislation, as needed and adoption of new regulations or amendment of existing regulations by the appropriate State agencies, including DNR, MDE and MDA.

J.2: Nutrient Trading for GHG Benefits

Lead Agency: MDA

Program Description

Since many of the agronomic, land use, and structural practices promoted by the Maryland Nutrient Trading Program administered by MDA also store carbon and lower other GHG emissions, the existing nutrient marketplace provides a platform for the addition or "stacking" of a voluntary carbon component. A public and private stakeholder advisory group started in November 2009 to assess mitigation activities, determine a menu of eligible practices and develop the policies and guidelines to implement a complementary carbon trading program. Just like the nutrient market upon which it will be based, carbon trading offers entities under regulatory requirements a potentially more cost-effective means to meet their obligations while providing farmers and landowners the opportunity to receive compensation for implementing and maintaining conservation practices.

MDA will add carbon credits and enhanced nutrient credits to the Maryland Nutrient Trading Program. Carbon and enhanced nutrient credits would be "stacked" onto existing nutrient credits as tradable commodities, thereby increasing the potential value of the total credit package and taking an incremental step in creating a comprehensive environmental marketplace. Encouraging trades between nonpoint sources, such as agricultural operations, and point sources, such as wastewater treatment plants, industrial facilities, and highway contract and development projects, would create new possibilities for GHG reductions while also improving water quality, reducing fertilizer runoff and soil erosion, restoring wetlands and wildlife habitat, providing supplemental income for farmers and foresters, and promoting Smart Growth goals by preserving agricultural and forested lands.

Estimated GHG Emission Reductions in 2020

Figure C-46. Low and High GHG Benefits for Ag and Forestry-10

Initial Reductions	0.09 $MMtCO_2e$	MDE Quantification Below
Enhanced Reductions	0.57 $MMtCO_2e$	MDE Quantification Below

Low and High Estimates – MDE Quantification

The Center for Integrative Environmental Research together with the World Resources Institute developed a dynamic systems model of agriculture in Maryland to calculate carbon sequestration and marketable supply resulting from various nutrient trading activities through 2030. The December 2010 "Multiple Ecosystem Markets in Maryland, Quantifying the Carbon Benefits Associated with Nutrient Trading" report quantifications form the basis for an estimated carbon credit calculation of 0.822 $MMtCO_2e$ of sequestration. Using the report (page 19), the adjusted carbon is calculated by reducing the total carbon high estimate from the Center for Integrative Environmental Research Report number by 20 percent. The result is 0.8224 $MMtCO_2e$ in 2020. MDE estimated an additional 0.21 $MMtCO_2e$ of GHG emission reductions through more efficient use of fertilizer and reduced runoff and volatilization.

Based on analysis and calculations, the total annual estimated benefits of the nutrient trading program for GHG emission reductions is 1.03 $MMtCO_2e$ emissions in 2020 for the high estimate model.

Assumptions

- Nutrient Management Plans – State law. Assumed 80 percent of land was associated with a plan; added 20 percent additional in increments.
- Conservation tillage – Low till methods have a small cost, assumed 2 percent property per year in cropland management.
- Cover crops – plant land that would sit open in off planting season; reduce runoff and sediment assumed 7 percent participation per year.
- Forest and Grass riparian buffer – 35 foot buffer, applied at 3 percent for forest and 1 percent grass.
- Wetland restoration (also called Critical Area Market) – redevelopment, increase 3 percent a year.
- Could include Species and Habitat Markets, Habitat banks, or conservation banks, are parcels of land that are conserved and managed to protect specified federal and State rare, threatened, and endangered species and their critical habitat.

Implementation

Maryland's Nutrient Trading Program is a public, voluntary marketplace for the buying and selling of nutrient credits. The program, administered by MDA, establishes economic incentives for the use of existing and/or additional agricultural practices and structures to offset new or increased nutrient loads and maintain reductions from all sources within a watershed. The requirements and procedures for point-to-nonpoint agricultural trading were issued in April 2008, provide the mechanism for generating credits from agricultural sources, and describe how credits will be exchanged between buyers and sellers. The program was developed with input from the private sector. The program is operational and accessible, however, no transactions have occurred and large-scale trading is not expected in the near term because of the large Phase I Watershed Implementation Plan growth allocations for wastewater treatment plans.

The Maryland Nutrient Trading Program developed by MDA already maintains the embedded capacity to stack carbon and sediment on the Maryland nutrient trading platform, which is based on the World Resources Institute's NutrientNet suite of tools and incorporates both the Chesapeake Bay Program models and the enhanced capabilities of the national Nutrient Tracking Tool developed by U.S. Department of Agriculture's Natural Resources Conservation Service. Through a federal grant awarded to the World Resources Institute in 2010, MDA joined with agencies from four other Bay states in the development, testing, and rollout of an interstate trading model, as well as a farm profit calculator to help landowners, producers, and service providers conduct cost benefit analysis of trading participation.

MDA received a Natural Resources Conservation Service's State Conservation Innovation Grant to use the online nutrient calculation tool to assess and inventory voluntary agricultural conservation practices to determine compliance with the Chesapeake Bay watershed's total maximum daily load limits for nitrogen and phosphorous. This inventory has served as a resource for a 2010 MDE study conducted by the University of Maryland's Center for Integrative Environmental Research investigating both the carbon sequestration potential associated with nutrient trading and marketable supply expectations under differing regulatory and pricing structures.

MDA will continue to train State soil conservation staff and other interested third parties in the use of the Nutrient Trading Program's online assessment tool, marketplace, and registry and continue to hold public meetings across the State to provide an overview of both point and nonpoint source policies, the salient features of the Nutrient Trading Program, and future carbon stacking opportunities. Work with DNR, MDE, and other public and private stakeholders will continue to develop menus, policies, and guidelines for use in the complementary program of carbon reduction that can be added to the nutrient trading platform. By 2020, MDA aims to achieve participation by 10 percent of farms and landowners in providing nutrient and carbon credits to an active environmental market in Maryland and establish commonalities among Bay State trading programs and create a shared platform to facilitate interstate trades. The Maryland program offers a template that can be used as a model for basin-wide trading programs in other parts of the country.

Sub-Appendix C-5: Buildings Programs

K: Building and Trade Codes

Lead Agency: DHCD

Program Description

Given the long lifetime of most buildings, amending State and/or local building codes to include minimum energy efficiency requirements and periodically updating energy efficiency codes provides long-term GHG savings. DHCD is in charge of adopting the Statewide building code known as the Maryland Building Performance Standards.[76] DHCD's Maryland Codes Administration adopts the Maryland Building Performance Standards through the regulation process, which includes a public informational hearing and a public comments period. Prior to starting the regulation process, the Maryland Codes Administration also seeks preliminary input from local building code officials.

As required by Statute, Maryland's core building code is based on two International Code Council publications – the International Business Code and the International Residential Code. Both sets of codes are incorporated by reference into the Maryland Building Performance Standards regulations and form the critical foundation for the Statewide standards. The Maryland Codes Administration also incorporates the International Energy Conservation Code into other codes recommended by the State Fire Marshall and the Department of Labor Licensing and Regulation.

The Maryland Building Performance Standards is updated by regulation every three years following the three-year cycle of the International Code Council for publishing new editions of the International Residential Code and the International Business Code.

[76] Annotated Code of Maryland, Public Safety, Title §12–503 Maryland Building Performance Standards.

Except for energy conservation standards, DHCD may not adopt provisions that are more stringent than what is contained in either international code.

The Maryland Building Performance Standards Statute requires local jurisdictions with building code authority to adopt the standards; however, local jurisdictions may amend the standards to suit local conditions (e.g., coastal communities may require stricter standards related to storm surge, wind, tides, etc.). Except for energy conservation standards, local jurisdictions may also adopt amendments that lessen certain requirements of the Maryland Building Performance Standards. DHCD does not have authority over the final form of the standard that is implemented by the local jurisdictions since local jurisdictions may make amendments and oversee compliance and enforcement activities within their respective jurisdictions. In addition, DHCD does not have authority over related local development activities such as planning, zoning, environmental permitting, etc. Therefore, the successful adoption and implementation of building codes depends on strong partnerships between the State and local jurisdictions with code authorities.

Estimated GHG Emission Reductions in 2020

Figure C-47. Low and High GHG Benefits for Buildings-2

Initial Reductions	3.15 $MMtCO_2e$	
Enhanced Reductions	3.15 $MMtCO_2e$	

Implementation

The Maryland Building Performance Standards adopted most recently (January 1, 2010) includes the 2009 International Energy Conservation Code, which is the latest energy code published by the International Code Council. Local jurisdictions were required to adopt the 2010 standard within six months (July 1, 2010).

One of the ways DHCD continually helps to reduce energy consumption in new or renovated buildings is through the timely adoption of the latest Statewide building codes, by incorporating the most recently published energy code into the Maryland Building Performance Standards. The most recently adopted standard has been estimated to achieve 15 percent energy efficiency improvements over the prior 2006 energy code. The next energy code will be released in 2012 and that code is expected to achieve an additional 15 percent in energy efficiency improvements over the 2009 codes.

DHCD will continue to provide training on the newest version of the Maryland Building Performance Standards to local jurisdictions, architects, engineers, green building professionals, and other stakeholders. DHCD will also continue to improve, assess, and adopt the latest building codes following the International Code Council three-year cycle of development; participate in the process to improve and develop building codes on a national level, including participation in annual conferences and code development hearings, as funding permits; and identify opportunities to improve and expand much-needed training on building codes, especially those that will continue to be developed relating to energy efficiency and other green building standards.

In 2011, approximately sixty local jurisdictions will adopt the current Maryland Building Performance Standards; this will be the first time that common standards will exist Statewide. DHCD will track local jurisdictions to ensure that updated information is available on the Maryland Codes Administration Web site.

As noted above, the most recent Maryland Building Performance Standards were adopted in January 2010 which includes 2009 International Energy Conservation Code that established 15 percent energy efficiency improvements over 2006 International Energy Conservation Code standards. In July 2010, the Maryland Building Performance Standards were adopted by local jurisdictions. Timely adoption of 2012 international codes into the 2013 Maryland Building Performance Standards will provide an additional 15 percent energy efficiency improvement over the 2009 International Energy Conservation Code.

More recently, in the 2010 General Assembly, Maryland passed House Bill 972 (Chapter 369) – Building Codes – International Green Construction Code. Also adopted in the 2010 session was House Bill 630 (Chapter 135) – Building Standards – High-Performance Homes.

Sub-Appendix C-5: Zero Waste

L: Zero Waste

Lead Agency: MDE

Program Description

In Maryland, waste diversion is defined as the amount of waste recycled and the amount of waste diverted from entering the waste stream through source reduction activities. Waste diversion saves energy, reduces GHGs and other pollutants generated in the manufacturing process and at landfills, saves natural resources, and reduces the amount of waste disposed at solid waste acceptance facilities (*e.g.*, incinerators, landfills, etc.). MDE promotes and encourages waste diversion across Maryland. The promotion and encouragement of waste diversion is accomplished by partnering with Maryland's jurisdictions and the public and private sectors to develop markets for recyclable materials and by working with other State agencies to increase the volume of materials that are diverted from landfills.

In 2012, MDE created a Zero Waste Action Plan. Zero waste is a concept that calls for nearly complete elimination of waste sent to landfills or incinerators for disposal. Instead, the great majority of waste is reused, recycled, composted, or prevented through source reduction. The Zero Waste Action Plan recognizes that in the short term, production of energy from waste through waste-to-energy (WTE) technologies will provide greenhouse gas reductions as the State transitions toward zero waste. The Action

Plan covers the years 2013 through 2030 and establishes the following recycling and waste diversion rate goals:

	2020	2030
Waste Diversion Goal	65%	80%
Recycling Goal	60%	75%

MDE strives to reduce the amount of waste generated (equal to the amount of waste disposed plus the amount of waste recycled) per person through source reduction programs designed to reduce the amount of waste entering the waste stream. MDE's waste generation goal is to maintain a maximum 1.26 tons per person per year waste generation by increasing the source reduction credit rate achieved from 3.55 percent in 2006 to 4.19 percent in 2015 and 5.00 percent in 2020.

MDE also strives to reduce the amount of waste disposed in Maryland through programs that expand recycling and enhance the re-use of products**.** MDE's main waste disposal goal is to reduce the amount of waste disposed by 10.66 percent by 2015 and 28.88 percent by 2020. In accordance with the zero waste goals established above, MDE will also work to increase the recycling rate achieved from 41.16 percent in 2006 to 48.11 percent in 2015 and 60.00 percent in 2020.

The Action Plan sets forth specific policies to achieve these goals, including actions aimed at increasing recycling of key wastes such as packaging (including beverage containers) and food scraps. It seeks to target all sources of waste, including commercial, institutional, multifamily, and residential generators as well as State government. Finally, it emphasizes product stewardship and extended producer responsibility, which are policies that place the environmental and economic costs of products throughout their life-cycle on the producers of those products. The Plan provides estimated timeframes for each action. Most of the actions identified in the Plan are projected to take effect by 2020. Many of the items in the Zero Waste Action Plan will require enabling legislation or new MDE regulations. MDE does not currently have the authority to require additional recycling or waste reduction activities by local or State governments or the business sector.

Composting of food scraps will be one of MDE's major focuses in increasing waste diversion through 2020. Food scraps and yard trimmings comprise an estimated 27.28% of the waste stream (US EPA 2010). In 2010, Maryland recycled 68.51% of yard trimmings but only 4.78% of food scraps. Capturing additional organics, especially food scraps, would provide a significant portion of the additional recycling needed to meet zero waste goals. To illustrate, the following table lists a few scenarios under which the State could meet its zero waste goal of 60% recycling in 2020 with increased composting:

Scenarios for Meeting 2020 Zero Waste Goals with Composting

	No Increase in Composting	Small Increase in Composting	Medium Increase in Composting	Large Increase in Composting
Recycling Rate, Food	4.78% (2010 rate)	50%	68.51%	90%

Recycling Rate, Yard Trim	68.51% (2010 rate)	90%	90%	90%
Recycling Rate Needed for All Other Waste	**67.15%**	**54.89%**	**51.44%**	**47.44%**

Estimated Greenhouse Gas (GHG) Emission Reductions

Figure C-48. Low and High GHG Benefits for Recycling-1

Low Estimate	2.80 $MMtCO_2e$	MDE Quantification Below
High Estimate	4.80 $MMtCO_2e$	MDE Quantification Below

Low and High Estimates – MDE Quantification

Reductions in GHG emissions are calculated using the EPA Waste Reduction Model, also known as the WARM model. This model calculates the benefits of recycling and source reduction (waste diversion) end-of-life waste management practices (vs. landfilling and incineration) and is based on a life-cycle approach (*i.e.*, from production of a product → use of a product → disposal/recycling of a product → production of a product) of a product. The low 2.0 $MMtCO_2e$ estimate is the result of Maryland maintaining a 7.45 pounds per person per day waste generation rate and an average recycling rate equal to the 2006 – 2008 recycling rate through 2020. The high 2.32 estimate raises the recycling rate to 55 percent. Without additional enabling legislation, MDE does not have the authority to require additional waste diversion activities over what the Counties are currently performing.

Other Environmental Benefits

The EPA Waste Reduction Model has produced the following energy scenarios over the life-cycle (*i.e.*, from production of a glass bottle → use of a glass bottle → disposal/recycling of glass bottle → production of a new glass bottle) of common recyclable materials when comparing alternative solid waste management methods vs. the landfilling of a product. (Figure C-74).

Figure C-49. Per Ton Energy Use (British Thermal Unit (BTU)^)

Material	BTU (million) – Landfilled	BTU (million) – Source Reduced	BTU (million) – Recycled	BTU (million) – Combusted
Aluminum Cans	0 **	(126.75) **	(206.95) **	0.12 **
PET Plastic Bottles	0 **	(71.28) **	(53.36) **	(10.57) **
Newspaper	0 **	(36.87) **	(16.91) **	(8.59) **
Glass	0 **	(7.46) **	(2.66) **	0.02 **

^ BTU = 1 British Thermal Unit is a unit of power that is equal to the amount of energy needed to heat 1 pound of water 1° F. It is also used to describe the heat value (energy content) of fuels.

** Values vs. the landfilling of the material. Assigns BTU (million) – Landfilled a value of 0. A negative value (*i.e.*, a value in parentheses) indicates a reduction in energy consumption, while a positive value indicates an increase in energy consumption compared to the landfilling of a material.

In all cases where either recycling or source reduction is used instead of landfilling, there were savings in the amount of energy used. Only when combusting a material instead of landfilling were there increases in the amount of energy used.

Other savings from the recycling of materials are related to conserving natural resources and preserving landfill space. Consider the following:

- According to the Gale Book of Averages and Conservatree.com, recycling 1 ton of paper saves an average of 7,000 gallons (26 liters) of water; 3.3 cubic yards (2.5 cubic meters) of landfill space; and 24 40 foot tall and 6 – 8 inch diameter trees.
- According to Reynolds Metal Company, recycling aluminum saves 4 pounds of bauxite ore for every pound of aluminum recycled
- RRR Technologies reports that natural resources saved by glass recycling are as follows: 1,330 pounds of sand, 433 pounds of soda ash, 433 pounds of limestone, and 151 pounds of feldspar. EPA reports that 1 ton of glass made from 50 percent recycled material saves 250 pounds of mining waste.
- RRR Technologies also reports that in 1987, the U.S. used almost one billion barrels of petroleum just to manufacture plastics. That is enough to meet U.S. demand for imported oil for five months.
- In 2009, 82,020,000 tons of municipal solid waste was recycled or composted in the U.S. According to the EPA Measuring Recycling: A Guide for State and Local Governments, the average municipal solid waste landfill capacity is 1,000 pounds (0.5 tons) per cubic yard. This calculates to a savings of 164,040,000 (*i.e.*, 82,020,000 ÷ 0.5) cubic yards of landfill space saved by recycling and composting in 2009.

Implementation

- Pursuant to 2012 House Bill 929, State government is required to reduce by recycling the amount of the solid waste stream generated for disposal by at least 30 percent or to an amount that is determined practical and economically feasible, but in no case may the amount to be recycled be less than 15 percent. State Agency Recycling Plans require the recycling of glass, paper, metal, and plastic at State-owned or State-operated buildings.

- A State Agency Recycling Plan was developed and implemented as a result of 2010 House Bill 595, which requires recycling of glass, paper, metal, and plastic at State-owned or State-operated buildings. Agencies are now revising their plans to meet the higher goal instituted by 2012 House Bill 929. MDE has encouraged all agencies to strive for at least 40% recycling by 2015.
- Group meetings were held and MDE met with State agencies on a one-on-one basis in order to assist with implementation of recycling programs for glass, paper, metal, and plastic at State-owned or State-operated buildings.
- Regular Solid Waste and Recycling Managers' meetings were held with counties in order to provide technical information to assist in improving waste diversion programs throughout the State.
- A Solid Waste Management Study Group was formed, as a result of the passage of 2010 House Bill 982, for the purpose of evaluating solid waste management processes that reduce the solid waste stream through recycling and source reduction, including: the expansion of recycling efforts in nonresidential markets; the feasibility of commodity-specific targets; and long term funding for solid waste and recycling management.
- A Composting Workgroup was formed in May 2012 in response to 2011 House Bill 817. The law requires MDE, MES, and MDA to study composting in the State and to report to the General Assembly by January 1, 2013 on ways to promote composting in the State.
- MDE participated in conference calls and meetings with State, federal, and local organizations designed to improve waste diversion (*i.e.*, recycling and source reduction) programs.
- Regular County Solid Waste and Recycling Managers' meetings were held, designed to present counties with technical information to assist in improving their waste diversion programs.
- MDE participated in conference calls and meetings on the proper disposal of pharmaceuticals.
- MDE participated in conference calls and meetings with the Association of State and Territorial Solid Waste Management Officials Product Stewardship Task Force to increase awareness of Product Stewardship and with the Solid Waste Recycling Task Force to promote actions that reduce waste, conserve resources, prevent pollution, and foster sustainability through identifying recycling opportunities.
- MDE participated in conference calls pertaining to the National Vehicle Mercury Switch Recovery Program that voluntarily recovers mercury switches from end of life vehicles before they are shredded for recycling.
- MDE regularly participates in the National Partnership for Environmental Priorities program that focuses on reducing the use of potentially hazardous chemicals from products and processes by forming partnerships representing industry, business, municipalities, federal facilities, and tribes with EPA.
- MDE, in partnership with the Maryland Environmental Service, operates a program to increase the number of used oil collection facilities, provide public education material, and maintain an information center to encourage citizens to recycle used motor oil.

- MDE actively participates in the Maryland Recycling Network, a non-profit, volunteer organization committed to promoting waste reduction, recycling, and the conservation of natural resources.
- The MDE provided assistance and sample language to counties to help them revise their county recycling plans to address multifamily residential recycling.
- State government is required to purchase products with recycled content whenever practicable. A 5 percent pricing preference over similar items not made from recycled material is allowed.
- State government agencies have been encouraged to join the State Electronics Challenge, a voluntary program that helps government agencies implement environmentally sound management of their electronics. MDE and Maryland Department of Transportation have joined the State Electronics Challenge.
- State government requires that the following language be included on all Maryland Invitation to Bid Solicitations and Purchase Orders: "All products used in packing, to cushion and protect during the shipment of commodities, are to be made of recycled, recyclable, and/or biodegradable materials".
- Leasing contracts must allow State offices to establish recycling programs.

Sub-Appendix C-6: Leadership-By-Example

M: Leadership-By-Example

M.1: Leadership-By-Example: State of Maryland Initiative

Lead Agency: DGS

Program Description

Through lead-by-example programs, state government in Maryland aims to improve efficiency, reduce waste, and integrate renewable energy practices in all of it's agencies' operations and facilities, as well as their purchasing practices. DGS currently oversees the following lead-by-example programs are embodied in five major initiatives:

- Maryland Green Building Council
- Maryland Green Purchasing Committee
- State Energy Database
- Renewable Energy Portfolio

The first two, The Maryland Green Building Council, and Maryland Green Purchasing Committee are addressed in this Section.[77] Collectively, the programs significantly advance the policy recommendations of the Maryland Commission on Climate Change for the State and local governments to lead by example by reducing their carbon footprints in the construction and operation of their buildings and facilities and in their purchasing practices.[78]

Existing Programs – High Performance Buildings

1. Design/Construction.

Two laws are driving the design and construction of high performance State buildings and schools. The first, the *High Performance Buildings Act of 2008,* requires all new and significantly renovated State buildings over 7,500 square feet, and all new public schools that receive State construction funds, to meet the LEED Silver building standard.[79] The second, *High Performance Buildings Act - Applicable to Community College Capital* Projects, requires community college capital projects that receive State funds to meet or exceed the LEED Silver standard required under the *High Performance Buildings Act.*[80] The Maryland Green Building Council makes recommendations about the State High Performance Building Program, which requires all new or substantially renovated State owned or funded buildings 7,500 gross square feet or larger to achieve USGBC LEED Silver certification.

State capital projects completed or in the pipeline include the following:

- 2008 and 2009 – Two pilot projects were completed and certified LEED Silver.
- Fiscal Year 2009 – Nine projects were funded for design; they are located in five counties and Baltimore City. Several are under construction and one, Pharmacy Hall at the University of Maryland Baltimore Campus (renovations and additions), was completed with LEED certification pending at the time of the *2010 Annual Report.*
- Fiscal Year 2010 - 17 projects were funded for design or design/construction, in nine counties and Baltimore City. Most are in the design phase; several are under construction.

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[77]The third initiative, Maryland Environmental Footprint, is addressed in policy Innovative Initiatives-5, "State of Maryland Carbon and Footprint Initiatives." The last two, Generating Clean Horizons and Project Sunburst, are addressed in policy Energy-12, "Incentive and Grant Programs to Support Renewable Energy".

[78] Maryland Climate Action Plan, August 2008.
http://www.mde.state.md.us/assets/document/Air/ClimateChange/Appendix_D_Mitigation.pdf
http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter4.pdf
The Commission's lead by example recommendations are contained in the Plan's Policy Option RCI-4, "Government Lead-by-Example: Improve Design, Construction, Appliances, and Lighting in New and Existing State and Local Buildings, Facilities and Operations" (Appendix D-3, pp. 28-38, and Chapter 4, p. 81), and Policy Option CC-4, "State and Local Governmental GHG Emissions (Lead-by-Example in Purchasing and Procurement) (Appendix D-5, pp. 10-12, and Chapter 4, p. 109).

[79] Senate Bill 208, Chapter 124, Acts of 2008.

[80] Senate Bill 234 / House Bill 1044, Chapters 527 and 528, Acts of 2010. The requirement applies to capital projects that have not initiated a request for proposals for the selection of an architectural and engineering consultant on or before July 1, 2011.

- Fiscal Year 2011 – Three projects were funded for design; they are located in three counties.
- Fiscal Year 2012 – At the time of the *Maryland Green Building Council 2012 Annual Report,* twenty-two (22) public school projects with LEED certification have been completed, twenty (20) are under construction, and twenty-four (24) are in the design/planning phase. All sixty-six (66) projects are LEED Silver or Gold certified or the LEED certification Silver or Gold status is pending. [81]

In addition, the State will, through Fiscal Year 2014, contribute 50 percent of the extra costs incurred by public schools meeting a LEED Silver rating or comparable standard required under the *High Performance Buildings Act of 2008.*

2. Operation.
DGS administers energy performance contracts to reduce electricity consumption in a number of State agency buildings. As of March 2011, 27 projects were under development with energy service companies. Project costs are to be paid from cost avoidance from guaranteed annual energy savings, which are significant. DGS oversees the monitoring and verification of actual savings throughout the payback period to ensure that the guaranteed savings are met.[82] This initiative is financed in part by the State Agency Loan Program, a revolving loan program through which MEA provides zero-interest loans to State agencies for energy efficiency improvements.[83]

In the Maryland Consolidated Capital Bond Loan of 2012, the Public School Construction Program was approved for a total of $326.393 million in new bond authorization, with $25 million of this amount dedicated to an energy efficiency initiative that is intended to promote projects that improve the energy efficiency of schools, including improvements to HVAC systems, lighting, mechanical systems, windows and doors, and any other type of improvement that is specifically designed to improve the energy efficiency of a school building, per standards to be developed by the Interagency Committee (IAC) in collaboration with the Maryland Energy Administration.

Existing Programs – Procurement

State government has massive purchasing power to select efficient goods from companies that practice energy reduction and sequestration of carbon dioxide as a powerful market stimulant for green businesses and jobs. The Maryland Green Purchasing Committee provides assistance to State units in developing strategies and best practices for

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[81] Detail on individual projects is found in Maryland Green Building Council 2012 Annual Report, http://www.dgs.maryland.gov/press/pubs/2009GreenBldgReport.pdf , 2010 Annual Report, http://www.dgs.maryland.gov/pdfs/2010GreenBldgReport.pdf, and 2012 Annual Report, http://www.dgs.maryland.gov/pdfs/2012GreenBldgReport.pdf

[82] For a list of facilities, estimated cost savings and carbon dioxide emission reductions, and the DGS oversight process, see http://www.dgs.maryland.gov/greeneffort.

[83] EmPOWERingMaryland Clean Energy Programs Fiscal Year 2011 Draft, MEA, pp. 7-8. energy.maryland.gov/documents/fy11programbook.pdf. State Agency Loan Program has been used to upgrade lighting, controls, boilers, chillers, and other energy equipment in State buildings and facilities. Principal funding comes from the RGGI's auction revenues and the American Recovery and Reinvestment Act. http://www.energy.state.md.us/Govt/stateLoan.html

implementing environmentally preferable purchasing practices, maintains a Best Practices Purchasing Manual, and maintains Purchasing Guidelines. The General Assembly established a legislative framework under the *Green Maryland Act of 2010* for environmentally preferable purchasing throughout State government. The law establishes the Maryland Green Purchasing Committee and annual reporting requirements for State agencies and directs DGS and MDE to develop implementing strategies, best practices and specifications. It boosts the State's required purchase of recycled paper from 40 percent to 90 percent of total volume purchase and increases the price preference for recycled products from five percent to eight percent. It also establishes preferential purchasing and goal setting to increase the use of compost as fertilizer in public lands and programs.[84]

<u>Programs under Consideration</u>

- DGS will work with the Governor and General Assembly to amend the State's high performance buildings standards to:
    - Require government-owned buildings, including public schools and hospitals, undergoing major renovations for which permits are requested between 2012 and 2013 to meet LEED Gold ratings or a comparable standard.
    - Require new construction and major renovations for which permits are requested between 2013 and 2020 to meet LEED Platinum ratings or a comparable standard.

- DGS will develop and administer an audit and tracking protocol to ensure that State building systems are installed and are performing as designed to meet high performance criteria.
- DGS will develop and administer a training program for technical personnel in charge of operating State building systems to ensure that the systems are operated and maintained to achieve the building's highest energy efficiency and performance standards.
- DGS will benchmark State buildings to compare efficiency among similar buildings to set priorities for improvement.
- DGS will work with State agencies to provide meters, energy accounting systems, and trained staff to measure and verify energy consumption and account for improvements and implementation of energy efficiency programs.
- DGS will develop and administer education and outreach programs to local governments, businesses, and institutions to promote widespread adoption of the State's lead-by-example practices in buildings, operations and purchasing.[85]
- DGS will develop strategies to encourage State and local government agencies, businesses and industry, and citizens to consider at the purchase stage, the end-of-life disposal stage of equipment and goods.

<u>Estimated Greenhouse Gas Emission Reductions in 2020</u>

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[84] Senate Bill 693 / House Bill 1124, Chapters 593 and 594, Acts of 2010.
[85] Some of these programs are recommended in the 2008 Climate Action Plan, su*pra*., fn. 2.

Figure C-50. Low and High GHG Benefits for Innovative Initiatives-5

Initial Reductions	0.56 $MMtCO_2e$	MDE Quantification Below
Enhanced Reductions	0.88 $MMtCO_2e$	MDE Quantification Below

High Estimate – MDE Quantification

Figure C-51. Summary of Estimated Avoided GHG Emissions in 2020 ($MMtCO_2e$)

Emissions Reductions	Low Estimate	High Estimate
1. eFootprint	0.39	0.79
2. Local Government	0.45	0.90
3. Schools	0.20	0.40
4. DGS Environmental Performance Contracts and Public School Energy Efficiency Initiatives	0.10	0.10
5. LEED	0.26	0.38
Total	**1.45**	**2.56**

1. Maryland eFootprint (Innovative Initiatives-6)

2008 base year emissions for State government operations were obtained from the eFootprint web site (http://www.green.maryland.gov/carbon_footprint_page.html). The benefits for 25 percent reduction from the base year (2008) and 50 percent reduction from the base year are summarized in the Figure C-93.

Figure C-52. Summary of GHG benefits for a 25 Percent Reduction

2008 Base Year $MMtCO_2e$	25% Reduction	Low Estimate	50% Reduction	High Estimate
1.58	1.19	0.40	0.79	0.79

2. Emissions for Local Governments

Six counties and three cities have prepared climate plans using the methods developed by the International Council for Local Environmental Initiatives. Part of these plans identifies emissions that result from government operations. Using base line data in the plans, the benefits are calculated for a 25 percent reduction from the base year and 50 percent reduction from the base year.

Figure C-53. Summary of County Data with a 25 Percent GHG Reduction

County	Base Year	Base Year Emissions		25% Reduction from Base	Low Estimate	50% Reduction from Base	High Estimate
		Metric tons of CO_2-	$MMtCO_2e$				

		equivalent					
Baltimore City	2007	608,988	0.61	0.46	0.15	0.30	0.30
Frederick	2007	134,667	0.13	0.10	0.03	0.07	0.07
Montgomery	FY2005		0.45	0.34	0.11	0.23	0.23
Howard	2007	340,042	0.34	0.26	0.09	0.17	0.17
Prince Georges	FY2007	95,877	0.10	0.07	0.02	0.05	0.05
Baltimore County	2006	142,701	0.14	0.11	0.04	0.07	0.07
Annapolis	FY2006	11,991	0.01	0.01	0.00	0.01	0.01
Chevy Chase	2007	162	0.00	0.00	0.00	0.00	0.00
Takoma Park	1990	1,901	0.00	0.00	0.00	0.00	0.00
					0.45		**0.89**

3. Emissions for Public Schools

The data is from the Maryland Public School Construction Program and includes schools that are currently used for educational purposes. (http://www.pscp.state.md.us/fi/MainFrame.cfm). To estimate emissions:

- STEP 1: Determine the square footage of the school.
- STEP 2: Determine the average annual electricity intensity for building space.

Use Education as the Principal Building Activity. The Annual Electricity Intensity = 11.0 kilowatt-hour per square foot (Source: 2003 Commercial Buildings Energy Consumption Survey, Energy Information Administration (http://www.eia.doe.gov/emeu/cbecs/)

- STEP 3: Calculate electricity consumption.
  - Space (in square feet) X Annual Electricity Intensity (11 kilowatt-hour per square foot) = Annual Electricity Consumption
- STEP 4: Calculate the GHG emissions associated with estimated annual electricity consumption. Use EPA's eGRID emissions factors for 2005
  US Emission Factors for Grid Electricity by eGRID Sub-region

Figure C-54. 2005 GHG Emissions Rates

Region	Pounds carbon dioxide/MWh	Pounds methane / gigawatt-hour	Pounds per nitrous oxide / gigawatt-hour
RFC East	1,139.07	30.2721	18.7146
RFC West	1,537.82	18.2348	25.7088

The base year for these calculations is 2005. A 25 percent to 50 percent reduction is assumed for 2020.

Figure C-55. Comparison of 25 Percent and 50 Percent GHG Reductions

	Base Year 2005	25% Reduction from Base 2020	Low Estimate	50% Reduction from Base 2020	High Estimate
$MMtCO_2e$	0.80	0.6	**0.20**	0.4	**0.40**

4. Energy Performance Contracts

Estimates from work conducted by SAIC under contract to MDE.

Figure C-56. GHG Reductions from Environmental Performance Contracts

Emissions Category	GHG Reductions (Million Metric Tons CO_2e)		
	2012	2015	2020
Environmental Performance Contracts	0.1	0.1	0.1
In-State Electricity	0.0	0.0	0.0
Imported Electricity	0.0	0.0	0.0
Natural Gas	0.0	0.0	0.0

5. LEED

The Lead by Example program is heavily dependent of implementation of the LEED Silver standard for new construction and renovation. According to a report prepared for the City of Santa Rosa in 2007,[86] in order to maximize the benefits from LEED requirements, it is prudent to mandate minimum requirements at some level higher than the minimum point level required for LEED certification. The following figure is from the report:

Figure C-57. Commercial Building GHG Emission Reductions due to Energy Efficiency

Approximate LEED Level	LEED NC Point Level	Metric Tons of GHG Reductions	
		2015	2020
Not Certified	20	1,500	2,400
Certified	26	1,800	2,800
Silver	33	2,000	3,200
Gold	39	2,600	4,000

The author also points out those green building requirements have to be aggressive in order to offset growth in the commercial and residential building sector. That is, if State facilities are to have a measurable impact on GHG emissions, they must be designed and built to the highest standard possible. Base line certification will not be sufficient. Setting a point standard, rather than mandating LEED certification may be more effective in ensuring GHG reductions.

[86] Wanless, Eric (2007) Green Building Policy Options for Reducing Greenhouse Gas Emissions: Analysis and Recommendations for the City of Santa Rosa. Report commissioned by the Accountable Development Coalition

LEED emissions were calculated using the assumptions about the number of buildings in the program description and the GHG reductions described in the quantification document. Base reductions represent 2020 Silver LEED and aggressive reductions represent 2020 Gold LEED

Figure C-58. GHG Reductions from LEED certified Public School Projects

				Metric Tons GHG Reductions		Estimated Benefits Metric Tons		Low Estimate $MMtCO_2e$
Fiscal Year	**Projects**	**Certification**	**Points**	**2015**	**2020**	**2015**	**2020**	**2020**
2012	66	Silver	33	2,000	3,200	132000	211200	0.21
							Total	**0.26**
				Metric Tons GHG Reductions		**Estimated Benefits Metric Tons**		**High Estimate $MMtCO_2e$**
Fiscal Year	**Projects**	**Certification**	**Points**	**2015**	**2020**	**2015**	**2020**	**2020**
2012	66	Gold	39	2,600	4,000	171600	264000	0.26
							Total	**0.26**

Implementation

The State's lead-by-example programs in high performance buildings and procurement are statutorily driven. DGS shares responsibility with the Board of Public Works, MDE, the Department of Budget and Management, Maryland Green Building Council, and Maryland Green Purchasing Committee for administering them. Programmatic progress is tracked in annual reports which both the Maryland Green Building Council and the Maryland Green Purchasing Committee are required to submit to the General Assembly

Innovative Initiatives-3: Leadership by Example: Maryland Colleges and Universities

Lead Agency: MDE

Program Description

Leadership by example accomplishes not only the fulfillment of a task or tasks, but also provides direction for others. Leadership by example offers a guide for others to do something they haven't done or aren't even sure is possible. As the State endeavors to achieve a 25 percent reduction of GHG emissions by 2020 (2006 baseline), leadership by example emerges as an essential element and becomes increasingly more crucial to a successful outcome as more businesses and households endeavor to reduce GHG emissions but need direction.

In Maryland, the presidents' of 22 colleges and universities have signed the American College and University Presidents Climate Commitment. The commitment requires each school to complete a GHG inventory, develop a climate action plan and implement strategies to reduce GHG emissions to achieve a set target. Schools are encouraged to commit to become climate neutral by a certain date, as established by each university. Climate neutrality requires GHG emissions sourced from the school, to be reduced or mitigated from a base year, with remaining emissions offset by purchasing carbon credits or other means.

All of the Maryland institutions have committed to other tangible actions in addition to the general requirements of the commitment, as depicted in Figure C-85, including:[87]

1. Establish a policy that all new campus construction will be built to at least the U.S. Green Building Council's LEED Silver standard or equivalent.
2. Adopt an energy efficient appliance purchasing policy requiring purchase of Energy Star certified products in all areas for which such ratings exist.
3. Establish a policy offsetting all GHG emissions generated by air travel paid for by the institution.
4. Encourage use of and provide access to public transportation for all faculty, staff, students and visitors to the institution.
5. Within one year of signing this document, begin purchasing or producing at least 15 percent of the institution's electricity consumption from renewable sources.
6. Establish a policy or a committee that supports climate and sustainability shareholder proposals at companies where our institution's endowment is invested.
7. Participate in the Waste Minimization component of the national RecycleMania competition, and adopt three or more associated measures to reduce waste.

Estimated GHG Emission Reductions in 2020

Figure C-59. Low and High GHG Benefits for Innovative Initiatives-3

Low Estimate	0.37 $MMtCO_2e$	MDE Quantification Below
High Estimate	0.37 $MMtCO_2e$	MDE Quantification Below

Estimates – MDE Quantification

In Maryland, the presidents of 22 colleges and universities have signed the American College & University Presidents' Climate Commitment, which requires each school to complete a GHG inventory, develop a climate action plan and implement strategies to reduce GHG emissions to achieve a set target. Of the Maryland institutions participating in the commitment, thus far 21 have completed a GHG inventory and nine have completed a climate action plan. The target dates vary by institution.

Each college and university participating in the commitment is required to develop a GHG inventory. To estimate the lower bound of GHG emission reductions expected by 2020, only schools with established targets for 2020 were included. The total estimated GHG emissions reduction in 2020 by 17 Maryland colleges and universities is 782,262

[87] ACUPCC Reporting System, November 10, 2010, available: http://acupcc.aashe.org/.

metric tons of carbon dioxide equivalents (0.782 $MMtCO_2e$). To estimate the upper bound, established targets for 2020 were used if available; otherwise, it was assumed each school would reduce emissions from scope 1 and scope 2 by 20 percent by 2020 based upon each school's base year.[88] The estimated GHG emissions reduction in 2020 including all 21 Maryland colleges and universities which have completed a GHG emission inventory is 820,989 metric tons of carbon dioxide equivalents (0.821 $MMtCO_2e$).[89]

B. Detailed Explanation of Methodology

Each college and university participating in the commitment is required to develop a GHG inventory. The GHG emission reductions were estimated by combining the business-as-usual baselines for 2020 from each school, then projecting the reductions expected in 2020. The business-as-usual baselines for each school (see Figure C-86) were projected for 2020 by using available data from each school's inventory. If only one year of data was available, the baseline emissions were assumed to increase by 2 percent each year.

To estimate the lower bound of GHG emission reductions expected by 2020 (Figure C-87), only schools with established targets for 2020 were included. The column labeled "assumptions for 2020 reductions" describes the established targets for 2020 according to school. The business as usual baselines for each school are transferred directly from Figure C-86. The result of applying the established target for 2020 for each school to the business as usual baseline is the amount in metric tons of carbon dioxide equivalents (metric tons of CO_2-equivalent) contained in the "2020 Reductions" column. The sum of the "2020 Reductions" column provides the final result. By including only schools which have an established GHG emission target in 2020, the total estimated GHG emissions reduction in 2020 by 17 Maryland colleges and universities is 782,262 metric tons of carbon dioxide equivalents (0.782 $MMtCO_2e$).

To estimate the upper bound (Figure C-88), established targets for 2020 were used if available; otherwise, it was assumed each school would reduce emissions from scope 1 and scope 2 or from scope 1, 2, and 3 (depending upon the inventory information available), by 20 percent by 2020 based upon each school's base year. In Figure C-88, the column labeled "assumptions for 2020 reductions" describes the established targets for 2020 according to school or if the school does not have a 2020 target, it is assumed that emissions from scope 1 and scope 2 will be reduced by 20 percent by 2020 based upon each school's base year. The business as usual baselines for each school are transferred directly from Figure C-86. The result of applying the established target for 2020 for each school to the business as usual baseline is the amount in metric tons of

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88 Scope 1 emissions are considered direct emissions from sources that are either owned or controlled by the school. Scope 2 emissions are indirect emissions resulting from the generation of electricity, heating and cooling, or steam generated off-site but purchased by the school. Scope 3 emissions are indirect emissions from sources not owned or directly controlled by the school but related to the school's activities, such as travel and commuting. (As defined by the EPA: http://www.epa.gov/greeningepa/ghg/index.htm)

89 One school has not completed a GHG inventory at this time and therefore, was not included in this estimation.

CO_2-equivalent contained in the "2020 Reductions" column. The sum of the "2020 Reductions" column provides the final result. The estimated GHG emissions reduction in 2020 including all 21 Maryland colleges and universities which have completed a GHG emission inventory is 820,989 metric tons of CO_2-equivalent (0.821 $MMtCO_2e$).

C. Calculations

In Figure C-86, actual data and projections from each school are used when available. If only one data point was available for the base year, then each subsequent year was assumed to increase by 2 percent or X_i * (1.02), where X is the value for year i.

If a baseline projection was not available for 2020, the amount of GHG emissions is projected using the method of least squares to fit a straight line to the arrays of known variables to determine the GHG emissions according to year, using the following formula:

$$GHG_i = Slope * Year_i + intercept$$

Where

GHG_i = Baseline GHG emissions projected in year i

The 2020 reductions in Figures C-87 and C-88 were estimated using the following formula:

$$RED_{2020i} = BAU_{2020i} - [(1 - TAR_i) * SCP_i)$$

Where

RED_{2020} = the total GHG emissions reduction estimated for 2020 based upon the assumptions for each school

BAU_{2020} = The business as usual emissions estimated for each school (i) in 2020

TAR_i = Percentage reduction target for 2020 for each school (i) in 2020

SCPi = Scope 1, Scope 1 and 2, or Scope 1, 2, and 3 emissions (depending upon each school's applicable target for 2020) estimated in 2020

D. Data and Data Sources

Figure C-60: Baseline GHG Emissions (metric tons of CO_2-equivalent) Projections

	2005	2006	2007	2008	2009	2010	2015	2020
Bowie State University	14,348	14,086	17,824	18,244	19,846	21,320	28,692	**36,065**
Community College of Baltimore County			18,135	18,498	18,868	19,245	21,248	**23,460**
Coppin State				3,975	4,055	4,136	4,566	**5,041**

University								
Frostburg State University	30,299	30,335	30,370	32,388	33,300	34,212	38,775	**43,337**
Goucher College								**11,500**
Harford Community College				6,057	6,178	6,302	6,958	**7,682**
Howard Community College	30,045	30,839	34,095	35,710	37,734	39,759	49,883	**60,007**
McDaniel College				15,259	15,564	15,875	17,528	**19,352**
Morgan State University					45,753	46,668	51,525	**56,888**
Mount St. Mary's University	15,621	15,826	16,899	16,734	17,021	17,307	18,740	**20,173**
Salisbury University	26,696	27,230	27,775	28,330	28,897	29,475	32,542	**35,929**
St. Mary's College of Maryland	14,289	16,036	21,085	25,937	19,322	20,379	25,701	**31,367**
Towson University			52,653	53,706	54,780	55,876	61,691	**68,112**
University of Baltimore				16,220	16,544	16,875	18,632	**20,571**
University of Maryland, Baltimore				166,307	169,633	173,026	191,034	**210,917**
University of Maryland, Baltimore County			89,761	90,952	92,143	93,335	99,291	**105,246**
University of Maryland, Center for Environmental Science				13,399	13,667	13,940	15,391	**16,993**
University of Maryland, College Park	365,334	370,506	387,967	405,428	422,889	440,350	527,655	**614,959**
University of Maryland, Eastern Shore					23,207	23,671	26,135	**28,855**
University of Maryland, University College				22,806	23,262	23,727	26,197	**28,924**
Washington			15,289	15,595	15,907	16,225	17,914	**19,778**

Figure C-61: Schools with Established 2020 GHG Reduction Targets (metric tons of CO_2-equivalent)

Institution	**Assumptions for 2020 Reductions**	**2020 Business As Usual Emissions**	**2020 Reductions**
Bowie State University	20% reduction in total scopes 1 & 2	36,065	7,213
Community College of Baltimore County			
Coppin State University	15% reduction in total scopes 1 & 2	5,041	1,008
Frostburg State University	50% reduction in total scopes 1, 2, 3	43,337	21,669
Goucher College	20% reduction in total Scopes 1, 2, 3	11,500	2,300
Harford Community College			
Howard Community College	90% reduction in total Scopes 1, 2, 3	60,007	56,597

McDaniel College	25% reduction in total scopes 1 & 2	19,352	4,838
Morgan State University			
Mount St. Mary's University			
Salisbury University	30% reduction in total scopes 1, 2, 3	35,929	10,779
St. Mary's College of Maryland	30% reduction in total Scopes 1, 2, 3	31,367	9,410
Towson University	20% reduction in total scopes 1 & 2	68,112	13,622
University of Baltimore	50% reduction in total scopes 1, 2, 3	20,571	10,285
University of Maryland Baltimore	25% reduction in total scopes 1, 2, 3	210,917	52,729
University of Maryland Baltimore County	25% reduction in total scopes 1, 2, 3	105,246	26,312
University of Maryland Center for Environmental Science	23% reduction in total scopes 1, 2, 3	16,993	3,908
University of Maryland College Park	50% reduction in total scopes 1, 2, 3	614,959	307,480
University of Maryland Eastern Shore	20% reduction in total scopes 1 & 2	28,855	5,771
University of Maryland University College	25% reduction in total scopes 1, 2, 3	28,924	7,231
Washington College	25% reduction in total scopes 1, 2, 3	19,778	4,944

TOTAL (metric tons of CO_2-equivalent) 546,097

Total Emissions Avoided ($MMtCO_2e$) **0.546**

Figure C-62: ACUPCC Schools with Estimated 2020 GHG Reductions (metric tons of CO_2-equivalent)

Institution	Assumptions for 2020 Reductions	2020 Business As Usual Emissions	2020 Reductions
Bowie State University	20% reduction in Total Scopes 1, 2, 3	36,065	7,213
Community College of Baltimore County	20% reduction in total scopes 1 & 2	23,460	4,692
Coppin State University	20% reduction in total scopes 1 & 2	5,041	1,008
Frostburg State University	50% reduction in total scopes 1, 2, 3	43,337	21,669
Goucher College	20% reduction in Total Scopes 1, 2, 3	11,500	2,300
Harford Community College	20% reduction in total scopes 1 & 2	7,682	1,536
Howard Community College	90% reduction in Total Scopes 1, 2, 3	60,007	54,006
McDaniel College	25% reduction in total scopes 1 & 2	19,352	4,838
Morgan State University	20% reduction in total scopes 1 & 2	56,888	11,378
Mount St. Mary's University	20% reduction in total scopes 1 & 2	20,173	4,035
Salisbury University	30% reduction in total scopes 1, 2, 3	35,929	10,779
St. Mary's College of Maryland	30% reduction in Total Scopes 1, 2, 3	31,367	9,410
Towson University	20% reduction in total scopes 1 & 2	0	0
University of Baltimore	20% reduction in total scopes 1 & 2	68,112	13,622
University of Maryland Baltimore	50% reduction in total scopes 1, 2, 3	20,571	10,285
University of Maryland Baltimore County	25% reduction in total scopes 1, 2, 3	210,917	52,729
University of Maryland Center for Environmental Science	25% reduction in total scopes 1, 2, 3	105,246	26,312
University of Maryland College Park	23% reduction in total scopes 1, 2, 3	16,993	3,908
University of Maryland Eastern Shore	50% reduction in total scopes 1, 2, 3	614,959	307,480
University of Maryland University College	20% reduction in total scopes 1 & 2	28,855	5,771
Washington College	25% reduction in total scopes 1, 2, 3	28,924	7,231

TOTAL ($mtCO_2$) 565,146

Total Emissions Avoided ($MMtCO_2e$) **0.565**

Source:

American College & University Presidents' Climate Commitment, http://www.presidentsclimatecommitment.org/

E. Assumptions

It is assumed that only Maryland colleges and universities which have signed the commitment currently have a GHG reduction target. The base year for each school is established by the school and varies according to institution. If only one or two years of GHG emissions are available, GHG emissions are estimated for future years increasing at two percent per year. If a school has an established GHG emission reduction target for 2020, it is expected that the school will meet the established target in 2020. For the high estimate, it is assumed that schools which do not have an established target will reduce scope 1 and scope 2 GHG emissions by 20 percent according to each school's base year.

Implementation

Figure C-89 below summarizes the progress and commitments of the Maryland institutions of higher learning that have signed the commitment. Of the 22 Maryland institutions, 20 have completed a GHG inventory and nine have completed a climate action plan thus far. The targets vary by institution, with some target dates as soon as 2012. For more aggressive reductions, the target dates are extended to 2030 and beyond.

Figure C-63 Summary of ACUPCC Maryland Institutions

Institution	GHG Inventory Completed	Climate Action Plan Completed	Target	Target Date	Baseline	Carbon Neutral Target	Tangible Actions						
							1	2	3	4	5	6	7
Bowie State University	X	X	20% reduction in electricity emissions	2012	2007	X	X	X	X	X	X	X	X
Coppin State University	X		Report In Progress				X						X
Community College of Baltimore County	X		Report In Progress				X	X		X			X
Frostburg State University	X	X	100% reduction in total scopes 1, 2, 3	2030	2007	X		X			X		X
Goucher College	X		Report In Progress				X	X		X	X		X
Harford Community College	X		Report In Progress				X	X					X
Howard Community College	X	X	10% reduction in electricity emissions	2012	2007		X	X					
McDaniel College	X	X	33% reduction in total scope 2	2025	2008	TBD		X			X		X
Morgan State University			Report In Progress				X	X	X	X	X	X	X
Mount St. Mary's University	X	X	100% reduction in total scopes 1, 2, 3	2050	2007	X		X					X
Salisbury University	X		100% reduction in total scopes 1, 2, 3	2050	2005	X	X	X					
St. Mary's College of Maryland	X		Report In Progress				X	X			X		X
The Universities at Shady Grove			Report In Progress				X	X		X			X
Towson University	X	X	20% reduction in scope 1	2020	2007	X	X			X			X
University of Baltimore	X		90% reduction in total scopes 1, 2, 3	2035	2008	X	X	X		X	X		X
University of Maryland Baltimore	X	X	25% reduction in total scopes 1, 2, 3	2020	2008	TBD	X			X			
University of Maryland Baltimore County	X	X	100% reduction in total scopes 1, 2, 3	2075	2007	X	X	X		X	X		X
University of Maryland Center for Environmental Science	X		90% reduction in total scopes 1, 2, 3	2050	2008	X	X				X		X
University of Maryland College Park	X	X	100% reduction in total scopes 1, 2, 3	2050	2005	X	X			X			X
University of Maryland Eastern Shore	X		Report In Progress				X	X	X	X	X	X	X
University of Maryland University College	X		25% reduction in total scopes 1, 2, 3	2020	2008	X	X	X					
Washington College	X		100% reduction in total scopes 1, 2, 3	2050	2007	X	X	X					X
TOTAL	**20**	**9**											

M.4: Leadership-By-Example: Local Government

Lead Agency: MDE

Program Description

Maryland county and municipal governments, together with the State, are adopting policies and practices to obtain high performance and energy-efficient buildings, facilities and vehicle fleets, and reduce the carbon footprint in purchasing, procurement and other government operations. Some jurisdictions have conducted GHG inventories, adopted climate action plans and targets, and implemented tracking protocol, such as those provided by the International Council for Local Environmental Initiatives. Where local government protocols for tracking quantifiable reductions exist, MDE conducted a survey to track actual and projected success in GHG emissions reductions. MDE's Statewide survey data results provide a 2010 snapshot of actual local government GHG reduction programs.

Estimated GHG Emission Reductions in 2020

Figure C-64. Low and High GHG Benefits for Innovative Initiatives-1

Initial Reductions	0.25 $MMtCO_2$	MDE Quantification Below
Enhanced Reductions	0.25 $MMtCO_2$	MDE Quantification Below

Estimates – MDE Quantification

Quantification of GHG emissions resulting from local government's efforts to show leadership by example is difficult for a variety of factors. First, local governments are comprised of both counties as well as cities, which means that there is a question of overlap between cities inside a county. Second, there is not a universal base year and/or goal(s) year. Further data is incomplete for a majority of the counties, less than 30 percent of counties have completed a GHG inventory. Further, there is concern that the counties reductions will be included in part of the State's Leadership-by-example efforts.

This analysis looks at seven counties that have completed inventories and goals. The goals are reduced to an annual reduction per county (total goal divided by number of years). The annual rate is then multiplied by the GGRA Goal year (2020) minus the base year of the county. The lone exception is Montgomery County which has a base year (2005) which is less than the GGRA base year (2006), in this case 2006 is used as a base year. This is done since any reduction made by Montgomery County in 2005 would be included in MDE's baseline inventory. For the low quantification, it is assumed that the counties just meet their target and no further counties adopt GHG goals. The result of this calculation is a reduction of 378,753 tons of CO_2-equivalent. For the high quantification, it is assumed either the existing seven counties with goals increase them and/or additional counties add significant reduction goals. It is assumed this result in a 50 percent increase in what would be achieved in the low-quantification scenario. So, an aggressive adoption of County GHG goals could result in a reduction of 568,130 tons of CO_2-equivalent. Overlap is an issue which must be accounted for as part of this GHG emissions mitigation program, since these reduction could be partially or totally subsumed as part of other mitigation program.

Figure C-65. Summary of County Government Climate Change Actions

County	GHG Inventory (status)	GHG Targets	Base Year	Goal Year	Target	2020 Goal	Base Inventory	Reduction (metric tons of CO_2-equivalent
Allegany	None currently planned	No						
Anne Arundel	Partial, In Progress	No						
Baltimore City	2007 updating 2011	Yes	2007	2015	15%	24%	608,908	146,137.9
Baltimore County	2006 GHG inventory completed for emissions related to County government operations (excluding schools and public libraries)	Yes	2006	2012	10%	23%	142,701	32,821.2
Calvert		No						
Caroline		No						
Carroll		No						
Cecil		No						
Charles		No						
Dorchester		No						
Frederick	Completed	Yes	2007	2025	25%	18%	134,667	24,240.1
Garrett		No						
Harford	In Progress	No						
Howard	Yes	Yes	2007	2014	7%	13%	294,130	38,236.9
Kent	Energy Conservation Study being completed by Washington College	No						
Montgomery	Completed		2005	2050	80%	25%	453,000	113,250.0
Prince George's	In progress		2008	2015	10%	20%	95,887	19,177.4
Queen Anne's	Completed, 2008	Yes	2009	2014	20%	44%	11,113	4,889.7
Somerset		No						
St. Mary's		No						
Talbot		No						
Washington		No						
Wicomico		No						
Worcester		No						
							TOTAL	**378,753**

Implementation

In 2010, MDE launched a comprehensive survey to gain a Statewide view of local government's actions that will contribute to Maryland's sustainability and GHG reduction goals. MDE expects to finalize data collection and share results toward the end of 2011. Survey results to date show many local governments have GHG emissions reduction efforts underway. Some are already identifying significant GHG reductions; others are in planning stages along the continuum of conducting GHG inventories, adopting reduction targets, developing and implementing climate action plans, and tracking progress.[90]

MDE and DNR are collaborating to provide forums for local governments and universities in the State to network and share best practices for implementing climate programs. MDE's survey results will inform this process. The work will also build on DNR's online Sustainability Network, where citizens, businesses and organizations can share sustainability and GHG projects and connect with others across the State interested in starting sustainability plans, energy reduction programs, rain gardens, and other green projects.[91]

M.4: Leadership-By-Example – Federal Government

Lead Agency: MDE

Program Description

Federal agencies with facilities located in Maryland would implement a comprehensive suite of lead-by-example programs to improve efficiency, reduce waste, and integrate renewable energy and sustainable practices into their operations, facilities and fleets. This would include tools to benchmark and track energy use and GHG emissions and transparently report progress toward meeting well-defined targets. Examples of programs include energy reduction in public buildings, facilities and lands, improved efficiencies in fleet vehicles and fuels, water conservation, waste reduction and recycling, purchasing of products and services with lower life-cycle impacts, and greater use of renewable energy.

Estimated Greenhouse Gas Emission Reductions

Figure C-66. Low and High GHG Benefits for Innovative Initiatives-2

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[90] See, e.g.:
City of Annapolis http://www.sustainableannapolis.com
Baltimore City http://www.cleanergreenerbaltimore.org/
Baltimore County
http://www.epa.gov/ttn/chief/conference/ei18/session7/brady.pdf Calvert County
http://www.co.cal.md.us/greenteam/
Cecil County http://www.ccgov.org/dept_planning/index.cfm
Charles County http://www.charlescounty.org/PF/sw/recycling/
Chestertown http://chestertowngoesgreen.com
Frederick County http://www.frederickcountymd.gov/index.aspx?NID=3530
Harford County http://www.harfordcountymd.gov/Green/
Howard County www.livegreenhoward.com
Montgomery County http://www.montgomeryplanning.org/environment/sustainable/index.shtm
Prince Georges County
http://www.princegeorgescountymd.gov/Government/AgencyIndex/GoingGreen/
Town of Somerset http://www.townofsomerset.com/environment/Climate_change.html

[91] http://www.dnr.state.md.us/sustainability/network.asp

Initial Reductions	0.27 $MMtCO_2e$	MDE Quantification Below
Enhanced Reductions	0.27 $MMtCO_2e$	MDE Quantification Below

Estimates – MDE Quantification

The White House's Council on Environmental Quality released Guidance for Federal Greenhouse Gas Accounting and Inventories, as part of President Obama's Executive Order 13514. The order establishes a federal government-wide target of a 28 percent reduction by 2020 in direct GHG emissions such as those from fuels and building energy use (Scope 1 and 2), and a target 13 percent reduction by 2020 in indirect GHG emissions, such as those from employee commuting and landfill waste (Scope 3).

Scopes 1, 2, and 3 emissions data, reduction goals, total number of employees and total number of facilities were obtained for 41 Federal agencies via agency sustainability plans (Figure C-84). MDE calculated Scopes 1, 2, and 3 reductions for each federal agency from this data.

Figure C-67. Federal Agency Scopes 1, 2, and 3 Emissions and Reductions

Agency	Scope 1&2 Goal (%)	Scope 3 Goal (%)	Scope 1&2 Emissions (MMtCO2e)	Scope 3 Emissions (MMtCO2e)	Total Employees	Total Facilities	Scope 1&2 Reductions (MMtCO2e)	Sc Redu (MM
Advisory Council on Historic Preservation	N/A	N/A	Blank	44.3	36	1	0	
Commodity Futures Trading Commission	N/A	N/A	N/A	N/A	669	4	0	
Court Services and Offender Supervision Agency	30	21?	?	969.812	?	?	0	
Department of Agriculture	21	7	616728	258765	110-115000	26026	129512.88	1
Department of Commerce	1	6	0.3619284	0.1832843	43000	858	0.003619284	0.010
Department of Defense	34	13.5	78.4	7	2328937	211266	26.656	
Department of Education	0	3	232	14965	4348	26	0	
Department of Energy	28	13	4634	0.858	127376	19214	1297.52	
Department of Health and Human Services	15.2	3.3	0.96	0.29	83745	3983	0.14592	

Department of Homeland Security	25	7.2	1717333.5	1602912.6	237629	14190	429333.375	1154
Department of Housing and Urban Development	47.4	16.2	17715	31726	9462	108	8396.91	5
Department of Justice	16.4	3.8	1.61	0.62	112000	3861	0.26404	
Department of Labor	27.7	23.4	231403.1	86414.1	16404	4768	64098.6587	202
Department of State	20	2	139067	33652	14664	10	27813.4	
Department of the Interior	20	9	0.8351128	0.3614084	70000	47518	0.16702256	0.032
Department of the Treasury	33	11	0.2633017	0.5100492	125881	697	0.086889561	0.056
Department of Transportation	12.3	10.9	857.9	309.5	58011	11594	105.5217	
Department of Veterans Affairs	29.6	10	2.991	1.077	284316	7186	0.885336	
Environmental Protection Agency	25	N/A	0.14078	0.067315	17208	171	0.035195	
Farm Credit Administration	N/A	10	0	1921	287	0	0	
Federal Housing Finance Agency	50	5	13.5	1135.2	455	3	6.75	
General Services Administration	28.7	14.6	2270645	156676	12827	9624	651675.115	22
Marine Mammal Commission	N/A	35?	Blank	Blank	23?	Blank	0	
Millennium Challenge Corporation	N/A	15	2.174	2.513	279	2	0	
National Aeronautics and Space Administration	18.3	12.6	1.356	0.171	18490	4884	0.248148	0
National Archives and Records Administration	7	10	75.517	15.309	3611	68	5.28619	
National Capital Planning Commission	N/A	20	N/A	60.58	44	1	0	
National Endowment for the Humanities	N/A	6.4	N/A	392.7	173	1	0	

National Labor Relations Board	20	5	124.5	2721.1	1740	56	24.9	
National Mediation Board	Blank	?	Blank	Blank	49	1?	0	
Nuclear Regulatory Commission	4.4	3	13800.4	21552.7	2752	2	607.2176	
Office of Personnel Management	20	5	6547.18	21295.49	6568	73	1309.436	10
Overseas Private Investment Corporation	?	?	Blank	Blank	230	1	0	
Peace Corps	20	20	64.8	1164.6	3200	461	12.96	
Pension Benefit Guaranty Corporation	Blank	5	0	427.5	980	11	0	
Railroad Retirement Board	27.2	6.2	4100	542	900	56	1115.2	
Small Business Administration	28	9	291.3	11057	4740	190	81.564	
Social Security Administration	21.2	13	126204.7	150103	70898	1649	26755.3964	1
Tennessee Valley Authority	17	20.7	0.573	0.102	12457	2876	0.09741	0
US Army Corps of Engineers	23	5	338989	162274	35438	888	77967.47	
United States Postal Service	20	20	5.28	8.09	581775	33620	1.056	
Totals	**690.4**	**344.8**	**5,488,921**	**2,561,118**	**4,291,579**	**405,947**	**1420149.206**	**2139**

The White House established a 2008 baseline of 68.9 $MMtCO_2e$ for federal government-wide emissions. If the 28 percent reduction goal is applied to the 2010 Scopes 1 and 2 goal, and is added to the 13 percent reduction to the 2010 Scope 3 goal, a composite 20.5 percent reduction is produced. This translates to a total federal reduction of 14.12 $MMtCO_2e$ in 2020.

To obtain the low estimate, 1/51 of the total federal reductions was assumed, resulting in 0.277 $MMtCO_2e$ of reductions in 2020.

Implementation

Executive Order 13514.

The federal government is the single largest energy consumer in the U.S. economy.[92] In 2009 President Obama signed an executive order, "Federal Leadership in Environmental, Energy, and Economic Performance", which calls on the federal government to reduce its GHG emissions from direct sources (e.g. federal buildings and fleets) to 28 percent below 2008 levels by 2020 and implement aggressive energy and water efficiency programs (*Executive Order 13514*, issued October 8, 2009).[93] To meet this directive, federal agencies are undertaking projects to increase their use of renewable energy, make their buildings and vehicles more efficient, and limit their use of fossil fuels. Federal agencies are specifically directed to set agency-wide reduction targets for Scope 1, 2 and 3 GHG emissions and to develop and implement Strategic Sustainability Performance Plans designed to meet the targets.

The executive order sets the following federal government-wide targets for fleet vehicle fuel, water efficiency, recycling and waste diversion, procurement, net zero-energy buildings, storm water management, and Livability Principles:

- 30 percent reduction in fleet vehicle petroleum use by 2020;
- 26 percent reduction in water consumption by 2020;
- 50 percent reduction in solid waste by 2015;
- 95 percent of procurement contracts to meet defined sustainability requirements;
- Net-zero energy design by 2030 for buildings planned in 2020 and later ;
- Storm water management requirements of Energy Independence and Security Act of 2007;
- Development of guidance for locating federal buildings in alignment with Livability Principles of the U.S. Department of Housing and Urban Development, EPA, and the U.S. Department of Transportation.[94]

In July 2010 the President expanded the federal government-wide target to require a 13 percent reduction by 2020 for GHG emissions from indirect sources, such as employee travel and commuting.[95] The President's Council on Environmental Quality estimates that, combined, the government-wide goals could result in a cumulative reduction of 101 million metric tons of carbon dioxide emissions nationwide, equivalent to the emissions from 235 million barrels of oil.[96]

Oversight of Executive Order 13514 is provided by the Office of Management and Budget with support by the President's Council on Environmental Quality and the Federal Environmental Executive.

[92] "President Obama Sets Greenhouse Gas Emissions Reduction Target for Federal Operations", The White House, Office of the Press Secretary, January 29, 2010. In 2008, the federal government spent more than $24.5 billion on electricity and fuel. http://www.whitehouse.gov/the-press-office/president-obama-sets-greenhouse-gas-emissions-reduction-target-federal-operations.

[93] Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance", issued October 5, 2009. http://www.hss.doe.gov/nuclearsafety/env/rules/74/74fr52117.pdf

[94] Ibid.

[95] "President Obama Expands Greenhouse Gas Reduction Target for Federal Operations", The White House, Office of the Press Secretary, July 20, 2010. http://www.whitehouse.gov/the-press-office/president-obama-expands-greenhouse-gas-reduction-target-federal-operations.

[96] http://www.whitehouse.gov/administration/eop/ceq/sustainability/fed-ghg

Progress to Date.
The federal government has already achieved substantive results towards improved energy efficiency and cleaner energy. Data for FY09 shows that the federal government decreased energy consumption per square foot of building space by approximately 13.1 percent compared with FY03, surpassing the FY09 goal of 12 percent. The federal government also purchased or produced 2,331 gigawatt-hours of electricity from renewable sources – approximately 4.2 percent of its electricity use – surpassing the goal of 3 percent for FY09.[97]

Tracking of federal facilities in Maryland.
By January of 2011, all federal agencies were to submit their Scope 1, 2 and 3 inventories to an internal GHG Reporting Portal managed by the U.S. Department of Energy's Federal Energy Management Program.[98] Accounting is expected to be at the agency and facility levels, down to zip codes.

Executive Order 13514 also calls for the Office of Management and Budget to periodically prepare agency scorecards tracking their progress toward meeting the targets and to publish scorecard results on a public website. The website is expected to be up and running in 2011. Agency data will not be publicly available for certain high security facilities and operations, however. Nationally, the General Services Administration owns and operates about 20 percent of all federal facilities; the remainder is under the control of the U.S. Department of Defense or other national security agencies. In Maryland, this ratio is even more tilted toward national security facilities. In some cases even the existence of such a facility is high security and no public reporting will occur. In other facilities there may be some limited reporting.[99] While this will prevent a full picture of federal lead-by-example programs in Maryland, the public website will enable a detailed tracking of progress toward the GHG reduction targets for many of the federal facilities located in the State.

State-Federal Facility Partnerships. The Maryland Clean Energy Center is working to increase State funding and support for Federal Facility Partnerships, to leverage the requirement for federal facilities and military bases to provide 25 percent of their power from on-site renewable sources by 2025.[100]

Maryland Innovative Initiatives

N.1: Voluntary Stationary Source Reductions

[97] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, EERE News, "DOE Announces Winners of 2010 Federal Energy and Water Management Awards", October 7, 2010.
[98] FEMP Reporting Portal
[99] Telephone conversation with Sarosh Olpadwala, U.S. General Services Administration, September 13, 2010.
[100] The Current, MCEC Newsletter, April 2011.

Lead Agency: MDE

Program Description

GGRA provides two paths for sources in the State's manufacturing sector to follow to potentially get credit for any voluntary programs that they are implementing.

First, companies may simply take totally voluntary action and provide a good faith estimate of potential emission reductions. These efforts can then be acknowledged and, if appropriate, included in the plan as a reduction. The uncertainty of the emission reduction calculations will be a critical factor in whether or not the reductions are included as a reduction in the plan.

There are literally hundreds of manufacturers and other businesses in Maryland who are developing and implementing voluntary GHG or "carbon footprint" reduction strategies. Several examples include Perdue's efforts to install thousands of solar plans at their corporate offices in Salisbury Maryland and Northrop Grumman's energy reductions achieved through alternative workweek programs, tele-working, managed print services, high efficiency lighting, shipping load consolidation, and reflective roof systems.

The second, more formal mechanism included in GGRA, allows a company to implement an early voluntary GHG emissions reduction plan and secure a formal "credit" for those actions. These early reduction plans must be approved by MDE before January 1, 2012. Under the provisions of GGRA, a source that implements an approved voluntary reduction plan "may be eligible to receive voluntary early action credits under any future State law requiring GHG emissions reductions from the manufacturing sector."

Under GGRA, Voluntary Early Reductions are credits for GHG emission reductions which take place before a mandatory GHG emission program required GHG reductions. Companies identifying measures to reduce GHG emissions will usually implement the least costly strategies first. Typically these are GHG reduction measures resulting in greater efficiency, lower costs and decreased GHG emissions. During the development of GGRA, it was made clear Maryland industry, which already have made decisions to adjust business processes and have already reduced GHG emissions, wanted assurance that they will not be penalized later with tighter emissions limitations, without receiving some sort of "credit" for their early efforts. The credit concept ensures that proactive voluntary actions by companies, which result in GHG reductions now, count in their favor later and help counter potential financial burdens to those companies once more costly reduction strategies are required. It is expected many of the least expensive reduction tactics will be among those first implemented, and that there will be a point when they alone will not help Maryland to meet its GHG emissions goals. When this occurs, it will be necessary to implement more costly reduction programs to reach mandated GHG targets.

Since a future GHG program could be one required by either State or federal law, it is important for a Maryland voluntary early reduction program to comply with federal, regional and State programs currently in existence. This creates an incentive for companies to implement GHG reduction measures before the advent of a mandatory program. Offering a program resulting in credits for early voluntary reductions is consistent with proposed federal GHG legislation. Although implementation of an early reduction program in Maryland is still under development, participation in such a program would be voluntary.

Estimated GHG Emissions Reductions

Figure C-68. Low and High GHG Benefits for Innovative Initiatives-4

Initial Reductions	0.17 $MMtCO_2e$	MDE Quantification Below
Enhanced Reductions	0.17 $MMtCO_2e$	MDE Quantification Below

Estimates – MDE Quantification
Reductions in GHG emissions from VERs will depend on how many sources in Maryland's manufacturing sector elect to engage in voluntary GHG reduction programs, as well as the amount of GHG emissions reductions achieved by each source that participates. In 2009, Maryland's manufacturing sector reported approximately 8.6 million tons of CO_2-equivalent through their emission certification reports.

N.2: Buy Local for GHG Benefits

Lead Agency: MDA

Program Description

Although farm stands and farmers' markets have been around forever, the phenomenal surge in the locally grown movement has been fueled by not only by an increased awareness of the benefits of fresh, healthful foods, but also the fears raised by well publicized episodes of product contamination and foodborne illness. MDA's "Buy Local" campaign continues to be highly successful in promoting local farms as preferred sources of food to Marylanders by helping agricultural producers market their products directly to supermarket, food service, institutional, and other wholesale buyers, as well as consumers.

Increasing the sale and consumption of locally grown products will increase the sequestration of carbon dioxide on Maryland's agricultural lands. The enhanced productivity resulting from increased agricultural production will yield increased rates of carbon sequestration in agricultural biomass, increased amounts of carbon stored in harvested crops, and increased availability of renewable biomass for energy production.

In the past two years the growth of the public's interest in the source of their food coupled with MDA programs has sparked unprecedented consumer preference for locally-grown and -made agricultural products. Agriculture provides a traceable and healthy supply of local foods. Buying locally-grown products strengthens local economies and the health of our environment and our families, keeps land open and productive and improves quality of life. Farmers' markets provide an important source of income for farmers as more and more consumers seek the freshness, quality, and wide selection of locally-grown produce. By talking one-on-one with farmers, consumers develop a bond of trust in the integrity and accountability of our growers.

Estimated GHG Emission Reductions in 2020

Figure C-69. Low and High GHG Benefits for Ag and Forestry-9

Initial Reductions	0.02 MMtCO$_2$e	SAIC Quantification Appendix B, Pg. 142
Enhanced Reductions	0.02 MMtCO$_2$e	SAIC Quantification Appendix B, Pg. 142

Implementation

MDA received legislative authority to regulate the use of the terms “locally grown” and “local” when advertising or identifying agricultural products. In cooperation with the University of Maryland and Maryland farmers’ market managers, MDA was awarded a federal matching grant to assess the economic impact of farmers’ markets, identify ways to expand their customer base and increase sales, and explore the formation of a statewide market association. Through a partnership including MDA, the University of Maryland School of Nursing, the Future Harvest/Chesapeake Alliance for Sustainable Agriculture, the Southern Maryland Agricultural Development Commission, and the Maryland Organic Food and Farming Association, U.S. Department of Agriculture funding was received to promote the use of locally-produced, sustainable protein foods in the healthcare facilities and institutions.

MDA promotes the sustainable production and consumption of local agricultural goods and thereby helps to displace the production and consumption of products transported from other states and countries. In addition to the energy savings and GHG reductions resulting from decreased transportation emissions, greater demand for local products preserves the agricultural landscape, supports agro-biodiversity, and encourages beneficial environmental practices. MDA works with farmers, local governments, restaurants, food distributors and retailers, value-added producers, public and private institutions, and trade associations to maintain and expand its popular “Buy Local” program. By 2020, MDA aims to raise the number of farmers’ markets by 20 percent, establish a State farmers’ market association, and increase direct sales (buy/grower) by 20 percent.

MDA’s Marketing Department will work with farmers, local governments, restaurants, food distributors and retailers, value-added producers, public and private institutions, and trade associations to maintain and expand its popular “Buy Local” program. The web site Maryland's Best has been created as an online tool to find local products from Maryland farmers.

N.3: Pay-As-You-Drive®[101] Insurance in Maryland

[101] Pay-As-You-Drive is a registered trademark of Progressive Casualty Insurance Company.

Lead Agency: MIA

Program Description

Pay-As-You-Drive® automobile insurance is also known as use-based insurance. Generally, use-based insurance plans are designed to align the amount of premium paid with actual vehicle usage. The distance an automobile is driven, the speed at which it is driven, and the time of day it is driven all are factors that can be used to determine premiums under a use-based plan.[102]

Under traditional automobile insurance plans, insurance companies rely on the consumer to provide information at the time the policy is written about the number of miles the consumer expects to drive during the policy period. In contrast, under use-based plans, the cconsumer generally uses a telematics device to provide information about actual mileage and other driving behaviors to the insurance carrier. The carrier can use that information to adjust the price of coverage based on the degree of risk posed by the insured's actual driving behaviors.

In the fall of 2008, Progressive Insurance Group started offering its "MyRate" use-based program in Maryland. Consumers who elect to participate in this program receive a wireless device that plugs into their car. This device measures "how, how much and when the car is being driven" (Progressive News Release, September 15, 2008). "Cars driven less often, in less risky ways and at less risky times of day can receive a lower premium (Progressive News Release, September 15, 2008). Customers signing up for the program could receive up to a 10 percent discount and at renewal could earn up to a 25 percent discount. There is a thirty dollar technology expense for the cost of the wireless device and transmission of the data. This is imposed each policy period.

As of 2008, the GMAC Insurance Group also offered a Pay-As-You-Go insurance program to OnStar subscribers in Maryland. It works as a discount program: the fewer miles driven, the higher the discount earned. Customers driving less than 2500 miles annually may be eligible for up to a 50 percent discount. All information is transmitted through the OnStar Vehicle Diagnostic reports, so it is necessary to have an OnStar equipped vehicle with an active OnStar subscription.

As of August 2011, the Progressive and GMAC Insurance Groups were the only insurers offering a use-based insurance program for private passenger automobiles in Maryland[103]. Some carriers are offering programs or pilot programs similar to Pay-As-You-Drive® in other states.[104]

[102] Consumers receive discounts off of their insurance premiums for participating in most use-based programs.
[103] Two additional companies offer a commercial product (Montgomery Mutual and Ohio Casualty); however, it is unlikely that the usage will be reduced since this is a commercial product.
[104] Although currently only available in Texas, MileMeter Insurance Company offers a mileage based program that is available to consumers on-line. The rates for this program are based on the consumer's age, location and vehicle. The consumer purchases a specific number of miles for a 6 month period of time. When the consumer runs out of miles they may purchase more. This program relies exclusively on

Estimated GHG Emission Reductions in 2020

Figure C-70. Low and High GHG Benefits for Transportation-20

Initial Reductions	0.02 $MMtCO_2e$	SAIC Quantification Appendix B, Pg. 217
Enhanced Reductions	0.02 $MMtCO_2e$	SAIC Quantification Appendix B, Pg. 217

N.4: Job Creation and Economic Development Initiatives

Lead Agency: DBED

Program Description

This program promotes economic development opportunities associated with reducing GHG emissions in Maryland. It is based on Governor O'Malley's aggressive goal of creating, retaining or placing 100,000 green jobs in the State by 2015.[105] To support this goal, DBED formed a Green Jobs & Industry Task Force of public- and private-sector leaders representing diverse businesses and organizations.

The goal of the Green Jobs & Industry Task Force was to help Maryland create green jobs and move toward a smarter, greener Maryland economy. Specifically, the task force was charged with developing recommendations for the State to leverage Maryland's considerable workforce and natural resources to create and retain green jobs; utilize scarce and finite natural resources; protect and restore our environment; and support the use of clean and efficient energy.[106]

The Green Jobs and Industry Task Force issued recommendations to Governor O'Malley in July, 2010. The task force made six recommendations: Strengthen coordination and communication across State agencies, partners and stakeholders to provide strategic vision for advancing a green economy; promote energy and resource efficiency efforts; develop and foster clean, local energy production and industrial capacity; capitalize upon economic opportunities to restore and protect Maryland's natural resources; promote sustainable development practices that create jobs, generate prosperity and make Maryland more self-reliant; and increase access to capital for green businesses and projects.[107]

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vehicle's odometer to track mileage. Allstate is currently offering a program in Illinois which will give an additional discount based on when the policyholder drives, mileage, hard braking rapid acceleration and speed. Driving performance is tracked by device which is plugged into the policyholder's vehicle.

[105] The Governor's Workforce Investment Board, "Maryland's Energy Industry Workforce Report," September 2009, Accessible at: http://www.mdworkforce.com/pub/pdf/energyworkforce.pdf

[106] Ibid.

[107] DBED, "Green Jobs and Industry Task Force Report: A Report to Governor Martin O'Malley," July 2010, Accessible at: http://issuu.com/cybermaryland/docs/green_jobs_task_force_report.

The Green Jobs and Industry Task Force issued its next steps, to be pursued jointly with the Office of the Governor:

- Prioritize recommendations, placing greatest emphasis on those with the most potential to create jobs and promote economic recovery immediately; develop an action plan to implement these recommendations;
- Outline the budgetary and workforce resources necessary to implement these changes; draft legislation for consideration at future General Assembly sessions to implement recommendations requiring legislative action; and
- Convene short-term public-private working groups to handle specific issues raised within the recommendations.[108]

Estimated Greenhouse Gas Emission Reductions in 2020

The GHG reductions associated with this program are not applicable. While this program is not directly tied to a quantifiable reduction in GHG, it will help to reduce them. For example, if selected industries are forced to move offshore, then global GHG emissions may rise due to a lack of comparable controls outside the U.S.

Implementation

Maryland could one day establish itself as a leader in developing the green industry. Opportunities for job creation exist in designing and constructing green buildings; weatherizing existing buildings; retrofitting older buildings with energy efficient appliances and technologies; expanding the construction, maintenance, and operation of common-carrier and public transportation networks and systems; designing, constructing, and operating windmills, biomass generators, and solar collectors; and research and development on a wide array of new practices and technologies that can abate GHG production. DBED works with public and private sectors to create these job opportunities in Maryland.

DBED's mission is to attract new businesses, stimulate private investment, create jobs and encourage the expansion and retention of existing companies by providing workforce training and financial assistance to businesses relocating to or expanding within Maryland. DBED promotes doing business in Maryland at home and abroad to spur economic development and international trade. DBED's business development units are primarily charged with job creation and retention; and its financing and training programs are designed to support all businesses and industries, including those in the renewable energy and sustainability sectors.

To spur economic development in Maryland, DBED participates on both multi-agency initiatives and green business organization activities. DBED participates in multi-agency initiatives such as the Maryland Commission on Environmental Justice and Sustainable Communities, the U.S. 40 Carbon Neutral Corridor Interagency Steering Committee, and the Power Plant Research Program Advisory Committee. DBED supports and participates in the activities and programs of green business organizations such as the

[108] Ibid.

Maryland Clean Energy Center, the Maryland-Asia Environmental Partnership, and the Chesapeake Sustainable Business Alliance.

DBED targets a substantial part of its marketing efforts toward national trade shows and events that promote renewable energy and sustainability. Trade shows are more likely to attract participation by businesses within the renewable energy and sustainability sectors, which DBED then targets as potential prospects for relocation or expansion in Maryland. Examples of these events include the American Wind Energy Association Conference, The Renewable Energy Technology Conference and Exhibition 2011, the Renewable Energy World Conference, and the World Energy Engineering Congress.

DBED's business development units provide one-on-one assistance to businesses seeking to create jobs in the renewable energy and sustainability sectors. The types of assistance provided may include site location assistance, technical assistance, workforce training and financing. DBED also supported Maryland Green Travel, a Statewide program created to encourage environmentally-friendly practices and promote the State as a "green" destination to eco-minded travelers. The voluntary program helps businesses evaluate procedures, set goals and take specific actions towards environmental sustainability. Already, hotels with green practices are reducing waste, recycling and conserving energy and water.

O: Future or Developing Programs

O.1: The Transportation and Climate Initiative (TCI)

Lead Agency: MDE/MDOT

Program Description

The Transportation and Climate Initiative (TCI) is a regional effort of Maryland and 10 other Northeast and Mid-Atlantic states and the District of Columbia to reduce GHG emissions in the region's transportation sector, minimize the transportation system's reliance on high-carbon fuels, promote sustainable growth to address the challenges of vehicle-miles traveled, and help build the clean energy economy across the region.

Recognizing that the transportation sector currently accounts for approximately 30 percent of GHG emissions in the Mid-Atlantic and Northeastern U.S.[109], the energy, environment and transportation agency heads from the region convened a summit in Wilmington, Delaware in June 2010 to launch TCI.[110] On June 16, 2010 they

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[109] TCI Declaration of Intent, June 16, 2010. http://www.georgetownclimate.org/state/files/TCI-declaration.pdf

[110] Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and the District of Columbia were represented. All but Pennsylvania and the District of Columbia are also members of RGGI, and all eleven states are signatories to the 2009 Northeast and Mid-Atlantic Low Carbon Fuel Standard Memorandum of Understanding. Both initiatives are summarized later in this chapter.

unanimously signed a Declaration of Intent, affirming their intent to work collaboratively to "reduce greenhouse gas emissions, minimize our transportation system's reliance on high-carbon fuels, promote sustainable growth, address the challenges of vehicle-miles traveled and help build the clean energy economy" in the Mid-Atlantic/ Northeast region.[111] The collaborative is also expected to advance current efforts of individual TCI states to:

- "Reduce traffic congestion;
- Encourage job growth and accommodate the flow of goods and services;
- Establish state and local land use strategies that increase commercial and residential housing density and encourage transit-friendly design;
- Improve the performance of existing highway, transit and other transportation modes while enhancing neighborhoods and urban centers; and
- Promote mixed-use development that supports viable alternatives to driving."[112]

Estimated Greenhouse Gas Emission Reductions in 2020

Figure C-71. Low and High GHG Benefits for Transportation-4

Initial Reductions	0.03 $MMtCO_2$	MDE Quantification Below
Enhanced Reductions	0.03 $MMtCO_2$	MDE Quantification Below

Estimates – MDE Quantification
The 2008 Climate Action Plan predates TCI launch and includes no quantification of GHG emissions reductions for this initiative. Quantification is under development by TCI. The emissions reduction potential is significant. Although TCI has not formulated specific reduction goals at this time, the 3-year strategic work plan builds on reduction targets established in the climate action plans and statutes adopted by most TCI states and commits to developing key sets of data and metrics to:

- Establish baselines for emissions and energy use in transportation systems; and,
- Inform deliberations on establishment of regional goals that support and advance state goals.

Methods to measure and track the success of the TCI initiative are being developed in the three-year work plan. These may eventually be used to measure and track GHG reductions from this and related transportation programs in the 2012 GGRA Plan.
They include:

- Metrics to provide tools to measure effectiveness of individual reduction strategies and programs, both regionally and in states; and,
- Model policies, programs and rules for implementation at the state level, as well as, methods to evaluate the effectiveness.

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[111] Declaration of Intent, fn. 1, supra.
[112] Ibid.

This program has overlap with the E.1.A: Maryland Clean Cars Program, O.2: Clean Fuels Standard and E.3: Electric Vehicles. The assumptions used for this quantification are:

- The statutory/regulatory requirements of the Maryland Clean Car Program and the Clean Fuels Standard are met first.
- TCI will incentivize the introduction and use of 5,000 (low) and 10,000 (high) additional electric vehicles on Maryland's roads in 2020.
- All vehicles incentivized by this program will be electric vehicles (no plug-in hybrids assumed for this analysis) that have no tailpipe GHG emissions.
- Electric vehicles will replace gasoline powered vehicles.
- Since electric vehicles are replacing gasoline vehicles, there is no net increase in congestion or delay on the roadways.
- The vehicles accumulate 18,000 miles per year.
- Any GHG emissions associated with recharging electric vehicles are accounted for from the stationary source producing the power.
- The benefits were calculated using MDOT methodology in Appendix D for calculating VMT reduction.

Implementation

With support from the Georgetown Climate Center, the TCI states contribute in-kind staff resources to implementing the goals articulated in the *Declaration of Intent.* TCI is organized into a steering committee, an overall staff work group and four topic-specific work groups. Working through the summer and fall of 2010, they produced a three-year work plan which was approved by TCI agency heads in October 2010. The plan focuses on four key areas:

- Developing clean vehicles and fuels, with a particular emphasis on creating a regional electric vehicle charging network.
- Promoting the development of sustainable communities.
- Improving the efficiency of freight transportation.
- Implementing communication and information technology throughout the region.

Agency heads will meet at the second annual summit in June 2011 to provide guidance on further work plan development and implementation.

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- Establish baselines for emissions and energy use in transportation systems; and
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Methods to measure and track the success of the TCI initiative are being developed in the 3-year work plan. These may eventually be used to measure and track GHG reductions from this and related transportation programs in the 2012 GGRA Plan.
They include:

- Metrics to provide tools to measure effectiveness of individual reduction strategies and programs, both regionally and in states.
- Model policies, programs and rules for implementation at the state level as well as approaches to evaluate their effectiveness.

In August of 2010, TCI submitted an application for a $3 million TIGER II planning grant from the federal Departments of Housing and Urban Development and of Transportation for the strategic planning and pilot deployment of an electric vehicle charging infrastructure for the Interstate-95 corridor and connecting east-west interstates. TCI exceeded the required 20 percent match with commitments from public and private partners in the TCI states. Maryland was successful in obtaining a $67,500 in-kind contribution of engineering services from an in-state producer of electric vehicle charging stations. The grant process was highly competitive and although the TCI application was ranked near the top, it did not receive an award. However, the process produced strategic planning and partnering opportunities that TCI is building on as it moves the electric vehicle initiative forward and pursues other funding opportunities.

Through regional planning, including coordination with Metropolitan Planning Organization partners in their role as metropolitan transportation agencies, TCI is positioned to maximize the impact of transportation investments. The regional approach is also designed to boost the effectiveness of existing state programs, accelerate the growth of clean energy jobs, and promote public and private sector innovation.

TCI agency heads met in June 2011. TCI is expected to provide strategic guidance to TCI agency staff working group on plan implementation.

O.2: Clean Fuels Standard

Lead Agency: MDE

Program Description

The Clean Fuels Standard program is a cooperative effort being undertaken by eleven Northeast and Mid-Atlantic states to design and implement a regional low carbon fuel standard to reduce the carbon intensity of transportation fuels. The Clean Fuels Standard is a collaboration of commissioners from both the environmental and energy agencies and is modeled after the successful RGGI program. This regional program is being pursued by the following eleven Northeast and Mid-Atlantic states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont.

Transportation fuels account for approximately one-third of GHG emissions from the Northeast and Mid-Atlantic states. A clean fuel standard is designed to reduce the GHG emissions from these fuels. This program would be a market-based program to address the carbon content of fuels by lowering their carbon intensity through the use of low-carbon fuel alternatives. Carbon intensity is defined as the amount of GHGs released per unit of energy produced by the fuel over its full lifecycle. By analyzing the amount of GHG emissions released during the fuels' full lifecycle, including production, transport, and consumption, the fuels can be measured and compared with respect to their carbon intensity. The nation's first clean fuel standard was initiated by California in 2007, and similar programs are being considered in Oregon, Washington, and ten Midwestern states.

The Clean Fuels Standard program would require regional fuel suppliers to demonstrate that the average carbon intensity of fuels used in the region is reduced over time. A credit trading system could provide opportunities to control costs by allowing a supplier to purchase credits from low carbon fuel producers and average them with higher carbon fuels delivered to customers. Rather than imposing restrictions on specific fuel types, this approach allows fuel providers to choose among different fuels, based on cost effectiveness and environmental impact, in order to meet the carbon intensity reduction target set by the program. This program would allow the fuel industry flexibility to determine when and where new infrastructure can be introduced most efficiently, such as the use of electric vehicles or additional supplies of liquid low carbon fuels.

The Memorandum of Understanding signed by the eleven Northeast and Mid-Atlantic Governors in December 2009 committed the states to conduct an economic analysis, develop preliminary recommendations on program elements, and draft a program framework based on this previous work. The Northeast States for Coordinated Air Use Management is providing the technical support to the states in the development of this program. On August 18, 2011, Northeast States for Coordinated Air Use Management, on behalf of the 11 Northeast and Mid-Atlantic states, released a report entitled "*Economic Analysis of a Program to PromoteClean Transportation Fuels in the Northeast/Mid-Atlantic Region*". This report describes the economic impacts of a Clean Fuels Standard designed to reduce the carbon intensity of fuels used for transportation in the region by 5 percent to 15 percent over the next 10 to 15 years. The report suggests that transitioning to lower carbon fuels such as electricity, advanced biofuels and natural gas could help reduce GHG emissions, enhance energy independence, reduce vulnerability to price swings in imported oil, and strengthen the region's economy.

Key findings of the report indicate that a regional Clean Fuels Standard could:

- reduce transportation-related GHG emissions by 5–9 percent by replacing gasoline and diesel with lower carbon fuels;
- reduce gasoline and diesel use by 12–29 percent (4–9 billion gallons annually) in year 10 when the program is fully implemented;
- enhance energy security by replacing transportation fuels made from imported oil with domestic alternatives such as advanced biofuels, electricity and natural gas (gasoline and diesel would still remain dominant fuels in the region);

- achieve net savings on transportation costs when oil prices are high, with near parity at low oil price levels; and
- create a small but positive impact on jobs, gross regional product, and disposable person income within the region under a wide range of possible compliance scenarios.

Stakeholder meetings to present and discuss the findings of this analysis will be held in Boston and Baltimore in September 2011. At these meetings, Northeast States for Coordinated Air Use Management and state staff will present the assumptions and findings of the economic analysis, take questions and comments on the analysis, and discuss next steps.

This analysis suggests that a Clean Fuels Standard could reduce GHG emissions from the transportation sector, promote a more diverse fuel mix that would diminish the region's reliance on imported oil, and help protect consumers from price volatility in the global oil market. The results of the economic study indicate that the higher the price of gasoline and diesel, the greater the savings would be for consumers. The Clean Fuels Standard can result in economic growth and job creation under a wide range of possible market responses to the program's carbon intensity reduction requirements.

Estimated GHG Emission Reductions

This plan is not projected to be operational by 2020 so not benefit has been attributed to it.

Sub-Appendix C-7: Land Use Programs

P.2: GHG Benefits from Priority Funding Areas

Lead Agency: MDP

Program Description

Maryland established Priority Funding Areas to preserve existing communities; target State resources to build on past investments; and reduce development pressure on critical farmland and natural resource areas. By encouraging projects in already developed areas, Priority Funding Areas prevent the GHG emissions associated with sprawl.

Priority Funding Areas are geographic growth areas defined under State law and designated by local jurisdictions to provide a map for targeting State investment in infrastructure. A map of the Priority Funding Areas in Maryland is available on MDP's website at: http://planning.maryland.gov/OurProducts/pfamap.shtml. The law directs the use of State funding for roads, water and sewer plants, economic development and other growth-related needs to Priority Funding Areas, recognizing that these investments are the most important tool the State has to influence growth and development.

As required by Maryland law, many State agencies provide funding for "growth related" development and infrastructure only within Priority Funding Areas. Rather than requiring additional outlays beyond current funding to support compact development, the Priority Funding Area law instead requires a reallocation of existing funding. Maryland's Smart Growth Subcabinet provides an Annual Report on the Implementation of the Smart Growth Areas Act, which describes the State agency programs that are restricted to Priority Funding Areas and the amount of funds allocated within the fiscal year – see MDP's website at: http://planning.maryland.gov/OurProducts/PublicationsPlain.shtml#annual.

Some examples of Priority Funding Area-restricted State agency programs that prevent GHG emissions by supporting compact development patterns include:

- The Maryland Department of Housing and Community Development's "State funded neighborhood revitalization projects," which include funding from Community Legacy, Community Investment Tax Credit, Maryland Capital Access Program, and Neighborhood Business Works.
- The Maryland Department of Business and Economic Development's Maryland Economic Development Assistance Authority and Fund, which provides both loans and grants to businesses and local jurisdictions.
- The Maryland Department of Environment's Maryland Water Quality Revolving Loan Fund, which provides financial assistance to public entities and local governments for wastewater treatment plant upgrades.
- Maryland Department of Transportation "growth related" projects, which include all major capital projects (unless granted an exception) and are defined as "any new, expanded, or significantly improved facility or service that involves planning, environmental studies, design, right-of-way, construction, or purchase of essential equipment related to the facility or service".

The Rural Legacy Program assists counties and municipalities in their efforts to preserve areas rich in agricultural, historic, scenic, and cultural resources, and provides opportunities to acquire parkland. Maryland structured the program to encourage local land trusts and local jurisdictions to prepare rural legacy plans that seek to protect significant and threatened resources. Through an annual competitive selection process, counties choose plans to submit to the State for funding.

Priority Funding Areas were established by the 1997 Priority Funding Areas Act (the Smart Growth Act).[113] The law also directs MDP to coordinate the process of updating these areas by providing technical assistance, review, comment and the opportunity for public review. Although these areas have been in existence for more than a decade, there have been significant changes to the designation process, especially for municipalities, as a result of the passage of House Bill 1141 in 2006. The Smart Growth Act authorizes counties and municipalities to designate areas appropriate for growth as Priority Funding

[113] The criteria for Priority Funding Areas are defined in the Annotated Code of Maryland, State Finance and Procurement Article, §5-7B-02 and §5-7B-03.

Areas. Since October 1, 2006, municipalities must follow the same criteria as counties.[114] In 2009, the Smart Growth Goals, Measures, and Indicators and Implementation of Planning Visions law established a goal to increase the percentage of growth within Priority Funding Areas and decrease it outside these areas. Local governments are also required to set growth goals to keep pace with the State goal and report annually on ordinances and regulations that support the goal.

Estimated GHG Emission Reductions in 2020

The estimated GHG emission reductions for this program are aggregated in Land Use-1 and assume that 75 percent of Maryland's new development between 2011 and 2020 will be compact development. MDP will achieve this goal by achieving the following subgoals:

- 25 percent / 75 percent split between new multi-family and single-family homes (current trend, based on the past decade, was a 22 percent / 78 percent split, although the multi-family share has been trending higher in the last few years)
- 80 percent of homes located within the Priority Funding Area (current trend, 75 percent)
- 84 percent of residential lots within Priority Funding Areas equal to or smaller than ¼-acre (current trend, 72 percent)
- Similar or higher share of future nonresidential development in compact form (nonresidential development mostly follows population)

Implementation

Maryland has enacted measures, such as the Smart Growth Goals, Measures, and Indicators and Implementation of Planning Visions law and the Sustainable Communities Act of 2010, to help direct growth and development to Priority Funding Areas. In addition, MDP is working with other State agencies to develop Plan Maryland and Maryland's Phase I Watershed Implementation Plan, which supports Priority Funding Areas.

The Smart Growth Goals, Measures, and Indicators and Implementation of Planning Visions bill (Senate Bill 276/House Bill 295) requires local planning commissions or boards to submit annual reports to local legislative bodies beginning July 1, 2011 that include specified smart growth measures and indicators and information on a local land use goal as part of the report. With the exception of jurisdictions that issue less than 50 building permits per year, the measure and indicators that must be reported are the following: amount and share of growth that is being located inside and outside the Priority Funding Area; net density of growth that is being located inside and outside the Priority Funding Area; creation of new lots and the issuance of residential and commercial building permits inside and outside the Priority Funding Area; development capacity analysis, updated once every 3 years or when there is a significant zoning or land use change; and number of acres preserved using local agricultural land preservation funding.

[114] Locally designated Priority Funding Areas are evaluated by the MDP against criteria in §5-7B-02 and §5-7B-03.

The Sustainable Communities Act of 2010 broadened an existing tax credit focused on historic structures to one that emphasizes the importance of dense, sustainable development near mass transit in a variety of urban centers throughout the State. This tax credit supports the goals of the Main Street Maryland Program that aims to strengthen traditional downtown business districts. The Sustainable Communities Act also supports transit-oriented development that allows Marylanders greater choice in how they move between home, work, and play.

While the goal is to direct as much growth to appropriate areas as possible, some growth will inevitably occur outside of the Priority Funding Areas. Maryland works to protect valuable forests and farms from being developed. Once a property converts to a developed use, it rarely, if ever, is returned to its previous State of field or forest. Organizations including the Maryland Agricultural Land Preservation Foundation, the Maryland Environmental Trust, Program Open Space, and others work diligently to make sure that these lands remain in their current State into the future to protect the Chesapeake Bay and to make certain that future generations can enjoy them.

The implementation of PlanMaryland is a priority. Implementation will require both an evaluation of existing plans, programs and procedures and recommendations for additional programs and policies, many in support of Priority Funding Areas. Additionally, the development and implementation of the accounting for growth strategy of Maryland's Phase I Watershed Implementation Plan, which creates strong disincentives for sprawl development, also continues.

Q: Outreach and Public Education

Lead Agencies: MDE

Program Description

State-sponsored public education and outreach combined with community actions form the foundation for behavioral and life style changes necessary to reduce GHG emissions. This program is designed to encourage continuation of existing efforts and to promote new actions. The State supports current educational efforts and action campaigns of: State agencies, such as MDE, DNR, the Maryland State Department of Education, and University of Maryland; electric utilities; non-profit organizations; faith communities; and others. This combination of efforts insures that scientifically based factual information is made available through public education and outreach efforts and reaches all segments of the public. Many of these activities are already underway. Education and outreach program goals include:

- Educate and coordinate legislatures and agencies on climate change, conservation, and energy efficiency for government facilities, operations, and transportation.
- Develop Maryland-specific lessons on climate change, energy conservation, and energy efficiency aligned with the Voluntary State Curriculum and Core Learning Goals, and integrate into K-12 curriculum.
- The Governor's Regional Environmental Education Network.

- Support on-going efforts by higher education institutions to include climate change as part of their overall educational and facilities-management practices.
- Organize an annual one-day conference for regional public media representatives on: the state of climate change mitigation in Maryland and the level of attainment of State GHG goals; latest climate science and observations; climate change impacts on public health, regional environment, the Chesapeake Bay, and the economy; and applications of climate-friendly technologies.
- Collaborate with counties and utilities to educate and stimulate commercial organizations and homeowners to adopt climate friendly measures and promote climate friendly products.
- Develop/distribute guidelines to encourage farmers and forestry operators to practice climate friendly measures. Develop a website to host voluntary experts to answer climate-related questions from this target audience.

Estimated GHG Emission Reductions in 2020

Figure C-72. Low and High GHG Benefits for Multi-Sector-3

Initial Reductions	0.03 $MMtCO_2e$	MDE Quantification Below
Enhanced Reductions	0.03 $MMtCO_2e$	MDE Quantification Below

Estimates – MDE Quantification

This section presents a theoretical exercise in estimating GHG emissions reductions that could result from outreach (marketing) campaigns. Note: the data presented here has not been approved by MDE or any other agency. Its intended purpose is illustrative.

Education and outreach campaigns are most effective when they are targeted to a specific purpose. Much has been written about social marketing and it has had wide application in Canada and throughout the U.S. This report presents three theoretical campaigns that are categorized by their levels of effort, Big, Medium and Small. These categories apply to the size of the target audience as well as the financial commitment needed to effect the desired behavioral changes and environmental benefits.

Big Effort

This idea is a subset of work that utilities are conducting as part of the EmPOWER Maryland program. EmPOWER Maryland is a Statewide program that, among other goals, seeks to reduce per-capita energy consumption 15 percent by 2015.

For this exercise, the quarterly EmPower reports from BGE and PEPCO were used. Together, these companies provide utilities to a majority of Maryland consumers. EmPower Maryland has an enormous outreach campaign designed to encourage energy efficiency measures and, thereby, reduced consumption. There are three components that are being marketed to residential customers: lighting, appliances and quick home energy checkups. The baseline data was extracted from the utilities' reports to PSC.

Both utilities conducted extensive campaigns to promote the use of compact fluorescent lights, rebates for qualifying energy-efficient appliances and home energy check-ups. These included print and media campaigns, working with retailers and direct mailing of program information included with monthly bills. The utilities spend over $1 million on these and other campaigns to fulfill their obligations under EmPower Maryland.

These programs were rolled out in 2009 and are on-going. It is assumed that as people received the message, barring any issues such as economic constraints, that customers would steadily increase the purchase of compact fluorescent lightbulbs and energy-efficiency appliances and would sign up for the home energy check-ups.

The metric used in the reports is actual gross annualized energy savings in MWh. The $MMtCO_2e$ reduction is calculated to illustrate GHG reductions potential as participation in the programs increase.

Figure C-73. High Range GHG Benefits ($MMtCO_2e$)

2009 Base	2015 Modest (15%)	2020 High (20%)
0.0372	0.0428	0.0465

Medium Effort

The project in the medium effort is based on a conceptual interpretation of work conducted by Douglas McKenzie-Mohr in Canada. This type of campaign targets motorists with under-inflated tires on light and medium-duty vehicles. Typically, outreach would be conducted at points of service like gas stations and vehicle repair shops. The number of vehicles targeted for evaluation and corrective action is based on the scope of the project. That is, the campaign could be scaled from Statewide to county-wide to small events like car care clinics. This example uses Statewide VMT for light and medium duty vehicles.

Based on data gathered at MDE-sponsored clean car clinics, approximately 60 percent of light and medium duty vehicles have improperly inflated tires. This example assumes that all 4 tires are under-inflated by 10 pounds per square inch. The under-inflations are assumed to lower gas mileage by 3 percent. The goal of this sample campaign would be to have 20 percent of motorists regularly check tire pressure and take needed corrective action.

This project is to be run in 2010 and in 2020. The base case assumes 60 percent of the light and medium duty VMT driven on under-inflated tires. The assumed fuel economy is the Corporate Average Fuel Economy standard for new vehicles in those years. In reality, fuel economy would be somewhat less if we account for Maryland’s fleet including older and improperly maintained vehicles. The federal fuel standard represents a “best case” scenario. Fuel economy was reduced by 3 percent to account for under-inflated tires.

The target case is the result of a "successful" campaign that reduces the number of vehicles with under-inflated tires to 40 percent. Note: the smaller benefit in 2020 is the result of a higher Corporate Average Fuel Economy standard; the cars are cleaner.

Figure C-74. Middle Range GHG Reductions ($MMtCO_2e$)

Year	60% under-inflated	40% under-inflated	Benefit
2010	0.000436	0.000291	0.000145
2020	0.000375	0.000250	0.000125

Small Effort

The small effort considers a community-based effort to encourage people to ride bikes to work. The results are based on estimates derived from Bike to Work days in the Baltimore Metropolitan Region in 2008, 2009 and 2010. The Baltimore Metropolitan Council participates in National Bike to Work Day and promotes the event extensively on the web and through local interest groups.

For this exercise, it is assumed that people do not bike to work for distances greater than 15 miles. Most bikers are assumed to bike within 2.5 and 5.5 miles; 10 percent bike 15 miles, 20 percent bike 7.5 miles, 30 percent bike 5.5 miles and 40 percent bike 2.5 miles. Each bike trip was assumed to replace one car trip. Based on survey data from 2009, 43 percent of the people who participated in Bike to Work Day would have driven a car as their usual transportation. The carbon emissions benefits of biking to work are compared to driving a vehicle for the same distance and are weighted by the number of people who chose to ride a bike and who would have driven as their usual commute mode. The GHG emissions avoided are expressed in pounds because the numbers are small. The numbers after 2010 are extrapolated. Increasing the number of people who replace vehicle commute trips with bike commute trips shows a benefit in GHG emissions avoided. In 2020 the benefit is estimated to be 0.000007 $MMtCO_2e$ emissions avoided.

Figure C-75. Bike to Work Benefits

Year	People	GHG emissions avoided (pounds)	GHG emissions avoided (Metric Tons)	GHG emissions avoided ($MMtCO_2e$)
2008	344	3,017	1.3685	0.000001
2009	430	3,770	1.7100	0.000002
2010	568	4,977	2.2575	0.000002
2111	671	5,881	2.6677	0.000003
2012	783	6,861	3.1122	0.000003
2013	895	7,841	3.5568	0.000004
2014	1,007	8,821	4.0013	0.000004
2015	1,119	9,801	4.4458	0.000004
2016	1,231	10,781	4.8903	0.000005
2017	1,343	11,761	5.3349	0.000005

2018	1,455	12,741	5.7794	0.000006
2019	1,567	13,721	6.2239	0.000006
2020	1,679	14,701	6.6684	0.000007

Implementation

Outreach and public education are supporting efforts to other programs. They do not exist as separate, quantifiable entities. In the 2008 Climate Action Plan, these activities were presented as part of the cross-cutting group of policies which were not quantified. There is, therefore, no base line from which to estimate benefits.

There are many models from which to estimate emissions benefits from social programs. Surveys, like the ones performed by the Clean Air Partners to evaluate the effectiveness of Ozone Action Day messaging, are one way to assess how effectively a set of messages has been delivered and received. These work well to assess actions taken in response to specific episodes, in this case code red ozone days. They do not attempt to quantify reductions in ozone pollution. Other well-documented social engineering techniques have been used to promote recycling in communities. The attitudes and actions of people are quantified and the tons of recycled materials are measured. There is not an environmental benefit directly ascribed to the outreach program because there are usually many external factors that confound the quantification effort (both positive and negative).

All programs to reduce GHG emissions should include an educational component to ensure that people understand what is trying to be accomplished. Extending the traditional methods to include social media and other evolving communication techniques must be considered for successful education and outreach.

MADE-CLEAR

In addition to taking action to mitigate climate change, Maryland schools are expected to implement climate change curriculum at all levels of the education system. The National Science Foundation has awarded a highly competitive, $1 million two-year planning grant to the University System of Maryland to implement the Maryland-Delaware Climate Change Education, Assessment and Research, also know as MADE-CLEAR, project in collaboration with University of Maryland Center for Environmental Science, the University of Maryland, and the University of Delaware.[115] The award funds a two-year strategic planning process that will build on partnerships among the two states' universities, public schools, federal agencies, and public and private sectors to assess needs and identify key stakeholders and resources needed to implement an innovative P-20 climate change curriculum, develop new pathways for teacher education and professional development leading to expertise in climate change content and pedagogy, and promote better communication for public understanding of the science of climate change. A strategic plan will be developed and will serve as the basis of a proposal for a full implementation grant of several million dollars per year. The overall goal of the project is to establish a coordinated national network of partnerships devoted to

[115] National Science Foundation award information available at: http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=1043262.

increasing the adoption of educational programs and resources related to the science of climate change and its impacts.

College Climate Action Group

MDE is facilitating a group called the College Climate Action Group, for Maryland colleges and universities which have either signed the American College and University Presidents' Climate Commitment or are considering implementing strategies to reduce GHG emissions. The MDE-coordinated College Climate Action Group is envisioned to provide a forum for Maryland colleges and universities to share information relating to the implementation of a climate action plan or target. The meetings will be held quarterly in 2011.

Maryland State Department of Education

The Maryland State Department of Education has developed Environmental Literacy Curriculum,[116] which includes climate change topics. The curriculum is additional to the Maryland-Delaware Climate Change Education, Assessment and Research plan. Climate change instructional resources for teachers are provided by the National Oceanic and Atmospheric Administration under the Communications and Education Program. The Maryland Environmental Literacy Standards are based on national standards and provide a flexible structure that allows for more in-depth study of particular issues using critical thinking skills and investigation to learn long-term reasoning, research and interpretation skills. The purpose of Maryland's Environmental Education program is to enable students to make to make informed and responsible decisions about the environment in all its complexity and take actions to increase public awareness about environmental issues, and to preserve and protect the unique natural resources of Maryland.

The Maryland State Department of Education's Environmental Education website hosts a Climate Change Education resource page and classroom toolkit. Lessons, websites, and unit plans for all appropriate grade levels are included on the site. The agency incorporated language from the national Climate Literacy Standards into the draft Maryland State Environmental Literacy Standards. These standards represent what an environmentally literate Maryland high school graduate will know about climate and climate change, as well as describe the analysis and decision-making skills involved in the investigation of environmental issues. Input on the standards was garnered from more than 100 members of the education and climate science communities. The Climate Literacy Standards define climate literacy as one who "understands the influence of climate on you and society and your influence on climate".[117] Moreover, a climatically literate person:

[116] Curriculum information available:
http://www.marylandpublicschools.org/MSDE/programs/environment/?WBCMODE=PresentationUnpubli%25%3E%25

[117] Climate Literacy: Essential Principles and Fundamental Concepts, 2007, NOAA, AAAS Project 2061.

- Understands the essential principles and fundamental concepts about the functioning of weather and climate and how they relate to variations in the air, water, land, life and human activities both in time and space;
- Can communicate about the climate and climate change in a meaningful way;
- Is able to make scientifically informed and responsible decisions regarding the climate.

GREENet

The Governor's Regional Environmental Education Network, also known as GREENet, was created in the Fall of 2008 to serve as a communications tool for formal educators, informal environmental educators, non-profits, community groups, State agencies, and others interested in and engaged in environmental education. There is a network contact for every county in Maryland. The network forum is available online: http://mdinformee.ning.com/.

Maryland Climate Action Plan

Maryland Department of Transportation
Draft 2012 Implementation Plan

Martin O'Malley, Governor

Anthony G. Brown, Lt. Governor

Beverley K. Swaim-Staley, Secretary

April 11, 2011

Maryland Department of Transportation

report

Maryland Climate Action Plan - MDOT Draft 2012 Implementation Plan

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April 11, 2011

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Executive Summary

In 2007 Governor Martin O'Malley signed an Executive Order establishing the Maryland Commission on Climate Change (the Commission). Sixteen state agency heads, six General Assembly members, local government officials, and representatives from the private sector and non-governmental organizations comprise the Commission. The Commission released a plan of action for addressing climate change in August 2008, and will report each year in November to the Governor and Legislature on progress in implementing the recommendations found in the Climate Action Plan (CAP) and in meeting the preliminary greenhouse gas (GHG) emission reduction goals.

On May 7, 2009, Governor Martin O'Malley signed into law the Maryland Greenhouse Gas Emissions Reduction Act of 2009 (Act) requiring Maryland to achieve a 25 percent reduction in 2006 GHG emissions by 2020. While the majority of GHG related emissions are created by power generation, the transportation sector produces approximately 32 percent of the state's GHG emissions. Achieving a significant reduction in GHG emissions from the transportation sector will be critical to supporting the requirements articulated in the Act.

The Act requires the Maryland Department of Environment (MDE) to develop a proposed Statewide GHG reduction plan by 2011, to solicit public comment on the proposed plan from interested stakeholders and the public, and to adopt a final plan by 2012. The Act also requires the State to demonstrate that the 25 percent reduction can be achieved in a way that has a positive impact on Maryland's economy, protects existing manufacturing jobs and creates significant new "green" jobs in Maryland.

By 2011 the Act requires MDE to:

- Develop a 2006 Statewide greenhouse gas emissions inventory;
- Develop a projected "business as usual" emissions inventory for 2020; and
- Develop and publish for public comment a proposed plan to achieve a 25 percent GHG emissions reduction by 2020.

The MDOT work program summarized in this document supports the ongoing effort of MDE to develop the proposed statewide GHG reduction plan. As part of the GHG reduction plan process, MDE developed agency-based GHG targets that are designed to support the overall State goal. Using key elements of the 2008 Climate Action Plan and the 2009 MDOT Implementation Status Report, MDE provided MDOT a GHG reduction target for 2020 of 6.2 mmt CO_2e in February, 2011. This document provides a summary of the MDOT work program that addresses the GHG reduction target and goals in the Act.

THE MDOT WORK PROGRAM – PAST & PRESENT

Through the Commission's work, MDOT was designated as the implementing agency for six Transportation and Land Use (TLU) mitigation and policy options, and is a primary supporting agency on two others. The policy options (and subsequent work accomplished by MDOT) are primarily focused on reducing GHG emissions through a wide array of strategies that address infrastructure investment, travel demand management programs, transit investment, clean fuel programs, and new vehicle technology standards.

MDOT was also charged to work with the Maryland Department of Planning (MDP) on land use and location efficiency policies and programs, the Maryland Insurance Administration (MIA) to support the analysis of the Pay-as-You-Drive (PAYD) insurance in Maryland, and the Maryland Department of the Environment (MDE) to implement transportation technologies to reduce GHG emissions per mile. As part of the Phase III work program, MDP took over the responsibility for the TLU mitigation and policy option that addressed land use, and MIA took over the policy option addressing PAYD. The results of both the land use and PAYD initiatives will be presented by MIA and MDP in separate documents (they are referenced in this document in Section 3.5). Both of these policy options affect GHG emissions in the transportation sector, and as such, will be included in subsequent updates of this document.

Phase I

In January 2009, MDOT engaged in a multi-phase work plan to define specific programs, actions, and strategies to address the eight TLU mitigation and policy options. The goal of the Phase I work program focused on defining, evaluating, ranking and determining the feasibility of a series of transportation strategies and actions – consistent with the Commission's Climate Action Plan – that will assist Maryland in achieving GHG reduction targets.

MDOT created seven broad Working Groups to address each of the TLU policy options, and a Coordinating Committee to oversee the process of identifying GHG reduction strategies. The Coordinating Committee membership was designed to ensure full representation of all MDOT modal agencies and other relevant State agencies. The Working Groups provided technical guidance and included local representation though the participation of the Baltimore Metropolitan Council (BMC), the Metropolitan Washington Council of Governments (MWCOG), Montgomery County and the City of Baltimore.

In Phase I, 72 strategies were defined by the working groups and 57 were considered critical or important to reducing GHG emissions. Of the 57 strategies, 44 were capable of being implemented by 2020. A macro-level assessment of the strategies was completed as part of Phase II.

Phase II

Phase II began in July 2009 with the objective of quantifying the contribution the strategies defined during Phase I. Under the Phase II work program MDOT organized the strategies into six specific areas to account for potential GHG emission reductions. They included:

- **The proposed national vehicle standards program** to improve fuel economy and reduce greenhouse gases, which were formally proposed by USEPA and USDOT on September 15, 2009.

- **The Maryland Clean Car Program** signed into law by Governor Martin O'Malley in April 2007, which adopts California's more stringent vehicle emissions standards for cars sold in the state.
- **USEPA's proposed National Renewable Fuels Standards** program for 2010 and beyond, which requires new volume standards to be used for renewable transportation fuels.
- **Currently funded and planned transportation system investments 2006-2020**, which are defined in the Maryland 2009 - 2014 Consolidated Transportation Program (CTP), and in the Metropolitan Planning Organizations (MPOs) Transportation Improvement Programs (TIPs) and Long-Range Plans (LRPs) through 2020.
- **Currently funded and planned Transportation Emissions Reduction Measures (TERMs)**, which are defined in the 2009-2014 CTP and in the MPO TIPs and LRPs, including off-highway projects as defined by MAA and MPA.
- **Unfunded TLU strategies** defined by the Phase I Working Groups and Coordinating Committee.

Phase III

Phase III began in December 2010. Phase III provides an update of work completed in previous phases and provides MDE with data and information to support the development of the proposed Statewide GHG reduction plan. The purpose of the Phase III work program is to update the contribution of the transportation sector related strategies that support the Act and to provide the data and information to MDE for incorporation into the proposed 2011 plan submittal.

The major work elements of the Phase III process include:

- Revise the on-road mobile 2006 inventory and 2020 business-as-usual (BAU) forecast of statewide GHG emissions based on EPAs MOVES model.
- Update the GHG emission reduction benefits and costs of Maryland funded transportation plans and programs through 2020, existing and proposed TERMs, and new State and Federal fuel and vehicle technology programs and standards.
- Review and refine the definition, description, costs and GHG emissions benefits of the unfunded transportation GHG reduction strategies through 2020.
- Consult with policy option partner agencies (including MDP for TLU-2, MIA for TLU-6, and MDE for TLU-10) throughout development of the *2011 Implementation Status Report*.
- Address the 2009 GHG Reduction Act legislative requirements in preparation of the *2011 Implementation Status Report*.

RESULTS OF THE MDOT WORK PROGRAM

Phase III of the MDOT work program confirmed the status of the transportation sector related strategies along with updating the GHG emissions estimates associated with the strategies. Several key findings have been identified as part of the Phase III work program.

- MDOT has adopted programs and strategies that achieve **85 percent** or **5.30 mmt CO_2e** of the MDE assigned 2020 GHG emission reduction target.
- GHG beneficial projects adopted in the 2011-2016 CTP and MPO plans and programs total a **$13.2 billion** capital investment through 2020 that represents **50 percent** of the current capital programs.
- Other transportation sector related GHG reduction strategies focusing on clean fuels and improved state and federal fuel economy standards will result in **6.42 mmt CO_2e** reductions in on-road mobile source emissions by 2020.
- In total, transportation sector GHG related emissions could be reduced by a total of **11.72 mmt CO_2e** in 2020, with a total transportation infrastructure capital investment $13.2 billion through 2020.
- Using the 25 percent reduction from 2006 emissions as a benchmark to measure progress of the transportation sector, the **11.72 mmt CO2e** reduction by 2020 achieves **68 percent** of the Act goal.
- If additional transportation funding becomes available, MDOT identified a set of strategies that could reduce GHG up to **3.14 mmt CO_2e** at a cost ranging from **$2.9 - $7.1 billion** (cost range is based on the potential level of implementation).
- Based on the 25 percent reduction from 2006 emissions, at the highest level of strategy implementation, including unfunded transportation sector strategies, the transportation sector could achieve a **14.86 mmt CO_2e** reduction by 2020, or **87 percent** of the Act goal.

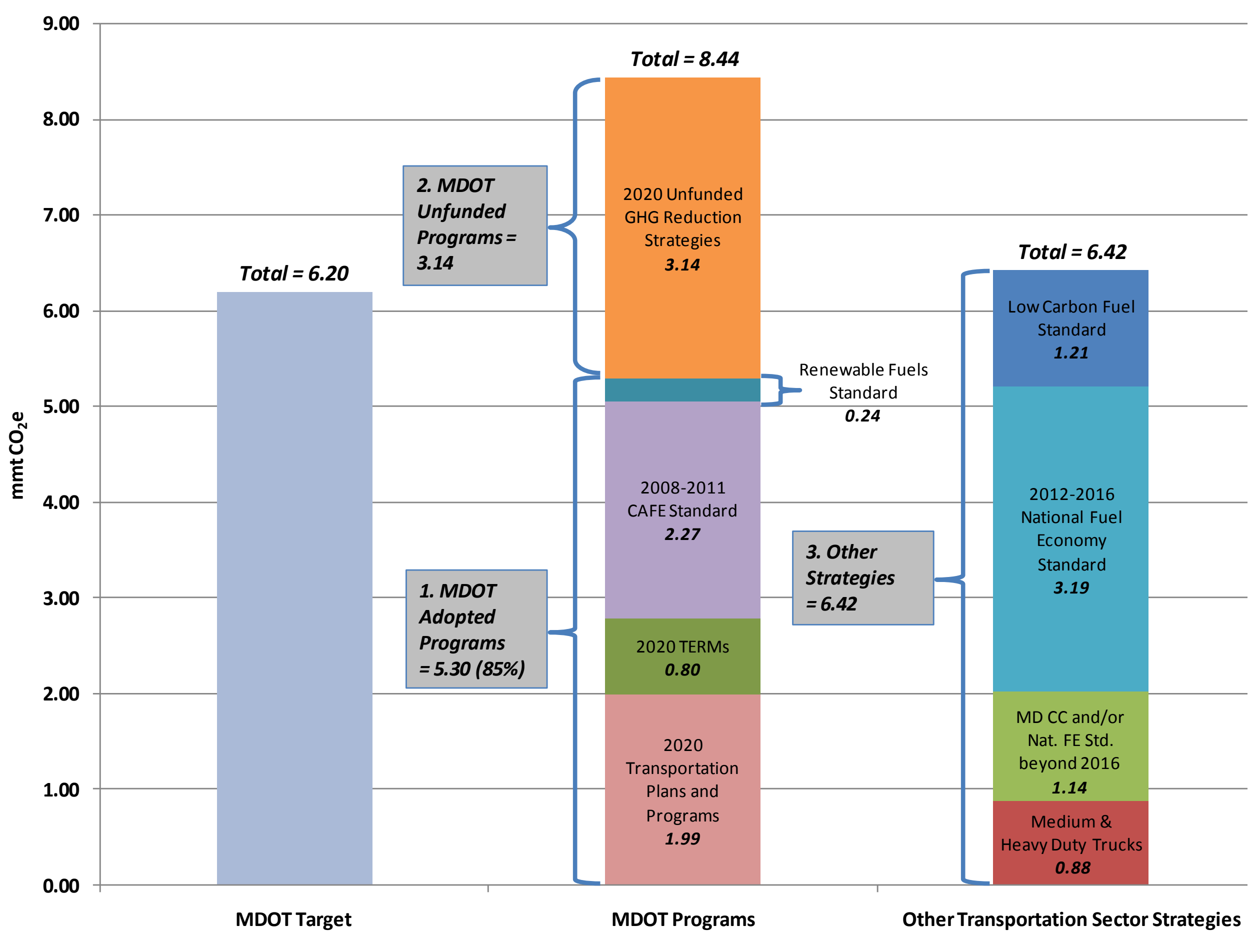
Figure ES.1 provides a summary of the GHG emissions for all programs analyzed as part of this effort. MDOT has identified and adopted programs and strategies that achieve 85 percent or 5.30 mmt CO_2e of the 6.2 mmt CO_2e 2020 target emission reduction target established by MDE. This includes all transportation infrastructure plans and programs currently defined in the adopted *MDOT 2011 - 2016 Consolidated Transportation Program (CTP)*, and all adopted metropolitan planning organization long range plans and programs. In total, this represents a $13.2 billion capital investment in the transportation system statewide. Major projects include the MARC growth and investment plan, the MTA light rail "Red Line" in Baltimore, and the light rail "Purple Line" in the Washington D.C. suburbs.

Figure ES.1 also includes a summary of "unfunded" strategies that could reduce transportation related GHG emissions by another 3.14 mmt CO_2e by 2020. These strategies were identified during Phase I of this work program and could be implemented by 2020 if funding was available. Based on the final design of these strategies, the capital cost could range from $2.9 billion to $7.1 billion. Major projects types in the unfunded program include an expansion of public transit statewide, expanded statewide travel demand management programs, and a targeted congestion pricing program.

Taken together, MDOT has identified plans, programs and strategies that could reduce transportation related emissions by 8.44 mmt CO_2e by 2020. The capital cost to implement this package could range from $16.1 billion to $20.3 billion, with $13.2 billion already fully committed.

MDOT has also accounted for other transportation sector related GHG reduction strategies (Figure ES.1) that focus on cleaner fuels and improved fuel economy standards. Implementing these state and federal programs will result in another 6.42 mmt CO_2e reduction by 2020 with little or no direct cost to Maryland.

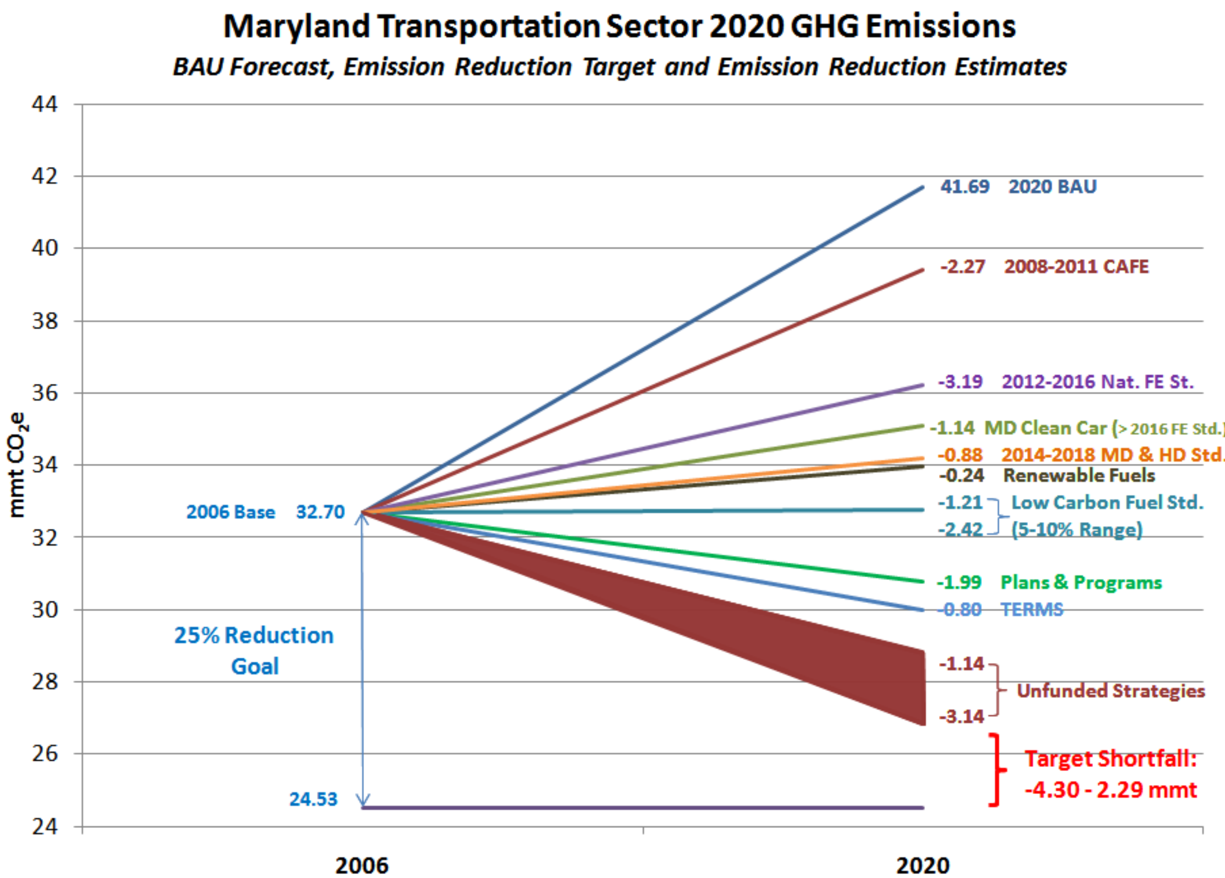
Figure ES.1 MDOT Greenhouse Gas Emissions Summary



Based on the Phase III work program results, transportation sector GHG related emissions could be reduced by a total of 14.86 mmt CO_2e by 2020. This represents a significant reduction in GHG emissions statewide with an equally significant overall investment ranging from $16.1 billion to $20.3 billion.

Prior to receiving the MDE GHG target of 6.2 mmt CO_2e, MDOT used a benchmark for achieving a 25 percent reduction in 2006 emissions as a way to evaluate progress toward achieving the goal of the Act. Figure ES.2 illustrates the anticipated 2020 transportation sector reductions within the framework of a statewide reduction goal of 25 percent below 2006 levels by 2020. To achieve a 25 percent GHG emissions reduction in 2006 by 2020 from the transportation sector, a 17.16 mmt CO_2e reduction in emissions is required. By implementing all strategies and programs included in Figure ES.2, 2020 transportation sector emission reductions could reach as much as 87 percent (14.86 mmt) of the 25 percent GHG reduction goal for 2020. The figure further illustrates a 2.29 to 4.30 mmt CO_2e target shortfall for the transportation sector.

Figure ES.2 Maryland 2020 Transportation GHG Emissions Forecast and Reductions



While these programs provide the State significant reductions in transportation related GHG emissions, MDOT and the modal administrations continue to actively pursue and implement energy conservation strategies into the daily operating activities of each agency. Included in this report are several samples of energy conservation strategies that have been implemented by MDOT and the modal administrations to gain greater energy independence, efficiency, and focus on the application of cutting edge "green" technology.

MDOT is committed to supporting and consulting with MDE throughout the process in developing the Statewide GHG Reduction Plan. MDOT has been mindful to focus on strategies that will achieve GHG reductions and will positively impact Maryland's economy, and protect existing manufacturing jobs while creating new "green" job opportunities in Maryland. MDOT also affirms that the strategies included in this plan document will not negatively impact rural communities and will continue to support Maryland's ability to attract, expand and retain aviation services.

1.0 The MDOT Climate Action Plan Implementation Process

1.1 BACKGROUND

In response to the threat and growing concern with climate change, the Maryland Commission on Climate Change (the Commission) was established in April 2007. The Commission includes 16 Maryland agency heads, six General Assembly members, local government officials, and representatives from the private sector and non-governmental organizations. The Commission released a plan of action for addressing climate change in August 2008. Each year in November, the Commission will report to the Governor and Legislature on progress in implementing the Climate Action Plan (CAP) and in meeting the preliminary GHG reduction goals set in it.

In May 2009, Governor Martin O'Malley signed The Maryland Greenhouse Gas Emissions Reduction Act of 2009. The Act establishes a requirement that Maryland achieve a 25 percent reduction of 2006 emissions by 2020. Since the transportation sector contributes 32 percent of the state's GHG emissions, achieving a significant reduction in transportation GHG emissions will be critical to supporting the requirements articulated in the Greenhouse Gas Emissions Reduction Act.

Through the Commission's work, MDOT has been designated as the implementing agency for six Transportation and Land Use (TLU) mitigation and policy options, and is a primary supporting agency on two others. MDOT's policy options are primarily focused on reducing GHGs through vehicle miles of travel (VMT) reductions. MDOT is also charged to work with the Maryland Department of Planning (MDP) on statewide land use and location efficiency strategies, Maryland Insurance Administration (MIA) on expanding deployment of Pay-As-You-Drive insurance, and Maryland Department of the Environment (MDE) to implement transportation technologies to reduce GHG emissions per mile.

1.2 PROCESS

To develop an implementation plan for the policy options developed by the Commission, MDOT established a fully collaborative process comprised of seven Working Groups focused on each TLU policy option, and a Coordinating Committee to provide guidance and oversight for the entire process. Working Group meetings held between February and May 2009 defined a total of 72 strategies (Phase I). The Coordinating Committee reviewed and adjusted the strategy definitions, leading to a list of 44 strategies prioritized for analysis in Phase II.

The Phase II work program conducted a detailed GHG emissions analysis and supported MDOT in the continued refinement of the MDOT Climate Action Plan Implementation activity. The objective of the Phase II work program was to understand the contribution that the transportation sector can make to meeting the 2020 target included in The Maryland

Greenhouse Gas Emissions Reduction Act of 2009 while supporting long term (beyond 2020) GHG reduction goals.

The final Phase II MDOT Draft Implementation Status Report and Appendices were submitted to MDE in November 2009 and are currently posted as part of the November 2009 Report to the Maryland Commission on Climate Change on MDEs website (www.mde.state.md.us).

This document summarizes the Phase III process which updates the *Maryland Climate Action Plan - MDOT 2009 Implementation Status Report* and provides the materials supporting MDE's completion of the *2012 Draft Implementation Plan* as required by the Maryland Greenhouse Gas Emissions Reduction Act of 2009 (Act).

1.3 REPORT

The remainder of the report is organized into the following major sections.

Section 2 – 2006 Baseline and 2020 Business-as-Usual (BAU) Forecast Greenhouse Gas Emissions Inventory Update

- Establishes an updated transportation sector 2006 baseline GHG emissions inventory and a 2020 BAU forecast of GHG emissions based on EPAs MOVES model.

Section 3 – 2020 Transportation Sector Detailed Assessment

- Quantifies GHG reduction strategies associated with existing and proposed vehicle technology and fuel standards.
- Quantifies by transportation GHG reduction policy option the GHG reductions and costs from the MDOT Consolidated Transportation Program (CTP), Metropolitan Planning Organizations (MPOs) Transportation Improvement Programs (TIPs) and Long-Range Plans (LRPs), and Transportation Emission Reduction Measures (TERMs) through 2020.
- Refines the unfunded transportation GHG reduction strategy definitions and provides forecasts of GHG emissions reductions and capital costs through 2020.

Section 4 – 2020 Transportation Sector Summary Results

- Summarizes MDOTs progress in meeting the GHG reduction target through MDOT adopted programs and other transportation sector programs.
- Summarizes overall progress in the transportation sector in reducing GHG emissions through 2020.

Appendices

A. 2006 Baseline and 2020 BAU Emissions Inventory Documentation

B. CTP, MPO TIP/LRP Project Listings by Policy Option

C. TERM Analysis Assumptions, Costs, and Results

D. Unfunded GHG Reduction Strategy Emission Reductions and Cost Assumptions

E. MDOT Summary Forms

2.0 2006 Baseline and 2020 BAU Forecast Greenhouse Gas Emissions Inventory Update

The greenhouse gas (GHG) inventory for Maryland's transportation sector includes the 2006 baseline and the 2020 business-as-usual (BAU) forecast year. The inventory was calculated by estimating emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) then converting those emissions to carbon dioxide equivalents that are measured in the units of million metric tons (mmt CO_2e). Carbon dioxide represents about 97 percent of the transportation sector's GHG emissions. The inventory includes both on-road and off-road sources as defined by the Energy Information Administration (EIA).

The on-road portion of the inventory was developed using EPA's new emissions model MOVES (Motor Vehicle Emissions Simulator). The inventory results represent an update of previous analyses conducted by the Center for Climate Strategies (CCS) for the Climate Action Plan (CAP) in 2008 and MDOT's Implementation Status Report, dated November 2009. Those inventory efforts were performed with EPA's MOBILE6.2 emission factor model. The MOVES model provides a more robust estimate of greenhouse gas emissions as compared to the simplified approaches used in MOBILE6.2. In MOVES, greenhouse gases are calculated from vehicle energy consumption rates and vary by vehicle operating characteristics including speed. In addition, the MOVES model includes the affects of current legislation on future vehicle fuel economy standards. The off-road portion of the inventory uses emission rates and data from EPA's State Greenhouse Gas Inventory Tool (SIT) and remains unchanged from the November 2009 MDOT Implementation Status Report.

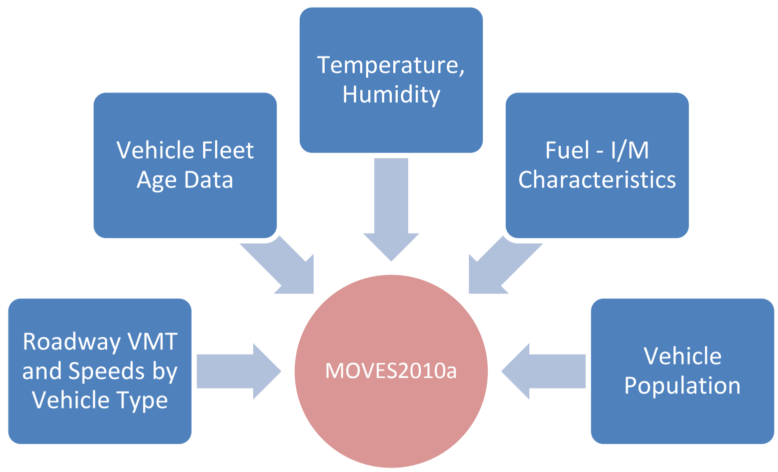
The inventory includes the revised 2006 base year and 2020 BAU forecast based on traffic count data (VMT-based) from the Maryland State Highway Administration (SHA). A more detailed description of the 2006 baseline and 2020 BAU forecast GHG emissions inventory update process can be found in Appendix A.

2.1 On-Road Analysis Process

The data, tools and methodologies employed to conduct the on-road vehicle GHG emissions inventory were developed in close consultation with MDE and are consistent with the *Technical Guidance on the Use of MOVES2010 for Emission Inventory Preparation in State Implementation Plans and Transportation Conformity, EPA-420-B-10-023, April 2010.* EPA's MOVES model was officially released on March 2, 2010 and was followed with a revised version (MOVES2010a) in August 2010. The MOVES2010a version incorporates new car and light truck greenhouse gas emissions standards for model years 2012-2016 and updates effects of corporate average fuel economy (CAFE) standards for model years 2008-2011. The MOVES2010a model estimates the reductions in greenhouse gases associated with those standards in future calendar years.

As illustrated in Figure 2.1, the MOVES2010a model has been integrated with local traffic, vehicle fleet, environmental, fuel, and control strategy data to estimate statewide emissions.

Figure 2.1 Emission Calculation Data Process



The modeling assumptions and data sources were developed in coordination with MDE and are consistent with other SIP-related inventory efforts. The process represents a "bottom-up" approach to estimating statewide GHG emissions based on available roadway and traffic data. A "bottom-up" approach provides several advantages over simplified "top-down" calculations using statewide fuel consumption. These include:

- Addresses potential issues related to the location of purchased fuel. Vehicle trips with trip ends outside of the state (e.g. including "thru" traffic) create complications in estimating GHG emissions. For example, commuters living in Maryland may purchase fuel there but may spend much of their traveling in Washington D.C. The opposite case may include commuters from Pennsylvania working in Maryland. With a "bottom-up" approach, emissions are calculated for all vehicles using the transportation system.
- Allows for a more robust forecasting process based on historic trends of VMT or regional population and employment forecasts and their relationship to future travel. For example, traffic data can be forecasted using growth assumptions determined by the MPO through their analytic (travel model) and interagency consultation processes.

GHG emission values are reported as annual numbers for the 2006 baseline and 2020 BAU scenarios. The annual values were calculated based on 12 monthly MOVES runs. Each monthly run used traffic volumes, speeds, temperatures, and fuel values specific to an average day in each month.

For the 2006 and 2020 BAU emissions inventory, the traffic data was based on roadway segment data obtained from the Maryland State Highway Administration (SHA). This data does not contain information on congested speeds and the hourly detail needed by MOVES. As a result, post-processing software (PPSUITE) was used to calculate hourly congested speeds for each roadway link, apply vehicle type fractions, aggregate VMT and vehicle hours traveled (VHT), and prepare MOVES traffic-related input files. The PPSUITE software and process methodologies are consistent with that used for regional inventories and transportation conformity analyses throughout Maryland.

Other key inputs including vehicle population, temperatures, fuel characteristics, and vehicle age were obtained from and/or prepared in close coordination with MDE staff. The following sections summarize the key input data assumptions used for the inventory runs.

Traffic Volume and VMT Forecasts

The traffic volumes and VMT within the SHA traffic database were forecast to estimate future year emissions. Several alternatives are available to determine forecast growth rates, ranging from historical VMT trends to the use of MPO-based travel models that include forecast demographics for distinct areas in each county.

For the 2020 BAU scenario, the forecasts were determined using assumptions from the original Maryland CAP, which was based on historic trends of 1990-2006 highway performance monitoring system (HPMS) VMT growth. Table 2.1 summarizes the growth rates by county. The average statewide annualized growth rate was assumed to be 1.8 percent.

Table 2.1 Maryland VMT Annual Growth Rates for 2020 BAU

County	Annualized 2006-2020 Growth
Allegany	1.3%
Anne Arundel	2.0%
Baltimore	1.3%
Calvert	2.5%
Caroline	1.3%
Carroll	1.9%
Cecil	2.4%
Charles	2.2%
Dorchester	0.9%
Frederick	2.5%
Garrett	1.4%
Harford	1.8%
Howard	3.2%
Kent	0.5%
Montgomery	1.5%
Prince George's	1.7%
Queen Anne's	2.2%
Saint Mary's	2.0%
Somerset	0.9%
Talbot	1.8%
Washington	2.1%
Wicomico	1.5%
Worcester	1.3%
Baltimore City	0.8%
Statewide	***1.8%***

The analysis process (e.g. using PPSUITE post processor) re-calculates roadway speeds based on the forecast volumes. As a result, future year emissions are sensitive to the impact of increasing traffic growth on regional congestion. The VMT summary is provided in Table 2.2.

Table 2.2 Maryland 2006 and 2020 BAU VMT Forecast

Annual VMT (millions)	2006 Baseline	2020 BAU Forecast
Light Duty	51,212	63,878
Medium/Heavy Duty Truck & Bus	5,406	6,775
TOTAL VMT (in Millions)	**56,618**	**70,653**

2.2 OFF-ROAD ANALYSIS PROCESS

Off-road GHG emission analyses rely on the emission factors and methodologies provided in EPA's State Inventory Tool (SIT). The tool estimates off-road CO_2, CH_4 and N_2O emissions. The SIT methodologies for estimating CO_2 follow a simple, top-down approach using state fuel consumption data. Emission factors based on fuel type are applied directly to the fuel consumption data to produce CO_2 estimates. This includes fuel consumption data for transportation fuel types including aviation gasoline, distillate fuel, jet fuel, motor gasoline, residual fuel and natural gas. Off-road CH_4 and N_2O emissions were estimated by the SIT tool based on fuel consumption data, emission factors, energy contents for aircraft and density factors for rail and marine vehicles. Inputs to the SIT tool for the 2006 baseline inventory are based on the United States Department of Energy (US DOE) Energy Information Administration (EIA) State Energy Data (SED).

Forecasting Assumptions

Historical information from EIA's SED was used to project off-road source emissions to future years. Consistent with the Maryland CAP off-road methodology, the SIT model was used to estimate the GHG emissions. Historical fuel consumption was updated to include 2007 data that was not available when the CAP was developed. Based on the transportation emissions source, fuel consumption projections used the historical fuel consumption data to forecast the growth. For aviation, specific forecasts were obtained from the Federal Aviation Administration's (FAA) APO terminal area forecasts. The growth rates selected for each off-road component were conservative, reasonable and consistent with historic trends. Table 2.3 summarizes the off-road inventory growth rate data sources.

Table 2.3 Off-Road Transportation Source Growth Rate Assumptions

Fuel Type	Category	Data Used for Forecasting
Motor Gasoline	Marine	1990-2007 Data
Distillate Fuel	Vessel Bunkering	Same as 2007 Data
	Military	Same as 2007 Data
	Railroad	Half the growth as 2000-2007
Natural Gas	Other (Total Minus Vehicle Fuel Consumption)	1990-2007 Data
Residual Fuel	Vessel Bunkering	2000-2007 Data
	Military	Same as 2007 Data
	Other (Total Minus Military & Other)	2000-2007 Data
Aviation Fuel	Aviation	FAA APO Terminal Forecasts

2.3 Transportation Sector Inventory Results

The 2006 baseline and 2020 BAU transportation sector GHG emissions forecast are summarized in Table 2.4. The on-road analyses include data, methods, and procedures approved by MDE during the consultation process of developing the inventory methodology. Off-road analyses utilized the SIT tool and updated information obtained from EIA.

Table 2.4 Maryland 2006 and 2020 Transportation Sector GHG Emissions

GHG Emissions (mmt CO_2e)	2006 Baseline	2020 BAU Forecast
Light Duty Vehicles	*24.22*	*31.48*
Medium/Heavy Duty Trucks & Buses	*5.45*	*7.11*
Total On-Road	29.67	38.59
Off-Road	3.03	3.10
TOTAL GHG Emissions	**32.70**	**41.69**

3.0 2020 Transportation Sector Detailed Assessment

The 2020 transportation sector assessment identifies the GHG emissions reduction impact of anticipated vehicle technology improvements in fuel economy or GHG emissions per mile, renewable fuel standards and low carbon fuels, and implemented and adopted transportation plans, programs and TERMs in Maryland through 2020. It also provides an assessment of the overall GHG emissions reduction benefit resulting from unfunded transportation GHG reduction strategies defined by the Working Groups and Coordinating Committee in Phase I. Both funded and unfunded transportation GHG reduction strategies focus on transportation investments, technology and other related programs that lead to a reduction in VMT, a reduction in fuel consumption, and improved travel efficiency.

The goals and objectives in MDOT's Maryland Transportation Plan (MTP) and the associated projects, programs, and TERMs identified in the CTP, MPO TIPs and LRPs lead to significant GHG reductions from the transportation sector by 2020. The MTP and its goals of quality of service, safety and security, system preservation and performance, environmental stewardship, and connectivity for daily life, help guide MDOT in a direction that is consistent with the objectives of the Climate Action Plan and the Maryland Greenhouse Gas Reduction Act of 2009.

Section 3 describes the estimated GHG emission reductions and associated costs of the following subsections.

3.1 Vehicle Technology Improvements

3.2 Transportation Fuels

3.3 Implemented and Adopted Transportation Plans and Programs

3.4 Unfunded Transportation GHG Reduction Strategies

3.5 Other Transportation GHG Reduction Initiatives

These subsections each provide an overview, strategy definitions, GHG reduction approach, and a summary of results that include GHG emission reductions and estimated capital costs. All related information for projects included in the MDOT 2011 - 2016 CTP, adopted MPO plans, and TERMs is presented in Appendix B and C. The detailed GHG emission reductions, cost assumptions, implementation tracking process, and co-benefits for the unfunded transportation sector strategies are presented in Appendix D.

3.1 VEHICLE TECHNOLOGY IMPROVEMENTS

Overview

Vehicle fuel economy standards are a key consideration in estimating future GHG emissions. By 2020, a number of state and federal initiatives that affect fuel economy standards will be in-place and significantly contribute to the 2020 transportation sector GHG reductions. The MOVES2010a emissions model was used to estimate the GHG emissions impact for each of the programs. The technology advances are designed to improve vehicle fuel economy and reduce average GHG emissions per mile. The standards are phased-in for each vehicle model year starting with model year 2008. The technology improvements include:

- The existing CAFE standards for vehicle model years 2008 to 2011,
- The Obama administration's National Program for model years 2012 to 2016 as finalized in the May 7, 2010 joint rulemaking by US DOT and EPA, and
- The Maryland Clean Car Program that incorporates the California emission standards beginning with model year 2011.

Assuming federal approval, there are two federal proposals for additional vehicle standards that would affect fuel economy and potential greenhouse gas emissions prior to 2020. These include:

- The national program covering 2017-2025 model year cars and light-duty trucks, and
- Fuel efficiency and greenhouse gas standards for 2014-2018 model year medium and heavy-duty vehicles.

The effects of the above proposed programs are included as potential greenhouse gas emissions reduction strategies for the Maryland transportation sector by 2020. The programs were analyzed in the MOVES2010a model by adjusting vehicle energy consumption rates by the proportional change in fuel economy or engine standards. Assumptions have been made on each vehicle program based on the best available information at the time of the analysis. The assumptions and modeling methodology were reviewed and approved by MDE. Legislative action or further program refinement could change or modify assumptions used to complete the GHG emission estimates.

National Fuel Economy Standards

There are two promulgated national programs in place that strengthen the fuel economy standards for light duty cars and trucks. They include:

- *CAFE Standards (Model Years 2008-2011)* – Vehicle model years through 2011 are covered under existing CAFE standards that will remain intact under the new national program.
- *National Program (Model Years 2012-2016)* – The light-duty vehicle fuel economy for model years between 2012 and 2016 are based on the May 7, 2010 Rule "*Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule*" *(EPA-HQ-OAR-2009-0472-11424:http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2009-0472-11424).* Fuel economy improvements begin in 2012 until an average 250

gram/mile CO_2 standard is met in the year 2016. This equates to an average fuel economy near 35 mpg.

The above programs are included in the MOVES vehicle energy consumption rates. To analyze the GHG emissions impacts of the programs, the MOVES2010a vehicle energy consumption rates default database was adjusted by holding constant the emission rates for post-2007 model years. The difference between the default modeling runs and the adjusted emission rates scenario provide the GHG emission reductions for the CAFE and National Program fuel economy standards. The details of the adjustments to the MOVES2010a vehicle energy consumption rates table are provided in Appendix A.

Maryland Clean Car Program

The Maryland Clean Car Program implements California's low emissions vehicle standards to vehicles purchased in Maryland starting with model year 2011. By creating a consistent national fuel economy standard, the 2012-2016 National Program, which closely resembles the California program, replaces Maryland's Clean Car Program for those model years. As a result, the GHG reduction credits for the Maryland Clean Car Program, apply only to 2011 and post-2016 model year vehicles.

The Maryland Clean Car Program is not a direct input to the MOVES2010a model. Therefore, adjustments to the default vehicle energy consumption rates were needed to estimate the GHG reduction. These adjustments were based on the percentage change in fuel economy values between the programs. The fuel economy performance estimates required for model years 2011 and post-2016 were obtained by the California Air Resources Board (CARB) report, *Comparison of Greenhouse Gas Reductions for the United States and Canada Under U.S. CAFE Standards and California Air Resources Board Greenhouse Gas Regulations, dated February 25, 2008*.

Proposed National 2017-2025 Light-Duty Vehicle Standards

The US DOT, EPA and the state of California are currently working towards additional fuel economy standards for light-duty vehicles beyond the 2016 model year. It is expected that a single set of national standards will be proposed by September 2011 covering model year 2017-2025 cars and light-duty trucks. If adopted, the national standards will replace the Maryland Clean Car Program for post-2016 model year vehicles.

The energy rates for the proposed standards were developed based on EPA and DOT's National Highway Traffic Safety Administration (NHTSA) establishment of 2017 and later model year light-duty vehicle greenhouse gas emissions and CAFE standards, *Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards (published May 7, 2010)*. A range of options are being considered for new standards ranging from a 3 - 6 percent annual improvement in fuel economy from 2017 to 2025. The adjustments to the MOVES2010a vehicle energy rates were based on these percentage changes in fuel economy.

Proposed National 2014-2018 Medium and Heavy Vehicle Standards

EPA and NHTSA are proposing new standards for three categories of medium and heavy-duty vehicles: combination tractors, heavy-duty pickups and vans, and vocational vehicles. The proposed rulemaking for these standards is *Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles (published November 30, 2010).* The categories were established to address specific challenges for manufacturers in each area. For combination tractors, the agencies are proposing engine and vehicle standards that begin in the 2014 model year and achieve up to a 20 percent reduction in carbon dioxide (CO_2) emissions and fuel consumption by the 2018 model year.

For heavy-duty pickup trucks and vans, the agencies are proposing separate gasoline and diesel truck standards, which phase in starting in the 2014 model year and achieve up to a 10 percent reduction for gasoline vehicles and a 15 percent reduction for diesel vehicles by the 2018 model year (12 and 17 percent respectively if accounting for air conditioning leakage). Lastly, for vocational vehicles, the agencies are proposing engine and vehicle standards starting in the 2014 model year that would achieve up to a 10 percent reduction in fuel consumption and CO_2 emissions by the 2018 model year.

Specific standards have not yet been proposed for this program. Based on the percent ranges provided above, analyses have been conducted by adjusting existing MOVES fuel economy assumptions to estimate the GHG reduction estimates.

Results

The GHG reductions from National Fuel Economy Standards, the Maryland Clean Car Program, the proposed National Fuel Economy Standards beyond 2016, and the proposed Medium and Heavy Duty Vehicle standards reduce projected 2020 GHG emissions by 7.47 mmt CO_2e as shown in Table 3.1.

Table 3.1 Maryland 2020 Vehicle Technology GHG Emissions Reductions

GHG Emissions Reduction by Program	Annual GHG Emission Reduction (mmt CO_2e)
CAFE Standards (2008 – 2011 MY)	2.27
National Program (2012 – 2016 MY)	3.19
Maryland Clean Car Program (2011 MY) & National Fuel Economy Standards (2017 – 2025 MY)	1.14
Proposed National 2014-2018 Medium and HDV Standards	0.88
2020 GHG Emission Total	**7.48**

While this analysis focuses on 2020, it is important to highlight that preliminary 2030 GHG emissions forecasts provide insight into the relationship between the currently proposed vehicle technology programs, continued vehicle turnover, and VMT growth. It is probable that continued growth in VMT, if additional standards are not implemented, will eventually offset the benefit of the proposed improvements to vehicle technology and fleet turnover. The goal of transportation and land use strategies is to reduce the rate of growth in VMT so that the combined benefits of VMT related strategies and vehicle and fuels technology will be more significant. Understanding these relationships will be essential in attempting to achieve potential post-2020 targets, such as those outlined in the Maryland Greenhouse Gas Emission

Reduction Act of 2009 (90 percent below 2006 by 2050). Additional improvements to fuel economy standards and continued fleet turnover will be critical to meeting post-2020 GHG reduction targets.

3.2 TRANSPORTATION FUELS

Overview

Accounting for increases in the availability of renewable and low carbon fuels in 2020 is an important component of estimating potential GHG emission reductions from the Maryland transportation sector. The 2020 GHG inventory projection considers the final National Renewable Fuel Standard Program (RFS2) as well as a range of potential benefits associated with the 11-state Northeast and Mid-Atlantic Low Carbon Fuel Standard (LCFS) Memorandum of Understanding.

The potential effects of these fuel programs are included as GHG emissions reduction strategies for the Maryland transportation sector by 2020 and will augment the GHG emission reduction benefits achieved through vehicle technology improvements.

Renewable Fuels and Fuel Assumptions

The MOVES2010a greenhouse gas analysis uses fuel assumptions through 2012 as developed and reviewed by MDE. Assumptions for years beyond 2012 continue to use the same fuel standards and characteristics within the MOVES model.

The EPA issued the Renewable Fuel Standard Program (RFS2) final rule in March 2010, which mandates the use of 36 billion gallons of renewable fuel annually by 2022. Based on an approach utilized by the Metropolitan Washington Council of Governments (MWCOG), the use of renewable fuels will represent a 2 percent reduction in total mobile CO_2 emissions in 2030. For this analysis, a 1 percent overall reduction in 2020 on-road emissions was assumed to result from the implementation of the proposed renewable fuel standard.

Low Carbon Fuel Standard

On December 30, 2009, eleven Northeast and Mid-Atlantic states signed a Low Carbon Fuel Standard (LCFS) Memorandum of Understanding. The Signatory States committed to evaluating a regional low carbon fuel program that will reduce the average carbon intensity of transportation and potentially heating fuels in the Northeast and Mid-Atlantic Region. The states are working to evaluate and develop an agreed upon framework for the program, which would be followed by a model rule based on that framework. The framework and model rule are to include key program elements that could be adopted through state-specific administrative rulemaking or state legislative authority, if individual states choose to adopt and implement a LCFS.

The Signatory States committed to finalizing a proposed program framework in early 2011 that addresses the following elements: 1) compliance goals expressed as a percent reduction in average carbon intensity from an agreed upon baseline, to be achieved over a specific timetable; 2) parties to be regulated under the program; 3) whether heating fuels are to be included in the program and, if so, options for including such fuels; 4) appropriate mechanisms for creating and trading credits for the sale of low carbon fuels; and 5) appropriate monitoring, compliance and enforcement mechanisms, and approaches to program review.

The LCFS framework, including compliance goals, has not yet been established. As a result, a conservative dissemination approach representing a range of impacts was utilized. The use of low carbon fuels was assumed to represent a 5-10 percent reduction in total mobile CO_2 emissions in 2020.

Results

The GHG reductions in Maryland from the National Renewable Fuel Standard Program and the 11-state Low Carbon Fuel Standard reduce projected 2020 GHG emissions by 1.45-2.66 mmt CO_2e as shown in Table 3.2.

Table 3.2 Maryland 2020 Transportation Fuels GHG Emissions Reductions

GHG Emissions Reduction by Program	Annual GHG Emission Reduction (mmt CO_2e)
Renewable Fuel Standard Program (RFS2)	0.24
Low Carbon Fuel Standard (5% - 10%) (1)	1.21 – 2.42
2020 GHG Emission Total	**1.45 – 2.66**

Note: (1) Figure ES.1, Figure 4.2 and Table 4.1 present only the result of the 5 percent reduction assumption, 1.21 mmt.

3.3 IMPLEMENTED AND ADOPTED TRANSPORTATION PLANS & PROGRAMS

Overview

Transportation projects, TERMs, land use, and travel forecast data from the following list of approved transportation programs were used to assess and quantify the GHG emissions of the State's proposed transportation investments through 2020.

- Maryland 2011-2016 CTP
- MWCOG 2011-16 TIP and 2010 CLRP adopted 11/17/10
- BRTB 2011-14 TIP adopted 7/27/10 and Transportation Outlook 2035 (adopted 11/07, amended 2/24/09)
- Hagerstown/Eastern Panhandle MPO 2010-2013 TIP adopted 6/16/10 and 2035 LRMTP adopted 4/28/10
- Salisbury-Wicomico MPO 2010-2013 TIP adopted 9/28/09 and Draft 2010 LRTP scheduled for adoption in October 2010

- Cumberland Area MPO 2010-2013 TIP adopted 10/15/09 and Draft 2010 LRTP schedule for adoption in October 2010
- WILMAPCO DRAFT 2012-2015 TIP and 2040 RTP (adopted 10/10)
- Modal Plans including – Maryland Area Regional Commuter (MARC) Growth and Investment Plan, Port of Baltimore Regional Landside Access Study, Maryland Statewide Freight Plan, Washington Metropolitan Area Transit Authority (WMATA) Capital Plan, Maryland Aviation Administration (MAA) Capital Plan

Based on the macro-level analysis of the State's fiscally constrained transportation infrastructure and program investment through 2020, and the associated local land use policies, statewide growth in VMT is forecast to be 1.4 percent annually. This represents a slower rate of growth than was included in the Maryland Climate Action Plan developed in 2007.

TERMs identified in the 2011-2016 CTP and MPO TIPs and LRPs to meet criteria pollutant targets, as well as continuation of current programs such as Commuter Connections, CHART, and Metropolitan Area Transportation Operations Coordination (MATOC) are assessed individually to determine estimates of GHG emission reductions and costs through 2020.

Funded Maryland Plans and Programs

Greenhouse Gas Emission Reductions

The 2020 BAU GHG emission forecast utilizes a methodology consistent with the Climate Action Plan (CAP). The HPMS historical growth rate was based on county reported HPMS VMT totals for the 1990-2006 timeframe. Using HPMS data and the associated timeframe, the average statewide annualized growth rate would be 1.8 percent, which is consistent with the assumptions used for past GHG analysis efforts under the Maryland CAP. Through consultation with MDE, it was determined in Phase II that the updated forecast should consider the MPO transportation and land use forecasts used in the development of TIPs, LRPs and the Maryland CTP. These plans and programs identify the committed and funded projects in Maryland. The modeling conducted by each regional MPO includes the impact of the planned projects and the adopted regional demographic forecasts.

To account for the impact of planned transportation plans and programs in 2020, MPO forecast travel and land use data were employed where available. For rural counties not included in a MPO or travel demand model domain, HPMS historical growth rates were used. The growth rates under this scenario incorporate the impacts of future regional demographic projections from each county, cooperatively developed by the MPO for modeling purposes, and the impacts of planned transportation projects (highway and transit) in the regional TIPs and LRPs. Under this scenario, the average statewide annualized growth rate is 1.4 percent (see Table 3.3). Project level analyses were not performed.

Table 3.3 Maryland VMT Forecasts and Annual Growth Rate

County	Annualized 2006-2020 Growth	
	HPMS Historical (CAP)	MPO Modeling (Plans/Programs/ Adopted Land Use)
Allegany	1.3%	-0.6%
Anne Arundel	2.0%	1.6%
Baltimore	1.3%	1.3%
Calvert	2.5%	1.9%
Caroline	1.3%	1.3%
Carroll	1.9%	2.1%
Cecil	2.4%	1.7%
Charles	2.2%	1.8%
Dorchester	0.9%	0.9%
Frederick	2.5%	2.0%
Garrett	1.4%	1.4%
Harford	1.8%	2.6%
Howard	3.2%	3.3%
Kent	0.5%	1.3%
Montgomery	1.5%	0.6%
Prince George's	1.7%	0.9%
Queen Anne's	2.2%	0.7%
Saint Mary's	2.0%	2.0%
Somerset	0.9%	0.9%
Talbot	1.8%	1.8%
Washington	2.1%	1.5%
Wicomico	1.5%	0.8%
Worcester	1.3%	1.3%
Baltimore City	0.8%	0.8%
Statewide	***1.8%***	***1.4%***

The statewide GHG reductions in 2020 are equivalent to the VMT difference between the BAU VMT growth rate (1.8 percent) and the 1.4 percent VMT growth rate. As presented in Table 3.4, this difference results in a VMT reduction in 2020 of 3.578 billion vehicle miles. The reduction in VMT is translated to a GHG emission reduction based on an emissions factor (grams CO_2e / mile) as calculated through the MOVES model based on Maryland's on-road vehicle fleet in 2020 (see section 2 and Appendix A).

Table 3.4 Maryland 2020 BAU VMT Compared to 2020 Plans and Programs VMT

Scenario	2020 BAU	2020 Plans & Programs Forecast
Annual VMT (millions)		
Light Duty	63,878	60,643
Medium/Heavy Duty Truck & Bus	6,755	6,432
TOTAL VMT (millions)	**70,653**	**67,075**

Project Implementation Costs

Maryland 2011-2016 Consolidated Transportation Program

Projects that contribute to a change in VMT growth and/or improve system efficiency are a subset of the complete state capital program. These are roadway and transit infrastructure projects, Transportation Emission Reduction Measures (TERMs), and other state and regional programs that act to reduce VMT and/or delay by adding capacity, improving flow, reducing bottlenecks, managing travel demand, or improving overall system efficiency through enhanced system management and operations. These projects are multimodal in nature and span multiple agencies, including MdTA, MAA, MPA, MTA, SHA, and WMATA, as well as local governments. The total costs of these projects are $4.832 billion (approximately 40 percent of the capital program in the 2011-2016 CTP). Table 3.5 illustrates the groupings of applicable 2011-2016 CTP projects by transportation GHG reduction policy option.

Table 3.5 2011-2016 CTP Projects by Transportation GHG Reduction Policy Option

GHG Reduction Policy Options	Projects	Total Cost (2011–2016) (billions $) (1)
Public Transportation (2)	38	$2.431
Intercity Passenger and Freight Transportation (3)	18	$0.348
Bike and Pedestrian (4)	19	$0.321
Transportation Pricing and Demand Management	2	$1.375
Transportation Technology	10	$0.358
2011 – 2016 CTP Total	**87**	**$4.832**

Note: (1) The total cost includes TERMs listed in the 2011 – 2016 CTP. These are documented in more detail in the TERM section on pg. 3-13 and Appendix C.

(2) The total cost includes 4 development and evaluation projects in the CTP (Red Line, Purple Line, Corridor Cities Transitway, Bethesda Metro South Entrance). Implementation costs for these projects not included in the CTP are included in the MPO plans and programs in Table 3.6.

(3) CTP projects include all capacity expansion and interchange improvements on interstate highways and intermodal connectors.

(4) CTP projects include all capacity expansion projects with accommodations for bike or pedestrian elements in the project description. The costs listed represent total project cost identified in the CTP.

Examples of CTP projects within each policy option are listed below:

- **Public Transportation**: Includes all MTA and WMATA capital projects dedicated to the expansion and increased level of service of public transportation services in Maryland. Projects include infrastructure expansion, vehicle purchase and replacement, transit operations and transit support facilities in the 2011-2016 CTP. Example projects include:
  - MARC Growth and Investment Plan implementation,
  - Completion of the Silver Spring transit center,
  - LOTS capital procurement projects,
  - WMATA Capital Improvement Program, and
  - Matching funds to WMATA for the Passenger Rail Investment and Improvement Act.
- **Intercity Passenger and Freight Transportation**: Includes all highway capacity projects on interstate highway system routes and intermodal connectors in Maryland. Also includes funding for the Baltimore intercity bus terminal, MARC infrastructure and operations improvements, American Recovery and Investment Act funding for planning and engineering for BWI MARC/Amtrak Station improvements and the Baltimore and Potomac tunnel, and rail freight capacity improvements on railroads owned by Maryland.
- **Bike and Pedestrian**: Combination of bicycle and pedestrian infrastructure inclusion in roadway projects (complete streets implementation), SHA's Sidewalk Program and Community Safety and Enhancement Program, projects and programs supporting completion of the statewide transportation trails network, and improved bicycle and pedestrian access to transit facilities. The total cost reported for roadway capacity projects with bicycle and pedestrian accommodations represents the total project cost.
- **Transportation Pricing and Demand Management**: Includes MDTA projects, primarily the Intercounty Connector and I-95 Express Toll Lanes. Also includes state funded commute alternative incentive programs in the Baltimore and Washington regions.
- **Transportation Technology**: Includes CHART program implementation, state and local programs for signal synchronization, MTA diesel-hybrid electric bus purchases, transit CAD/AVL system upgrades and high speed tolling at I-95 Fort McHenry toll plaza.

Maryland MPO TIPs and Long Range Plans

The total cost of the subset of projects and TERMs contributing to changes in VMT growth and/or system efficiency in the MPO TIPs and LRPs through 2020 is **$8.863 billion**. Table 3.6 illustrates groupings of applicable MPO TIP and LRP projects by transportation GHG reduction policy option.

Table 3.6 MPO TIP and LRP Projects by Transportation GHG Reduction Policy Option

GHG Reduction Policy Options	Projects	Total Cost (2011–2020) (billions $) (1)
Public Transportation (2)	31	$4.532
Intercity Passenger and Freight Transportation	33	$2.736
Bike and Pedestrian	32	$1.064
Transportation Pricing and Demand Management	4	$0.022
Transportation Technology	7	$0.032
MPO TIPs and LRP Total	**107**	**$8.387**

Note: (1) Total cost includes TERMs listed in the MPO TIPs and LRPs as documented in more detail in the TERM section on pg. 3-13 and Appendix C.

(2) Total cost excludes the cost of planning, preliminary engineering and ROW acquisition for four development and evaluation projects as identified in the CTP (Red Line, Purple Line, Corridor Cities Transitway, Bethesda Metro South Entrance).

Projects in MPO TIPs and LRPs funded and committed for completion by 2020 include:

- **Public Transportation**: Major projects planned for opening by 2020 include the Purple Line (Bethesda to New Carrolton), Corridor Cities Transitway (Shady Grove to COMSAT), Red Line (Social Security Administration to Bayview Medical Center), and the MARC Penn Line extension from Perryville to Elkton.
- **Intercity Passenger and Freight Transportation**: Major roadway capacity projects impacting truck freight movement in Maryland planned for opening by 2020 include: I-695 from I-95 South to MD 122, I-695 from I-83 to I-95 North, MD 32 grade separation and interchange at I-795, MD 4 upgrade in Prince Georges County, and US 50 access control improvements in Wicomico County. In addition, there are funded long range projects associated with the MARC Growth and Investment Plan and Maryland Statewide Freight Plan included under this strategy. The GHG reduction benefit from full implementation of the National Gateway and Northeast Corridor Infrastructure Master Plan are included in the unfunded GHG reduction strategy assessment.
- **Bike and Pedestrian**: Combination of bicycle and pedestrian infrastructure inclusion in roadway projects (complete streets implementation), projects supporting completion of the statewide transportation trails network, as well as improved bicycle and pedestrian access to transit facilities. This policy option also includes implementation of a number of local and regional sidewalk, trail, recreation and enhancement programs.
- **Transportation Pricing and Demand Management**: Includes implementation of Baltimore regional ride share and guaranteed ride home programs and MWCOGs Commuter Connections program.
- **Transportation Technology**: Includes installation, repair and replacement of variable message signs; congestion management programs including the employment of variable message signs, CCTV, signal coordination, the deployment of local Intelligent Transportation Systems (ITS) projects (transit signal priority systems, automatic passenger

counters, traffic signal control software, etc.), and the development of park and ride facilities; Congestion Mitigation and Air Quality Improvement Program (CMAQ) projects; Clean Air Partners; and advanced transportation management systems utilizing fiber optics.

Transportation Emission Reduction Measures (TERMs)

Greenhouse Gas Emission Reductions

The Clean Air Act Amendments of 1990 (CAAA) and the Safe, Accountable, Efficient, Flexible, Transportation Efficiency Act (SAFETEA-LU) requires MPOs and state departments of transportation to perform air quality analyses, to ensure that the transportation plan and program conform to the mobile emission budget established for the criteria pollutants such as NOx, VOCs, CO and particulates in the State Implementation Plans (SIP). As a result, MPO's and DOT's are required to identify transportation emissions reduction measures (TERMs) that provide criteria pollutant emission-reduction benefits. These measures are assessed in conformity documentation and include specific information on the costs and expected air-quality benefits.

The criteria pollutant reductions of a large share of these strategies are included in the BRTB, MWCOG, HEPMPO, and WILMAPCO air quality conformity processes. For these strategies, reductions in VMT or fuel consumption as estimated by BRTB, MWCOG, MDOT and MDE are adjusted to reflect 2020 conditions and converted to GHG emission reductions. For the strategies where a prior analysis has not been completed, observed data on the benefits of these strategies in other locations or research reports were utilized to determine potential 2020 benefits (see Appendix C for all TERM assessment approaches).

Project Implementation Costs

The range of TERMs considered is diverse in strategy, scope and implementation requirements. The total cost of TERMs listed within the CTP and MPO TIPs and LRPs is estimated at $483 million.[1] The total cost of additional TERMs sponsored by Maryland Aviation Administration (MAA) and Maryland Ports Administration (MPA) is not included in this report.

The TERMs were organized into the transportation GHG reduction policy options as follows (this list is representative and not inclusive of all the TERMs included in the analysis, refer to Appendix C for descriptions of all the TERMs):

- **Public Transportation:** Projects that enhance public transportation amenities and improve level-of-service through station access improvements, bus stop programs, traveler information, activity center shuttle services, park-and-ride lot expansion, free bus transfers, enhanced commuter and reverse commute service, MTA college pass and commuter choice Maryland pass.

[1] TERMs listed within the CTP and MPO TIPs and LRPs are also included in the total cost estimates presented in Tables 3.5 and 3.6. The summary of total TERM project costs by GHG reduction policy option are listed in Appendix C, Table C.1.

- **Intercity Passenger and Freight Transportation:** No TERM projects.
- **Bike and Pedestrian:** Projects include sidewalk and street rehabilitation, bicycle and pedestrian facilities, acquisition of scenic easements, streetscapes, and functional/safety improvements.
- **Transportation Pricing and Demand Management**: Projects are tied to commute alternative and incentive programs including specific projects such ridesharing (Commuter Connections), guaranteed ride home, TDM program management and marketing, outreach and education programs (Clean Air Partners), parking cash-out subsidies, transportation information kiosks, local carsharing programs, telework partnerships, parking impact fees, and vanpool programs.
- **Transportation Technology:** Projects fall across two primary categories: clean vehicle technology and intelligent transportation systems. Clean vehicle technology includes truck idling (truck stop electrification or auxiliary power units), transit bus purchases, state fleet purchases. Intelligent transportation systems includes CHART, MATOC, and signal coordination/management/upgrade programs. Also includes projects at BWI Marshall such as aircraft taxi/idling/delay reduction strategies, vehicle fleet purchases, dedicated lanes, smart park facilities, APUs for ground service equipment, and facility electricity usage. Maryland Port Administration (MPA) projects include cargo handling equipment replacements and engine repowers, and truck replacements and engine repowers.

Implementation of many of the TERMs requires capital investments along with annual administrative and operations costs. The costs included in Table 3.5 are predominantly capital costs, reflecting expenditures for new technologies, equipment and vehicles as well as transit support infrastructure (bus shelters, park-and-ride lots). For commuter programs and most ITS related programs, there are significant annual administrative and operations costs included.

Results

Greenhouse Gas Emission Reductions

The reduced forecasted rate of VMT growth resulting from implementation of the CTP and MPO TIPs and LRPs through 2020 contributes to a 1.99 mmt CO_2e reduction by 2020 compared to the 2020 BAU forecast.

VMT reduction or fuel consumption savings resulting from the implementation of TERMs through 2020 results in a 0.795 mmt CO_2e reduction in 2020. The TERM strategies are all exclusive of the VMT impacts and resulting GHG emissions from existing plans and programs analysis, ensuring that no double counting of benefits occurs. The contribution of TERMs by each GHG emission reduction strategy policy option is presented in Table 3.7.

Table 3.7 GHG Reduction Summary by Transportation GHG Reduction Policy Option

GHG Reduction Policy Options	Annual 2020 GHG Reduction (mmt CO_2e)
Maryland Funded Plans and Programs (excluding TERMs)	**1.99**
Transportation Emission Reduction Measures (TERMs)	**0.795**
Public Transportation	0.277
Intercity Passenger and Freight Transportation	--
Bike and Pedestrian	0.001
Transportation Pricing and Demand Management	0.199
Transportation Technology	0.319
Total – Implemented and Adopted Transportation Plans and Programs	**2.785**

Project Implementation Costs

The total cost of the subset of projects, programs, and TERMs within the 2011-2016 CTP and MPO long-range plans through 2020 that contribute to the reduction in GHG emissions is $13.219 billion (approximately 50 percent of the complete State capital program 2011 – 2020).

Table 3.8 presents the total capital cost summary of Maryland plans, programs and TERMs 2011 – 2020 by transportation GHG reduction strategy policy option. Refer to Appendix B for the complete project listing.

Table 3.8 Draft Cost Summary by Transportation GHG Reduction Policy Option

GHG Reduction Policy Options	Total Cost (2011–2020) (billions $) (2)
Public Transportation	$6.963
Intercity Passenger and Freight Transportation (1)	$3.085
Bike and Pedestrian (1)	$1.385
Transportation Pricing and Demand Management	$1.397
Transportation Technology	$0.390
Total – Implemented and Adopted Transportation Plans and Programs	**$13.219**

Note: (1) The total cost reported represents the complete project cost. The specific cost of the bike or pedestrian element is not reported. There are no overlaps with any roadway capacity projects identified in the intercity passenger and freight transportation policy option.

(2) Total cost includes $483 million for TERMs documented in more detail in Appendix C.

3.4 UNFUNDED TRANSPORTATION GHG REDUCTION STRATEGIES

Overview

The 2008 Maryland Climate Action Plan (CAP) established GHG emission reduction targets from 2006 levels including targets of 25 percent by 2020 and 90 percent by 2050. In order to assist Maryland in meeting these targets, the Commission also identified 42 GHG "mitigation" policy options designed to reduce GHG emissions. A total of eight transportation and land use policy options were outlined in the CAP. While many State agencies are involved, MDOT was designated as the implementing agency for six policy options, and is a supporting agency on the two others. MDOT's policy options are primarily focused on reducing GHG emissions through vehicle miles of travel (VMT) reductions and vehicle and transportation system technology improvements.

MDOT developed a multi-phase approach in order to address the responsibility of acting as the implementing agency for the six policy options. That process included the development of a coordinating committee as well as working groups for each policy option.

In Phase I, a total of 44 strategies were determined to have an implementation timeframe of 2020 or before. These were evaluated in Phase II, with the understanding that these strategies could only be realized should funding become available.

Phase III takes the findings of the working groups and coordinating committee in Phase I and Phase II and reassesses the GHG emission reduction benefits through:

1. A more careful consideration of the barriers to implementation by 2020;
2. A review of the GHG reduction and cost methodologies, and;
3. Inclusion of updated emission factors based on vehicle technology and transportation fuel forecasts for Maryland in 2020 from EPAs MOVES model.

The incremental benefit of the unfunded transportation GHG reduction strategies evaluated in Phase III is a 1.14 mmt to 3.14 mmt CO_2e reduction in 2020. The implementation cost estimate (capital costs only) of the Phase III unfunded transportation sector GHG reduction strategies from 2011 to 2020 is $2.911 to $7.011 billion in addition to the funded transportation plans, programs and TERMs through 2020.

Unfunded Transportation GHG Reduction Strategy Policy Options

The strategies described in this section were determined by the working groups and coordinating committee in Phase I to be priorities for GHG emission reduction in Maryland and are considered feasible for implementation by 2020. These strategies could only be realized should additional funding become available.

More detailed information, regarding the strategy analysis approach and assumptions can be found in Appendix D.

Public Transportation

This policy option identifies public transportation strategies to reduce on-road mobile source transportation GHG emissions. The strategies are designed to help Maryland meet a goal of doubling transit ridership by 2020, and continuing that same growth rate beyond 2020. In order to achieve this growth, actions to increase the attractiveness and convenience of public transportation, improve the operational efficiency of the system, and increase system capacity are required. Policies also involve supportive actions with regard to land use planning and policy, pricing (disincentives to auto use), and bike and pedestrian access improvements. Policies to reduce GHG produced by public transportation services are also included.

The following strategies defined by the public transportation working group were identified to address the expected gap in meeting the transit ridership goal defined in the Climate Action Plan (e.g. a doubling of 2000 transit ridership by 2020). The intent is for these strategies to complement and support funded MTA and WMATA plans and programs identified for implementation by 2020 in the 2011-2016 CTP and MPO TIPs and long-range plans.

- Additional Capacity on Existing Transit Routes
- Increase Frequencies of Transit Services Statewide
- Expanded Park and Ride Capacity
- Increase Coverage of Transit Services – New Commuter / Intercity Bus Routes
- Increase Coverage of Transit Services – New Local Bus Routes
- Implement Bicycle and Pedestrian Improvements to Support Transit
- Reduce GHG Emissions from Transit Vehicles
- Bus Priority Improvements
- Plan Transit in Conjunction with Land Use

Intercity Passenger and Freight Transportation

This policy option enhances connectivity and reliability of non-automobile intercity passenger modes and multimodal freight through infrastructure and technology investments. For intercity passenger modes, this includes expansion of intercity passenger rail and bus services as well as improved connections between air, rail, intercity bus and regional or local transit systems. For freight movement, this includes expansion and bottleneck relief on priority truck and rail corridors and enhanced intermodal freight connections at Maryland's intermodal terminals and ports.

The intercity transportation working group identified improving passenger convenience for intermodal connections at airports, rail stations, and major bus terminals as the primary pre-2020 unfunded intercity transportation strategies. Two primary strategies are assessed for intercity passenger transportation in Maryland by 2020: (1) improve passenger access, convenience, and information across all modes at BWI Airport, and (2) improve travel times, reliability and overall level of service on the MARC Penn Line and Amtrak NE Corridor consistent with the MARC Growth and Investment Plan, and Northeast Corridor Infrastructure Master Plan.

The intercity transportation working group did not recommend specific freight strategies in addition to projects identified in implemented and adopted transportation plans and programs for consideration before 2020. Recent developments and Maryland strategic involvement in the CSX Transportation National Gateway initiative will result in implementation of freight rail projects in Maryland and the mid-Atlantic region that will help reduce truck VMT in Maryland by 2020. Funding for the National Gateway is a public-private partnership between the federal government, six states and the District of Columbia, and CSX. The benefit of the National Gateway is assessed in this report.

The benefits of Norfolk Southern's Crescent Corridor initiative is not assessed in this report as direct GHG emission reduction benefits to Maryland are unknown, and a level of support and funding commitment from Maryland has not been recommended to date (see Section 3.5 for more details).

Bike and Pedestrian

This policy option includes infrastructure design and construction policies; funding, regulatory, and land use strategies; and education and marketing measures. These strategies result in improved bike and pedestrian amenities, resulting in an increase in the number of trips made on foot or bicycle, particularly in urban areas and adjacent to Maryland's trail networks. This policy recognizes that local governments are responsible for the design and maintenance of approximately 80 percent of roads in Maryland. Land use and location efficiency strategies addressing density, mix of uses, and urban design represents a very strong predictor of bike and pedestrian travel.

The following strategies were recommended for possible implementation prior to 2020 by the bike and pedestrian working group:

- Promote use and regular review/updates to existing manuals and design standards
- Complete Streets – improve bike/pedestrian access through corridor retrofits and new roadway construction projects
- Update existing land use policy guidance and zoning/development standards to include provisions for bike and pedestrian supportive infrastructure
- Bike facility and supportive infrastructure placement at strategic locations, including transit stations and government facilities
- Provide funds for low-cost safety solutions
- Education, safety programs, and marketing programs to encourage bicycle travel

Transportation Pricing and Demand Management

This policy option addresses transportation pricing and travel demand management incentive programs. It also tests the associated potential GHG reduction benefits of alternate funding sources for GHG beneficial programs. These strategies amplify GHG emission reductions from other strategies by supporting Smart Growth, transit, and bike and pedestrian investments. The draft MDOT policy design, developed by the pricing working group in Phase I, considers four strategy areas combined with an education component for state and local officials.

The detailed definitions of the four strategy areas are listed below:

- **Maryland motor fuel taxes or VMT fees** – There are two primary options for consideration: (1) an increase in the per gallon motor fuel tax consistent with alternatives under consideration by the Blue Ribbon Commission on Maryland Transportation Funding, and (2) establish a GHG emission-based road user fee (or VMT fee) statewide by 2020 in addition to existing motor fuel taxes. Both options would create additional revenue that could be used to fund transportation improvements and systems operations to help meet Maryland GHG reduction goals.
- **Congestion Pricing and Managed Lanes** – Establish as a local pricing option in urban areas that charges motorists more to use a roadway, bridge or tunnel during peak periods, with revenues used to fund transportation improvements and systems operations to help meet Maryland GHG reduction goals.
- **Parking Impact Fees and Parking Management** – Establish parking pricing policies that ensure effective use of urban street space. Provision of off-street parking should be regulated and managed with appropriate impact fees, taxes, incentives, and regulations.
- **Employer Commute Incentives** – Strengthen employer commute incentive programs by increasing marketing and financial and/or tax based incentives for employers, schools, and universities to encourage walking, biking, public transportation usage, carpooling, and teleworking.

Transportation Technology

This policy option aims to reduce GHG emissions from on and off-road vehicles/engines through the deployment of technologies designed to cut GHG emission rates per unit of activity through such measures as idling reduction, engine/vehicle replacements, and the promotion of fuel efficient technologies. This policy option also encompasses improvements to transportation system efficiencies through measure such as traffic signal synchronization/optimization and active traffic management.

The following strategies were identified for further analysis and possible implementation under this policy option:

- **Active Traffic Management (ATM) / Traffic Management Centers** – Provide real-time, variable-control of speed, lane movement, and traveler information (for drivers and transit users) within a corridor and conduct centralized data collection and analysis of the transportation system. System management decisions are based on inroad detectors, video monitoring, trend analysis, and incident detection (currently performed by CHART).
- **Traffic Signal Synchronization / Optimization** – Traffic signal operations are synchronized to provide an efficient flow or prioritization of traffic, increasing the efficient operations of the corridor and reducing unwarranted idling at intersections. The system can also provide

priority for transit and emergency vehicles. Specific performance measure is "reliability." Traffic Signal Synchronization is currently performed by SHA and local jurisdictions.

- **Marketing and Education Campaigns –** Initiate marketing and education campaigns to operators of on-and off-road vehicles.
- **Timing of Highway Construction Schedules –** Consider requiring non-emergency, highway and airport construction be scheduled for off-peak hours that minimize the delay in traffic flow. Include incentives for completing projects ahead of schedule.
- **Green Port Strategy –** Develop and implement a "Green Port Strategy" consistent with industry trends and initiatives including EPA's Strategy for Sustainable seaports.
- **Reduce Idling Times –** Reduce idling time in light duty vehicles, commercial vehicles (including the use of truck stop electrification), buses, locomotive, and construction equipment.
- **Technology Improvements for On-highway Vehicles –** Promote and incentivize fuel efficiency technologies for medium and heavy-duty trucks (on-highway vehicles).
- **Incentives for Low-GHG Vehicles –** Provide incentives to increase purchases of fuel-efficient or low-GHG vehicles / fleets.
- **Technology Advances for Non-highway Vehicles –** Encourage or incentivize retrofits and/or replacement of old, diesel-powered non-highway engines, such as switchyard locomotives, with new hybrid locomotives.
- **Incentives for Low-Carbon Fuels and Infrastructure –** Incentivize the demand for clean low-carbon fuels and the development of infrastructure to provide for increased availability/accessibility of alternative fuels and plug-in locations for electric vehicles.

Evaluate the Greenhouse Gas Emission Impacts of Major Projects and Plans

This policy option focuses on the process of evaluating GHG emissions of all state and local major projects. The goals of this policy option are to understand the impacts of new, major projects on the Governor's GHG reduction commitment; and to develop guidance for the state and other major project sponsors to use. In Phase I, the working group identified three potential implementation strategies for this policy option:

- Participate in Framing National Policy
- Evaluation of GHG Emissions through the NEPA Process
- Evaluation of GHG Emissions through Statewide/Regional Planning

Results

Table 3.9 presents the results of the Phase III unfunded transportation GHG reduction strategy analysis. The GHG reduction estimates summarized here represent GHG reductions beyond the benefits of implemented and adopted transportation plans, programs, and TERMs. The preliminary cost estimates of the unfunded strategies represent additional capital costs that are not included in the CTP or MPO plans. Ranges of GHG reductions and costs are illustrated in order to reflect the relationship between achieving more significant GHG reductions and the costs associated with achieving those reductions.

The GHG emission reductions from all projects, programs and TERMs included in funded plans and programs are accounted for within the bundled assessment of the emission reduction benefits in 2020 of implementing the State's implemented and adopted transportation plans, programs, and TERMs (see Section 3.3).

A more detailed summation of the analysis conducted for each policy option, including an overview and definition, approach to the analysis, assumptions and results, is provided in Appendix D.

Table 3.9 Unfunded GHG Reduction Strategy Policy Options – 2020 Emission Reduction and Cost Summary

GHG Reduction Policy Options	GHG Reduction (mmt CO_2e)	Total Additional Cost 2010 - 2020 (million $)
Public Transportation	0.39 - 0.62	$1,214 - $1,765
Intercity Passenger and Freight Transportation	0.11	$0.748
Bike and Pedestrian	0.16	$0.598 - $0.817
Transportation Pricing and Demand Management	0.24 – 2.01	$0.300 - $3,690
Transportation Technology	0.24	$0.051
Evaluate GHG Impacts of Major Projects & Plans	N/A	N/A
Total 2020 GHG Reduction and Costs	**1.14 – 3.14**	**$2.911 – $7,071**

3.5 Additional Transportation Sector GHG Emission Reduction Initiatives (Not Quantified)

Overview

MDOT and other Maryland agencies are collaborating on regional and state initiatives and programs that will result in GHG emission reductions from the transportation sector in 2020. These initiatives are documented in this section without quantified GHG emission reductions or costs because they are early in the planning and implementation process, and are not yet associated with specific projects and or identified funding.

In addition there are a number of management, maintenance, and operational activities ongoing or soon to be underway throughout MDOT that will result in GHG emissions from the transportation sector. These items are documented in this section in order to present the additional activities MDOT is undertaking to reduce or offset GHG emissions from the transportation sector. The magnitude of GHG emission reductions of these strategies are unknown at this time, and in many cases the strategies affect stationary or point source transportation sector GHG emissions which are not modeled in this report.

State and Regional Initiatives

Blue Ribbon Commission

The Blue Ribbon Commission (BRC) on Maryland Transportation Funding is currently evaluating transportation funding shortfalls, identifying potential new revenue sources and any legislation required to initiate them, and the potential uses for additional transportation funds. The overall purpose of BRC is to review, evaluate and make recommendations concerning Maryland transportation funding, particularly related to:

- The current State funding sources and structure of the Maryland Transportation Trust Fund,
- Additional financial support to address MDOTs increasing need for air quality and climate change beneficial projects, and water resource management,
- Short and long-term transit, highway, and pedestrian/bicycle construction and maintenance funding needs,
- Options for public-private partnerships, including partnerships with local governments,
- The structure of regional transportation authorities and the ability of those authorities to meet transportation needs,
- The impact of economic development and smart growth on transportation funding, and
- Options for sustainable, long-term revenue sources for transportation.

A final report on findings and recommendations of the BRC is due to the Governor and General Assembly on or before November 1, 2011. To date, the BRC has investigated existing state revenue sources and yields, historic transportation expenditures in Maryland, alternative revenue and transportation funding programs in neighboring states, and potential new revenue sources in Maryland. The potential new primary revenue sources in Maryland investigated by BRC thus far includes increases in the vehicle titling, sales and use taxes, motor fuel taxes, vehicle registration fees, driver's license fees, and corporate income taxes. Also investigated are changes to MTA transit fare policy and toll rates on MDTA facilities.

Potential uses of alternative revenue sources into Maryland's Transportation Trust Fund include GHG beneficial strategies such as MTA capital expansion needs to address the doubling transit ridership goal, unspecified climate change/air quality related projects, and facilitation of future TOD projects.

The ultimate findings and recommendations of the BRC and the next steps taken by the General Assembly in 2011 and 2012 should help to address the significant estimated cost of the unfunded transportation GHG reduction strategies identified in this plan.

Electric Vehicles

MDOT has been working closely with MDE, MEA, Baltimore City and the Baltimore Electric Vehicle Initiative (BEVI) to select appropriate locations for 65 electric vehicle re-charging stations around the state. Several of the re-charging stations will be located at MDOT and modal facilities such as MDOT Headquarters in Hanover, the BWI MARC / AMTRAK station, the BWI parking garage and park-and-ride lots maintained by SHA. MDOT's continued involvement in expanding the availability of electric vehicle recharging stations throughout the state will contribute to statewide GHG emission reductions and complement the efforts of the Maryland General Assembly, which has passed legislation approving electric vehicle tax credits and electric vehicle use of HOV lanes, and Governor O'Malley who has proposed legislation to create an Electric Vehicle Infrastructure Council, and establish a state income tax credit of 20 percent of the cost of electric vehicle charging equipment for individuals and businesses.

Transportation and Climate Initiative / NASTO Coordination

In June of 2010, the Secretary of the Maryland Department of Transportation, along with other transportation, environment and energy agency heads of eleven Northeast and Mid-Atlantic states and the District of Columbia, signed a declaration of intent to collaborate to:

- Improve the efficiency of the transportation system,
- Reduce roadway congestion,
- Upgrade public transport,
- Address the challenges of vehicle miles traveled,
- Reduce air pollution and energy use, and
- Ensure that long-term development is sustainable and enhances quality of life in communities within their jurisdictions

As an active member of the Transportation and Climate Initiative (TCI), MDOT will work with other state agency heads over the next three years to develop the most effective and efficient ways for states to meet their own energy, transportation and climate goals through state-based and regional strategies. As part of its three-year work plan, the TCI will focus development of state-level strategies and policies in four areas: alternative fuel and advanced technology vehicles, sustainable communities, freight movement, and information and communications technologies. While the framework is still under development, the TCI has the potential to generate a significant reduction in Maryland's transportation sector GHG emissions.

Transit Oriented Development (TOD) Designation

TOD is an important tool to help leverage future growth, public investments, and achieve Smart Growth and sustainable communities. Maryland has great TOD potential, with more than 75 existing rail, light rail, and subway stations, and dozens more proposed in the next 20 years. People living within a half mile of a transit station drive 47 percent less than those living elsewhere and are up to five times more likely to use transit.[2]

[2] http://www.mdot.maryland.gov/Planning/TOD/TOD_Basics.html

Legislation signed by Governor O'Malley in 2008 facilitates the development of TOD in Maryland by authorizing MDOT to use its resources to support "designated" TOD projects. Designated TOD projects are those that are good models of TOD, have strong local support, represent a good return on public investment, demonstrate strong partnerships, and can succeed with a reasonable amount of State assistance but not without state support.

Due to limited State and local resources, not all TOD projects that represent good sustainable development can be "designated" under this program. Instead, projects are prioritized that meet the criteria above and cannot succeed without public sector support. Designated projects could benefit from several potential tools, depending on the needs of the particular project at the particular stage of development. Among the benefits are prioritization for transportation funds and resources, financing assistance, tax credits, prioritization for the location of State offices and support from the State Highway Administration on access needs. As of June 2010, Maryland has designated the following 14 TODs for priority State support:

1. Aberdeen
2. Branch Avenue
3. Laurel
4. Naylor Road
5. New Carrollton
6. Odenton
7. Owings Mills
8. Reisterstown Plaza
9. Savage
10. Shady Grove
11. State Center
12. Twinbrook
13. Westport
14. Wheaton

TOD is consistent with Governor O'Malley's Smart, Green and Growing initiative that brings together state agencies, local governments, businesses and citizens to: create more livable communities, improve transportation options, reduce the state's carbon footprint, support resource based industry, invest in green technologies, preserve valuable resource lands, and restore the health of the Chesapeake Bay.

Carbon Neutral Corridor

Based on several ongoing initiatives within Maryland, MDOT in partnership with other state agencies has engaged in a unique project that takes a multidisciplinary approach to plan and evaluate policies, programs and actions to address energy efficiency and reduce GHG emissions.

The project titled the "Carbon Neutral Corridor" identifies strategies that focus on sustainable transportation, smart growth, land conservation and restoration, and energy efficiency practices that support a long-term goal of achieving significant reductions in carbon emissions. The project objective is the development of an implementation plan that will addresses specific actions and funding needs that would lead to eventual implementation of corridor strategies to reduce carbon emissions.

The selection in 2010 of the first project corridor, US 40 from the Baltimore City line to the Susquehanna River, was a critical first step in initiating the planning effort. Ongoing work in

2011 includes defining and testing multiple transportation, land use, conservation, and energy consumption scenarios, working with corridor stakeholders to build understanding of the Carbon Neutral Corridor concept and a coalition of support for corridor recommendations, and informing the public and seeking comment on corridor strategies for reducing GHG emissions from all economic sectors. The US 40 corridor's diverse transportation system, economy, and environment permits the recommendations of the US 40 corridor plan to be transferable to other areas in Maryland.

Crescent Corridor

Norfolk Southern's Crescent Corridor is expected to bring safety, environmental, and economic benefits to Maryland, including the creation of 1,800 green jobs in the next decade. Each year, the Crescent Corridor should divert more than 858,000 long-haul trucks from Maryland highways to the rails, especially along I-95. At the same time, it should conserve up to 2.8 million gallons of fuel and eliminate 31,000 tons of CO_2 emissions annually in Maryland by 2020.

The Crescent Corridor will provide Maryland shippers with a new high-speed intermodal freight option between the Northeast and Southeast that could reduce their annual logistics costs by nearly $35 million. The development of a new intermodal facility in Greencastle, Pa., located in Franklin County near the border of western Maryland, is expected to open in early 2012.

The Crescent Corridor program of projects is estimated to cost $2.5 billion for full development by 2020. There is no current plan for funding support from Maryland to NS, however MDOT, along with the National Capital Region Transportation Planning Board (TPB) have expressed support for the Crescent Corridor project. A critical concern of the TPB and MDOT (including the Hagerstown-Eastern Panhandle MPO) is that NS ensure that local impacts, including increased local truck traffic in the vicinity of intermodal facilities, noise, safety, grade crossing (conversion to separated grade crossings on major transportation routes), and hazardous materials considerations, are adequately addressed to the satisfaction of these entities as these projects are developed.

CSX Transportation's National Gateway initiative is described and quantified in Section 3.4 as an unfunded intercity freight transportation GHG reduction strategy.

PlanMaryland – Maryland Department of Planning

PlanMaryland, the State's first comprehensive plan for sustainable growth and development, presents an opportunity to address climate change mitigation and adaptation issues in Maryland, in the context of many related quality-of-life, economic, social and environmental goals. The strategies identified in TLU-2, Land Use and Location Efficiency, in the 2008 Climate Action Plan, are directly tied to the objectives of PlanMaryland and are overall consistent with Maryland's Smart, Green and Growing policies. MDP is working with MDOT and MDE with a focus on policies and programs implemented by 2020 to reduce dependence on motor vehicle travel (especially single-occupant vehicles). These policies and programs may include incentives and requirements for projects and regional land use patterns that shorten trip length and greatly facilitate the use of alternative transportation mode choices to reach employment, shopping, recreation, education, religious and other destinations. The benefits of PlanMaryland are documented separately from this document through MDPs role in developing the Draft 2012 Implementation Plan. There are VMT related benefits associated with PlanMaryland that will accrue to the transportation sector.

Pay-as-you Drive (PAYD) Insurance – Maryland Insurance Administration

For Pay-as-you Drive Insurance, the Climate Action Plan identified a policy goal to make PAYD coverage available to all Maryland drivers as early as possible and to push for adoption of incentives or pilot programs for Maryland drivers. The Maryland Insurance Administration (MIA) led a workgroup in 2009 with MDOT, MDE, representatives from the insurance industry, representatives from consumer advocacy groups, and other stakeholders to explore options for implementing and marketing insurance policies that tie the cost of premiums to miles or hours driven. The workgroup agreed that while the extent to which PAYD insurance will reduce GHG emissions is unclear, it is beneficial to encourage the expansion of these programs in the state as they do offer more options to consumers. Based on a survey with insurance carriers, most indicated they will not offer PAYD due to the cost of developing the product and the regulatory environment MIA will continue to monitor the carriers and work with them to the extent that they would like to offer this product in the state; however, based on the carriers' timeframe, PAYD will not have an immediate impact on the reduction of GHG.

MDOT Modal Administration Activities

A sample of ongoing or planned administrative, management, maintenance, and operations strategies that will result in reductions in energy consumption from the transportation sector are listed below by agency. These strategies reduce GHG emissions through helping to decrease rates of energy consumption from transportation infrastructure and support facilities. Potential greenhouse gas reductions from these strategies are not calculated, as emissions from non-mobile sources are not estimated by MDOT. Partnerships with other agencies are noted.

Maryland Aviation Administration (MAA)

1. Purchased CNG buses for use as shuttles for the Consolidated Rental Car Facility.
2. Implemented Smart Park way-finding system in parking garages that results in reduced vehicle roaming for parking spaces.
3. Designated a "cell phone" lot to reduce vehicle circulation in the terminal area when awaiting pickup of an arriving passenger.

Maryland Port Administration (MPA)

1. Applied for and received EPA grants for demonstration emission reduction projects on MPA fleet vehicles, cargo handling equipment at MPA terminals, and on construction equipment at Hart Miller Island and Poplar Island.
2. Applied for and received EPA grant for a Port-wide assessment of technologies that can effectively reduce emissions related to cargo movement.
3. Retrofit and repowered tugs with anti-idling technology and new engines.

4. Flex-fuel vehicles, alternative fuel vehicle, and hybrid vehicles have been introduced into the MPA fleet.
5. Plans to install a fuel tank capable of storing E85 will be included in the new fuel island configuration at Dundalk Marine Terminal.

Maryland Transit Administration (MTA)

1. In addition to its ongoing replacement of the bus fleet in the Baltimore region with diesel electric hybrid buses (assessed as a TERM in section 3.3), MTA is installing new electric cooling systems on older buses that provide an additional 9 percent fuel savings. In total 259 older diesel buses in the MTA fleet have had this technology installed. All current and future hybrid buses already have this system built in.
2. Installed front-mounted bike racks on all local MTA buses in 2009 and 2010.
3. All 219 MTA "New Flyer" buses, as well as all new hybrids, are equipped with an idle shut down feature that turns the bus off after idling more than 10 minutes.

State Highway Administration (SHA)

1. SHA in partnership with DNR, and Department of Corrections has a target of planting one million trees by 2011.
2. Pilot Study ongoing to convert sign lighting to LED is 90 percent complete
3. Conversion of traffic signals to LED is 25 percent complete
4. Conversion of roadway lighting to LED is ongoing
5. MEA Partnership to support pilot wind energy project at Westminster Maintenance Shop.
6. Transition to bio-diesel is 100 percent complete at all facilities
7. E85 tank was installed at the Hanover Complex through MEA grant and E85 is being dispensed to SHA and MAA vehicles.
8. SHA is working with contractors to locate truck staging areas and to avoid unnecessary idling of construction equipment. Delivery truck idling at sites limited to 5 minutes.

Maryland Transportation Authority (MDTA)

1. E85 dispensers are being installed at the Baltimore Harbor tunnel, ICC Eastern Operations Facility and other locations.
2. The ICC Eastern Operations Facility will use geothermal heating and cooling
3. Message signs and lane signal indications are being replaced with LED lighting
4. For the Travel Plaza Reconstruction Projects, MDTA is specifying that the site/building design and construction seek to obtain Silver LEED Certification.
5. All new roofs are being done to LEED standards as cool roofs.

MDOT Headquarters

1. 75 percent of Headquarters fleet are hybrids

2. Pilot program for hydrogen fuel cell vehicles
3. Electric vehicle recharging system

4.0 2020 Transportation Sector Results

This section presents an overview of the total emission reductions anticipated from the Maryland transportation sector in 2020 and compares those results against two distinct metrics:

1. The MDOT, agency-specific reduction target of 6.2 mmt CO_2e given to MDOT by MDE in February 2011; and
2. The 25 percent statewide GHG emissions reduction goal established in the Maryland Greenhouse Gas Emissions Reduction Act of 2009.

4.1 2020 Emissions Reduction Overview

Table 4.1 presents a summary of the total 2020 transportation sector emission reductions and costs broken down into the following categories: vehicle technologies; transportation fuels; funded and adopted Maryland Plans, Programs, and TERMs; and unfunded GHG reduction strategies that are all included in Section 3.0 of this document.

Table 4.1 Transportation Sector 2020 GHG Emission Reductions and Costs

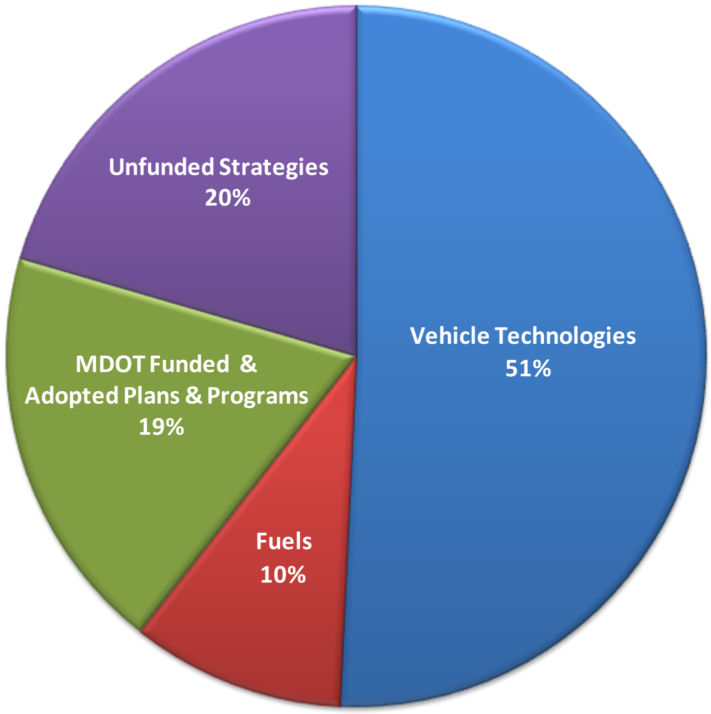
Transportation Sector GHG Reduction Strategy	2020 GHG Reduction (mmt CO_2e)	Total Cost (2010-2020) (billions $)
Vehicle Technologies		
CAFE Standards (2008 – 2011 MY)	2.27	-
National Fuel Economy Standards (Federal) (2012 – 2016 MY)	3.19	-
Maryland Clean Car Program (2011 MY) & Maryland Clean Car or National Fuel Economy Standards (2017 – 2025 MY)	1.14	-
Proposed National 2014-2018 Medium and HDV Standards	0.88	-
Vehicle Technologies Total	**7.48**	-
Transportation Fuels		
Renewable Fuel Standard Program (RFS2)	0.24	-
Low Carbon Fuel Standard (5%)	1.21	-
Transportation Fuels Total	**1.45**	-

Transportation Sector GHG Reduction Strategy	2020 GHG Reduction (mmt CO_2e)	Total Cost (2010-2020) (billions $)
Funded and Adopted Maryland Plans, Programs and TERMs		
Maryland Plans, Programs, and TERMs Total	**2.79**	**$13.219**
GRAND TOTAL FOR ADOPTED PROGRAMS		
GRAND TOTAL for Vehicle Technology, Transportation Fuels, and Funded Programs	***11.72***	***$13.219***
Unfunded GHG Reduction Strategies		
Land Use and Location Efficiency	--	*MDP Responsibility*
Public Transportation	0.39 – 0.62	$1,214 - $1,765
Intercity Passenger and Freight Transportation	0.11	$0.748
Pay-as-you-Drive Insurance	--	*MIA Responsibility*
Bike and Pedestrian	0.16	$0.598 - $0.817
Transportation Pricing and Demand Management	0.24 – 2.01	$0.300 - $3,690
Transportation Technology	0.24	$0.051
Unfunded Strategies Total	**1.14 – 3.14**	**$2.911 - $7.071**
GRAND TOTAL OF MDOT PROGRESS (ADOPTED AND UNFUNDED)		
GRAND TOTAL GHG Reductions and Costs	***12.86 – 14.86***	***$16.130 - $20.290***

The total emission reductions attributable to the transportation sector in 2020 are anticipated to range from 12.86 – 14.86 mmt CO_2e, with an estimated cost spanning $16.130 - $20.290 billion.

Figure 4.1 provides a breakdown of the transportation sector emission reductions by category. Notably, vehicle technologies and fuels, measures that result in little to no direct costs to the state, contribute 61 percent of the transportation sector's 14.86 mmt CO_2e reductions in 2020. MDOT strongly supports these programs and is also committed to the funded and adopted plans and programs that contribute 19 percent of the GHG reductions. Based on future funding availability, the unfunded measures and strategies have the potential to contribute as much as 20 percent of the total 2020 transportation sector emissions reductions.

Figure 4.1 2020 Transportation Sector Emission Reductions by Sector Category



4.2 PROGRESS TOWARD THE MDOT AGENCY-SPECIFIC TARGET

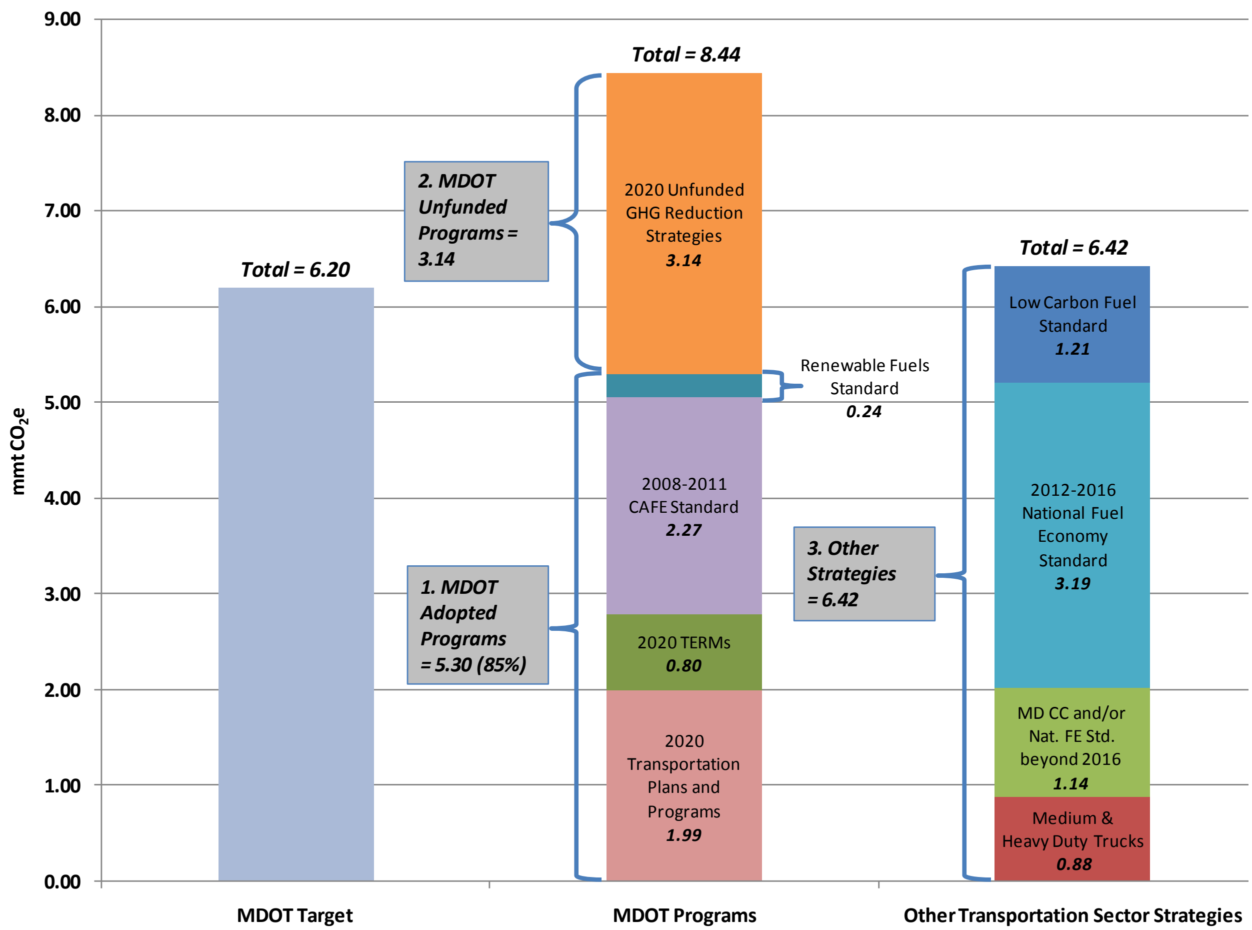
Figure 4.2 provides a summary of the 2020 transportation sector GHG emissions reductions within the context of the MDE-assigned 2020 GHG reduction target of 6.2 mmt CO_2e. The transportation sector reductions have been arranged into three categories for comparison purposes: (1) all MDOT adopted transportation programs, (2) MDOT unfunded transportation programs, and (3) other transportation sector strategies.

1. To date, MDOT has adopted programs that achieve approximately 5.30 mmt CO_2e reductions or 85 percent of the total 2020 target.
2. The unfunded GHG reduction strategies could yield an additional 1.14 – 3.14 mmt CO_2e reduction by 2020.

Should additional funding become available, in total the adopted programs and unfunded strategies would total 8.44 mmt CO_2e in 2020, or 136 percent of the 6.2 mmt reduction target.

3. By 2020, an additional transportation sector emissions reduction of 6.42 mmt CO_2e can be expected from the implementation of state and federal programs addressing cleaner fuels and improved fuel economy standards.

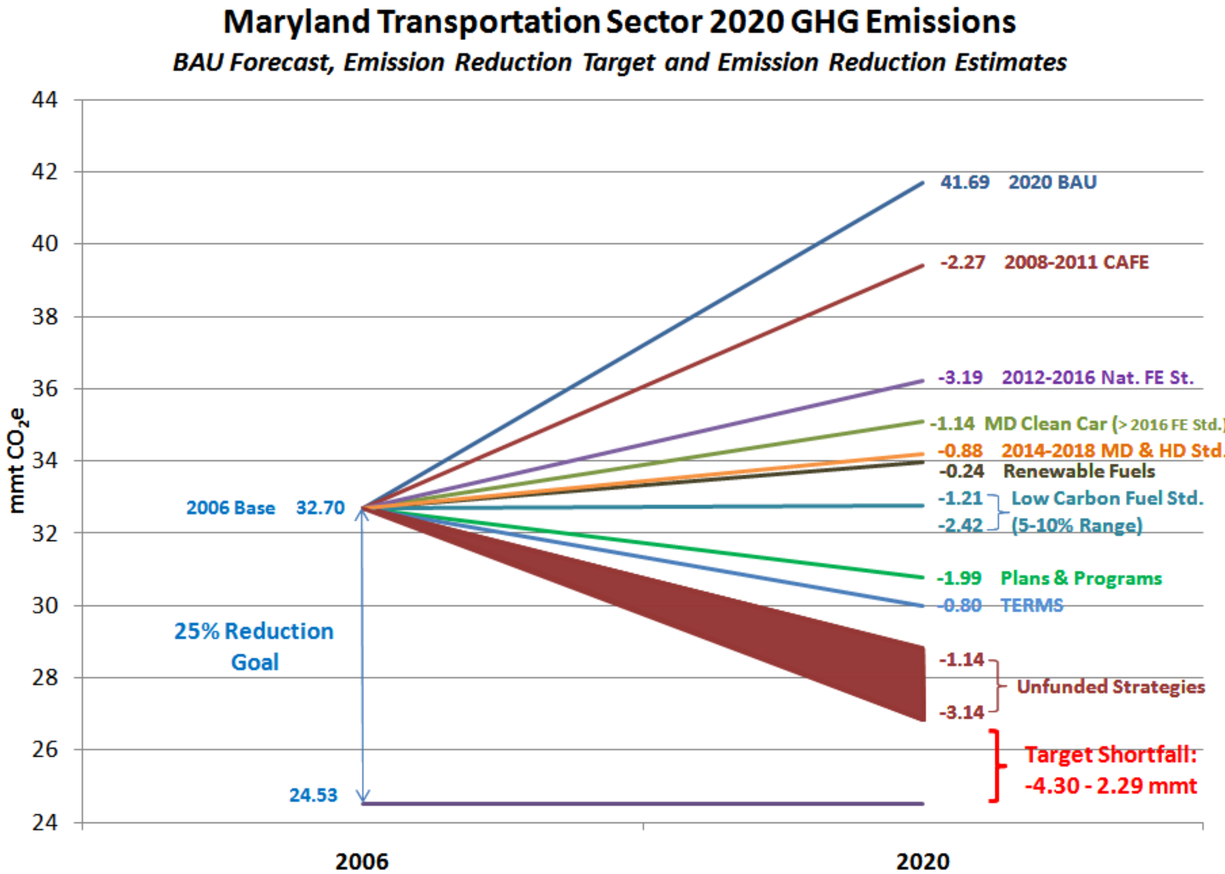
Figure 4.2 Maryland Transportation Sector GHG Emissions – Summary of 2020 GHG Reductions



4.3 Transportation Sector Progress Toward a Statewide 25 Percent Reduction Goal

As part of the Phase I and Phase II work program, MDOT used a 25 percent reduction in 2006 emissions as a benchmark to evaluate progress toward GHG reductions by 2020. Figure 4.3 illustrates the anticipated 2020 transportation sector reductions within the framework of a statewide reduction goal of 25 percent below 2006 levels by 2020. In order to achieve a 25 percent GHG emissions reduction from the transportation sector, a 17.16 mmt CO_2e reduction in emissions from the 2020 BAU forecast would be required. At the highest level of strategy implementation, 2020 transportation sector emission reductions could reach as much as 87 percent (14.86 mmt CO_2e) of the 25 percent GHG reduction goal for 2020. The figure further illustrates a 2.29 to 4.30 mmt CO_2e target shortfall for the transportation sector.

Figure 4.3 Maryland 2020 Transportation GHG Emissions Forecast and Reductions



Maryland Climate Action Plan

Maryland Department of Transportation Draft 2012 Implementation Plan – Appendix

Martin O'Malley, Governor

Anthony G. Brown, Lt. Governor

Beverley K. Swaim-Staley, Secretary

April 11, 2011

Maryland Department of Transportation

report

Maryland Climate Action Plan - MDOT Draft 2012 Implementation Plan - Appendix

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A. 2006 Baseline and 2020 BAU Emissions Inventory Documentation

This technical analysis report documents the methodology and assumptions used to produce the greenhouse gas (GHG) inventory for Maryland's on-road portion of the transportation sector. Statewide emissions have been estimated for a 2006 baseline and a 2020 forecast business-as-usual (BAU) scenario. The inventory was calculated by estimating emissions for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Those emissions were then converted to carbon dioxide equivalents that are measured in the units of million metric tons (mmt CO_2e). Carbon dioxide represents about 97 percent of the transportation sector's GHG emissions.

The on-road portion of the inventory was developed using EPA's new emissions model MOVES (Motor Vehicle Emissions Simulator). The inventory results represent an update of previous analyses conducted by the Center for Climate Strategies (CCS) for the Climate Action Plan (CAP) in 2008 and MDOT's Draft Implementation Plan, dated November 2009. Those inventory efforts were performed with EPA's MOBILE6.2 emission factor model. The MOVES model provides a more robust estimate of greenhouse gas emissions as compared to the simplified approaches used in MOBILE6.2. In MOVES, greenhouse gases are calculated from vehicle energy consumption rates and vary by vehicle operating characteristics including speed. In addition, the MOVES model includes the affects of current regulations on future vehicle fuel economy standards.

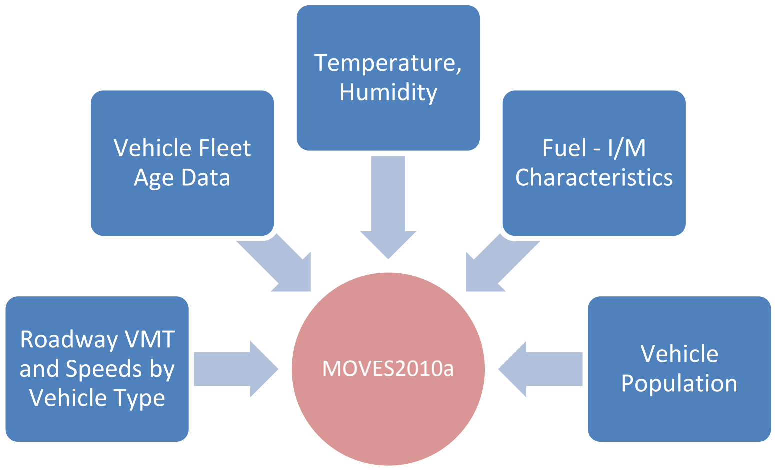
The off-road portion of the transportation sector uses emission rates and data from EPA's State Greenhouse Gas Inventory Tool (SIT). The data and assumptions were developed for the November 2009 MDOT Draft Implementation Plan and remains unchanged.

On-Road Analysis Process

The data, tools and methodologies employed to conduct the on-road vehicle GHG emissions inventory were developed in close consultation with MDE and are consistent with the *Technical Guidance on the Use of MOVES2010 for Emission Inventory Preparation in State Implementation Plans and Transportation Conformity, EPA-420-B-10-023, April 2010*. EPA's MOVES model was officially released on March 2, 2010 and was followed with a revised version (MOVES2010a) in August 2010. The MOVES2010a version incorporates new car and light truck greenhouse gas emissions standards for model years 2012-2016 and updates effects of corporate average fuel economy standards for model years 2008-2011. The MOVES2010a model estimates the reductions in greenhouse gases associated with those standards in future calendar years.

As illustrated in Figure A.1, the MOVES2010a model has been integrated with local traffic, vehicle fleet, environmental, fuel, and control strategy data to estimate statewide emissions.

Figure A.1 Emission Calculation Data Process



The modeling assumptions and data sources were developed in coordination with MDE and are consistent with other SIP-related inventory efforts. The process represents a "bottom-up" approach to estimating statewide GHG emissions based on available roadway and traffic data. A "bottom-up" approach provides several advantages over simplified "top-down" calculations using statewide fuel consumption. These include:

- Addresses potential issues related to the location of purchased fuel. Vehicle trips with trip ends outside of the state (e.g. including "thru" traffic) create complications in estimating GHG emissions. For example, commuters living in Maryland may purchase fuel there but may spend much of their traveling in Washington D.C. The opposite case may include commuters from Pennsylvania working in Maryland. With a "bottom-up" approach emissions are calculated for all vehicles using the transportation system.
- Allows for a more robust forecasting process based on historic trends of VMT or regional population and employment forecasts and their relationship to future travel. For example, traffic data can be forecasted using growth assumptions determined by the MPO through their analytic (travel model) and interagency consultation processes.

GHG emission values are reported as annual numbers for the 2006 baseline and 2020 BAU scenarios. The annual values were calculated based on 12 monthly MOVES runs as summarized in Figure A.2. Each monthly run used traffic volumes, speeds, temperatures and fuel values specific to an average day in each month.

Figure A.2 Calculation of Annual Emissions

For the 2006 and 2020 BAU emissions inventory, the traffic data was based on roadway segment data obtained from the Maryland State Highway Administration (SHA). This data does not contain information on congested speeds and the hourly detail needed by MOVES. As a result, post processing software (PPSUITE) was used to calculate hourly congested speeds for each roadway link, apply vehicle type fractions, aggregate VMT and VHT, and prepare MOVES traffic-related input files. The PPSUITE software and process methodologies are consistent with that used for state inventories and transportation conformity analyses throughout Maryland.

Other key inputs including vehicle population, temperatures, fuel characteristics and vehicle age were obtained from and/or prepared in close coordination with MDE staff. The following sections summarize the key input data assumptions used for the inventory runs.

Summary of Data Sources

A summary of key input data sources and assumptions are provided in Table A.1. Many of these data inputs are consistent to those used for SIP inventories and conformity analyses. There are several data items that require additional notes.

Traffic volumes and VMT are forecasted for the 2020 BAU analysis. A discussion of forecasted traffic volumes and vehicle miles of travel (VMT) is discussed in more detail in the following section.

Vehicle population is a key input that has an important impact on start and evaporative emissions. At the time of this study, final decisions (per MDE consultation) had not been made on the use of Maryland registration data as a surrogate for vehicle population. In urban areas, registration data can over-estimate the actual number of daily vehicle trips due to high transit usage. As a result, for this study, vehicle population was calculated from VMT using MOVES default estimates for the typical miles per vehicle by source type (e.g. vehicle type). The PPSUITE post processor automatically prepares the vehicle population file under this method. This alternative was determined to be acceptable for this inventory, especially considering that start and evaporative emissions are much lower for CO_2 as compared to other pollutants.

The vehicle mixes is another important file that is used to disaggregate total vehicle volumes and VMT to the 13 MOVES source types. MDE is still reviewing options to prepare these data input assumptions. For this inventory, the vehicle mix was calculated based on 2008 SHA vehicle type pattern percentages by functional class, which disaggregates volumes to four vehicle types: light-duty vehicles, heavy-duty vehicles, buses, and motorcycles. As illustrated in Figure A.3, the four vehicle groups were related to EPA's MOBILE6.2 weight-based vehicle categories. EPA's MOVES Technical Guidance was then used to convert the MOBILE6.2 categories to the MOVES source types.

Figure A.3 Defining Vehicle Types

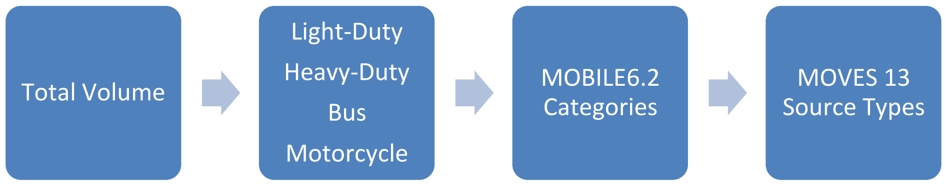


Table A.1 Summary of Key Data Sources

Data Item	Source	Description	Difference between 2006 and 2020BAU
Roadway Characteristics	2008 Maryland State Highway Administration (SHA) Universal Database	Includes lanes, segment distance, facility type, speed limit	*Same Data Source*
Traffic Volumes	2008 Maryland State Highway Administration (SHA) Universal Database	Average Annual Daily Traffic Volumes (AADT)	Volumes forecasted for 2020 BAU
Seasonal Adjustments	SHA 2008 *ATR Station Reports in the Traffic Trends System Report Module* from the SHA website	Adjust AADT to average day in each month	*Same Data Source*
VMT	Highway Performance Monitoring System 2006	Used to adjust VMT to the reported 2006 HPMS totals by county and functional Class	VMT forecasted for 2020 BAU
Hourly Patterns	SHA 2008 *Traffic Trends System Report Module* from the SHA website	Used to disaggregated volumes and VMT to each hour of the day	*Same Data Source*
Vehicle Type Mix	2008 SHA vehicle pattern data; MOVES Technical Guidance	Used to split traffic volumes to the 13 MOVES vehicle source types	*Same Data Source*
Ramp Fractions	MOVES Defaults	MOVES Defaults	*Same Data Source*
Vehicle Ages	2008 Maryland Registration data	Provides the percentage of vehicles by each model year age	*Same Data Source*
Hourly Speeds	Calculated by PPSUITE Post Processor	Hourly speed distribution file used by MOVES to estimate emission factors	Higher volumes produce lower speeds in 2020 BAU
I/M Data	Provided by MDE	Based on 2006 and current I/M program	Different I/M Program Characteristics
Fuel Characteristics	Provided by MDE	Fuel characteristics vary from 2006-2012 then constant to 2020	Different Fuel Characteristics
Temperatures	Provided by MDE	Average Monthly Temperature sets	*Same Data Source*

Vehicle Population	Calculated by PPSUITE Post Processor; MOVES Default Miles/Vehicle Data	Vehicle population calculated by PPSUITE from VMT using MOVES Default miles/vehicle estimates	2020 BAU based on VMT growth

Traffic Volume and VMT Forecasts

The traffic volumes and VMT within the SHA traffic database were forecast to estimate future year emissions. Several alternatives are available to determine forecast growth rates, ranging from historical VMT trends to the use of MPO-based travel models that include forecast demographics for distinct areas in each county.

For the 2020 BAU scenario, the forecasts were determined using assumptions from the original Maryland CAP, which was based on historic trends of 1990-2006 HPMS VMT growth. Table A.2 summarizes the growth rates by county. The average statewide annualized growth rate was assumed to be 1.8 percent. Table A.3 summarizes total 2006 baseline and 2020 forecast VMT by vehicle type.

Table A.2 VMT Annual Growth Rates (Per Maryland CAP) for 2020 BAU

County	Annualized 2006-2020 Growth
Allegany	1.3%
Anne Arundel	2.0%
Baltimore	1.3%
Calvert	2.5%
Caroline	1.3%
Carroll	1.9%
Cecil	2.4%
Charles	2.2%
Dorchester	0.9%
Frederick	2.5%
Garrett	1.4%
Harford	1.8%
Howard	3.2%
Kent	0.5%
Montgomery	1.5%
Prince George's	1.7%
Queen Anne's	2.2%
Saint Mary's	2.0%
Somerset	0.9%
Talbot	1.8%
Washington	2.1%
Wicomico	1.5%
Worcester	1.3%
Baltimore City	0.8%
Statewide	***1.8%***

Table A.3 2006 Baseline and 2020 BAU VMT by Vehicle Type

Annual VMT	2006 Baseline	2020 BAU
Light Duty	51,212	63,878
Medium/Heavy Duty Truck & Bus	5,406	6,775
Total VMT	***56,618***	***70,653***

The analysis process (e.g. using PPSUITE post processor) re-calculates roadway speeds based on the forecast volumes. As a result, future year emissions are sensitive to the impact of increasing traffic growth on regional congestion.

Vehicle Technology Adjustments

The MOVES2010a emission model includes the effects of the following post-2006 vehicle programs on future vehicle emission factors:

- *CAFE Standards (Model Years 2008-2011)* – Vehicle model years through 2011 are covered under existing CAFE standards that will remain intact under the Obama Administration's national program.
- *National Program (Model Years 2012-2016)* – The light-duty vehicle fuel economy for model years between 2012 and 2016 are based on the May 7, 2010 Rule "*Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule" (EPA-HQ-OAR-2009-0472-11424:http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2009-0472-11424).* Fuel economy improvements begin in 2012 until an average 250 gram/mile CO_2 standard is met in year 2016. This equates to an average fuel economy near 35 mpg.

The above technology programs were not included in the 2020 BAU, as they are included as credits applied to BAU emissions. To remove the potential emission credits of both of these programs, the MOVES2010a default database was revised. Fuel economy assumptions within MOVES2010a are provided as vehicle energy consumption rates within the "EmissionRates" table as illustrated in Figure A.4.

Figure A.4 MOVES Default "EmissionRate" Table

sourceBinID	polProcessID	opModelID	meanBaseRate	meanBaseRate...	meanBaseRateIM	meanBaseRate...	dataSourceId
1010146900000000000	601	300	0.814636	NULL	0.814636	NULL	406
1010147900000000000	601	300	0.814636	NULL	0.814636	NULL	406
1010146900000000000	602	100	0.294065	NULL	0.294065	NULL	406
1010147900000000000	602	100	0.294065	NULL	0.294065	NULL	406
1010146940000000000	601	300	0.814636	NULL	0.814636	NULL	406
1010147940000000000	601	300	0.814636	NULL	0.814636	NULL	406
1010146940000000000	602	100	0.294065	NULL	0.294065	NULL	406
1010147940000000000	602	100	0.294065	NULL	0.294065	NULL	406
1010146850000000000	601	300	0.517222	NULL	0.517222	NULL	406
1010146850000000000	602	100	0.186705	NULL	0.186705	NULL	406
1010146950000000000	601	300	0.814636	NULL	0.814636	NULL	406
1010147950000000000	601	300	0.814636	NULL	0.814636	NULL	406
1010146950000000000	602	100	0.294065	NULL	0.294065	NULL	406
1010147950000000000	602	100	0.294065	NULL	0.294065	NULL	406
1010146960000000000	601	300	1.55422	NULL	1.55422	NULL	406
1010147960000000000	601	300	1.55422	NULL	1.55422	NULL	406
1010146960000000000	602	100	0.56104	NULL	0.56104	NULL	406
1010147960000000000	602	100	0.56104	NULL	0.56104	NULL	406
1010146970000000000	601	300	1.66641	NULL	1.66641	NULL	406
1010147970000000000	601	300	1.66641	NULL	1.66641	NULL	406
1010146970000000000	602	100	0.601537	NULL	0.601537	NULL	406
1010147970000000000	602	100	0.601537	NULL	0.601537	NULL	406
1010146980000000000	601	300	1.69944	NULL	1.69944	NULL	406

To remove the benefits of the 2008-2011 CAFE standards and the 2012-2016 National Program, the database was revised so that all energy rates beyond 2007 were the same for each vehicle type, model year and fuel type. The table was updated per the following steps:

1. Open the "EmissionRate" table in the latest MOVES2010a default database (named: movesdb20100830). The fields to be modified include: *meanBaseRate* & *meanBaseRateIM* (values in both fields are the same)
2. Select records in the table that are related to energy consumption. This includes records with the polProcessID = 9101, 9102 and 9190.
3. Use the sourceBinID field to determine how each record correlates to vehicle type, model year and fuel type.
4. Modify meanBaseRate & meanBaseRateIM fields to be same for all model years beyond 2007 for the applicable vehicle type, model year and fuel type.

Emission Results

The 2006 and 2020 BAU emission results for the Maryland statewide GHG inventory are provided in Table A.4 and A.5 respectively. Within each table, emissions are also provided by fuel type and vehicle type.

Table A.4 2006 Annual On-Road GHG Emissions (mmt CO_2e)

	VMT (Millions)	CO_2	CH_4	N_2O	CO_2e
TOTAL	**56,618**	**29.101**	**0.047**	**0.521**	**29.67**
By Fuel Type					
Gasoline	52,720	23.195	0.0462	0.5183	**23.76**
Diesel	3,898	5.907	0.0003	0.0030	**5.91**
By MOVES Vehicle Type					
Motorcycle	319	0.120	0.0005	0.0004	**0.12**
Passenger Car	29,337	10.959	0.0178	0.1722	**11.15**
Passenger Truck	18,070	9.460	0.0202	0.2571	**9.74**
Light Commercial Truck	5,833	3.117	0.0067	0.0833	**3.21**
Intercity Bus	15	0.027	0.0000	0.0000	**0.03**
Transit Bus	40	0.052	0.0000	0.0000	**0.05**
School Bus	129	0.124	0.0002	0.0008	**0.13**
Refuse Truck	33	0.056	0.0000	0.0000	**0.06**
Single Unit Short-haul Truck	655	0.656	0.0008	0.0054	**0.66**
Single Unit Long-haul Truck	49	0.047	0.0000	0.0003	**0.05**
Motor Home	20	0.021	0.0000	0.0002	**0.02**
Combination Short-haul Truck	1,163	2.339	0.0001	0.0008	**2.34**
Combination Long-haul Truck	953	2.123	0.0001	0.0006	**2.12**

Table A.5 2020 BAU Annual On-Road GHG Emissions (mmt CO_2e)

	VMT (Millions)	CO_2	CH_4	N_2O	CO_2e
TOTAL	**70,653**	**38.360**	**0.048**	**0.186**	**38.59**
By Fuel Type					
Gasoline	65,686	30.502	0.0277	0.1815	**30.71**
Diesel	4,967	7.858	0.0201	0.0041	**7.88**
By MOVES Vehicle Type					
Motorcycle	402	0.155	0.0005	0.0006	**0.16**
Passenger Car	36537	14.247	0.0102	0.0744	**14.33**
Passenger Truck	22587	12.693	0.0137	0.0786	**12.79**
Light Commercial Truck	7295	4.177	0.0056	0.0268	**4.21**
Intercity Bus	18	0.033	0.0000	0.0000	**0.03**
Transit Bus	48	0.064	0.0001	0.0000	**0.06**
School Bus	155	0.155	0.0004	0.0004	**0.16**
Refuse Truck	45	0.077	0.0001	0.0000	**0.08**
Single Unit Short-haul Truck	805	0.852	0.0012	0.0024	**0.86**
Single Unit Long-haul Truck	75	0.075	0.0001	0.0002	**0.08**
Motor Home	27	0.029	0.0000	0.0001	**0.03**
Combination Short-haul Truck	1349	2.791	0.0016	0.0010	**2.79**
Combination Long-haul Truck	1309	3.013	0.0144	0.0010	**3.03**

Fuel Consumption Estimates

The MOVES output energy rates can be converted to fuel consumption values using standard conversion rates for gasoline and diesel fuel. Table A.6 provides the estimated 2006 and 2020BAU fuel consumption values. The 2006 values were compared to available information from FHWA and the Energy Information Administration (EIA). Differences result from the application of a "bottom-up" analysis approach and the issues discussed at the beginning of this Appendix.

Table A.6 2006 and 2020 BAU Fuel Consumption

Scenario	Fuel Type	MOVES2010a Output		Actual Statewide Fuel Sales[2] *(Thousand gallons)*
		Energy Consumption *(Trillion BTU)*	Estimated Fuel Consumption[1] *(Thousand Gallons)*	
2006	Gasoline	305.9	2,462,240	2,642,371
	Diesel	76.3	550,454	558,703
2020 BAU	Gasoline	402.3	3,237,943	-----
	Diesel	101.6	732,275	-----

Notes:

(1) Assumes following conversion rates:

- 1 gallon of gasoline fuel = 124,238 BTU
- 1 gallon of diesel fuel = 138,690 BTU
- http://www.eia.doe.gov/kids/energy.cfm?page=about_energy_conversion_calculator-basics

(2) On-highway Gasoline Fuel Consumption:

- FHWA - Highway Statistics 2007: Highway use of motor fuel - 2006, Table MF-27
- http://www.fhwa.dot.gov/policy/ohim/hs06/motor_fuel.htm

On-highway Diesel Fuel Consumption:

- EIA - Sales of Distillate Fuel Oil by End Use - Maryland
- http://tonto.eia.doe.gov/dnav/pet/pet_cons_821dst_dcu_SMD_a.htm

B. CTP, MPO TIP and CLRP Project Listings by Policy Option

The results presented in this Appendix summarize total costs by program and lists all projects and TERMs by transportation GHG reduction policy option. The review of project, program and TERM costs within the 2011-2016 CTP and MPO plans are sourced from the following documents:

- MDOT 2011 – 2016 Consolidated Transportation Program
- MWCOG 2011-16 TIP and 2010 CLRP adopted 11/17/10
- BRTB 2011-14 TIP adopted 7/27/10 and Transportation Outlook 2035 (adopted 11/07, amended 2/24/09)
- Hagerstown/Eastern Panhandle MPO 2010-2013 TIP adopted 6/16/10 and 2035 LRMTP adopted 4/28/10
- Salisbury-Wicomico MPO 2010-2013 TIP adopted 9/28/09 and Draft 2010 LRTP scheduled for adoption in October 2010
- Cumberland Area MPO 2010-2013 TIP adopted 10/15/09 and Draft 2010 LRTP schedule for adoption in October 2010
- WILMAPCO DRAFT 2012-2015 TIP and 2040 RTP (adopted 10/10)

The tables within this Appendix are described below:

- **Table B.1: Draft Cost Summary and 2020 GHG Reduction by Program / Transportation GHG Reduction Policy Option**

  A summary of total project cost by transportation sector policy option for capital projects and TERMs in 2011-2016 CTP and most recent MPO planning documents. The 2020 GHG reduction's presented in this table have been updated in 2011 per a new assessment of VMT growth rates, new data on implementation of TERMs, and new emission factors resulting from the transition from Mobile6 to MOVES.

- **Table B.2: Funded Maryland Plans, Programs and TERMs – Projects and Costs Grouped by Transportation GHG Reduction Policy Option**

  Project, program and TERM specific listing by transportation sector policy option including project source document, description and total cost.

Table B.1 Funded and Committed Maryland Plans, Programs, and TERMs Cost Summary

Program Element by Transportation GHG Reduction Policy Option	Total Cost (2011-2020) (billions $)[5]
Maryland Plans and Programs (1)	**$12.736**
Land Use and Location Efficiency	*MDP Responsibility*
Public Transportation	$6.757
Intercity Passenger and Freight Transportation	$3.085
Bike and Pedestrian	$1.269
Transportation Pricing and Demand Management	$1.375
Transportation Technology	$0.250
Maryland TERMs (2)	**$0.483**
Land Use and Location Efficiency	*MDP Responsibility*
Public Transportation	$0.206
Intercity Passenger and Freight Transportation	$ -
Bike and Pedestrian	$0.116
Transportation Pricing and Demand Management	$0.022
Transportation Technology	$0.139
TOTAL	**$13.219**

Notes:

1) Projects that contribute to a decrease in VMT growth and/or improve system efficiency are a subset of the complete state capital program. These are projects and programs that act to reduce VMT and/or delay by adding capacity, improving flow, managing travel demand, reducing bottlenecks, or improving overall system efficiency through enhanced system management and operations. These projects are multimodal in nature and span multiple agencies, including MdTA, MAA, MPA, MTA and SHA as well as regional and local transit operators.

2) Transportation Emission Reduction Measures (TERMs) identified in the CTP and MPO TIPs and LRPs to meet criteria pollutant targets, as well as continuation of current programs such as Commuter Connections, CHART, and Metropolitan Area Transportation Operations Coordination (MATOC) are assessed to determine estimates of GHG emission reductions and costs through 2020.

5) Projects listed within the 2011-2016 CTP and MWCOG and BRTB TIP/CLRP adopted or amended since June 2010 and the most recent or available draft versions of plans for Cumberland, Hagerstown/Eastern Panhandle, Salisbury/Wicomico and WILMAPCO.

Table B.2 Funded Maryland Plans, Programs and TERMs – Projects and Costs Grouped by Representative GHG Reduction Policy Option

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
FY 2011-16 CTP	MARC Frederick Extension	Service extension from Point of Rocks to City of Frederick including downtown Frederick and suburban stations connecting to the Brunswick Line and providing access to Washington, D.C.	Transit Construction	$4,186	Ongoing
FY 2011-16 CTP	MARC Improvements on Camden, Brunswick, and Penn Lines	Ongoing program of improvements on the MARC Camden, Brunswick, and Penn lines to ensure safety and quality of service.	Transit Construction	See intercity transportation	Ongoing
FY 2011-16 CTP	MARC Edgewood Station	Phase I of the project includes expanded parking and ADA platform improvements. Phase II improvements are to include replacement of the existing station trailer with a permanent building and site enhancements to enhance customer service and provide improved ADA access.	Transit Construction	$4,998	2013
FY 2011-16 CTP	MARC Growth and Investment Plan	Purchase of new railcars, improvements to station facilities and rail infrastructure, and expansion of parking are planned.	Transit Construction	$141,006	Ongoing
FY 2011-16 CTP	Paul S. Sarbanes Transit Center	This project provides a fully integrated transit center at the Silver Spring Metrorail Station. It includes the construction of bus bays for Metrobus and Ride On, an intercity bus facility, a taxi queue area, kiss and ride parking, and a MARC ticketing office.	Transit Construction	$66,133	2012
FY 2011-16 CTP	MARC Halethorpe Station Improvements	Phase I of the project provided an additional 428 surface parking spaces at the Halethorpe MARC Station. Phase II includes installation of high level platforms, a pedestrian bridge, new shelters, lighting, streetscaping, and improved ADA access.	Transit Construction	$19,285	2011

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
FY 2011-16 CTP	Owings Mills Joint Development	Project involves a master plan and site infrastructure improvements for joint development of the existing 46-acre surface parking lot at Owings Mills Metro Station.	Transit Construction	$13,879	2014
FY 2011-16 CTP	Metro Train Control System Upgrade	Project will replace the existing train control system. The current electronic components have exceeded recommended industry standard life cycles. The new technology will add reliability and provide new diagnostic capabilities for servicing.	Transit Construction	$25,043	2015
FY 2011-16 CTP	Metro Station Fire Management Systems (SCADA)	Design, acquisition, and installation efforts to replace equipment for the Metro system.	Transit Construction	$11,295	2012
FY 2011-16 CTP	Bus Procurement	Annual purchase of clean diesel hybrid electric buses to replace those that have been in service for 12 or more years.	TERM	See transportation technology	Ongoing
FY 2011-16 CTP	Bus On-Board CCTV Retrofit	Retrofit 541 buses with an on-board wireless closed circuit television (CCTV) system that will be compatible with the system being procured for new buses. The new system will link to various system components such as vehicle monitoring, automatic vehicle location (AVL), voice announcements and passenger counters.	Transit Operations	$10,187	2013
FY 2011-16 CTP	Replacement of Fare Collection Equipment and Smart Card	Replace existing fare collection equipment on Bus, Light Rail and Metro Subway with automatic fare collection equipment which includes the implementation of smart card technology and credit card readers on the rail systems. The project also includes the implementation of a customer service center to support the MTA and Washington Region transit properties.	TERM	$12,098	Complete
FY 2011-16 CTP	Intercounty Connector Buses	Purchase motor coaches to provide express bus service on the ICC when complete.	Transit Construction	$10,000	2011

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
FY 2011-16 CTP	CAD/AVL Systems	Provides radio data channel expansion to improve the bus fleet's voice and data communication. Will improve customer service by providing real time management and schedule adherence.	Transit Operations	See transportation technology	2011
FY 2011-16 CTP	Closed Circuit Television Improvements	Installation of CCTV equipment in stations and maintenance facilities. Phase I of the project included 1 Light Rail and 10 Metro locations. Phase II includes additional work at 4 Metro, 1 MARC and 5 Light Rail Stations as well as the Metro Portal.	Transit Operations	$2,740	2011
FY 2011-16 CTP	Southern Maryland Commuter Bus Initiative	Construction of Commuter Bus Park and Ride lots at Dunkirk, Prince Frederick, Waldorf, La Plata, Charlotte Hall, and Newmarket in Southern Maryland.	Transit Construction	$28,807	2014
FY 2011-16 CTP	Locally Operated Transit Systems Capital Procurement Projects (Local Jurisdictions)	Funding to rural and small jurisdictions for transit vehicles, equipment and facilities. In addition, the MTA provides rideshare funds to Baltimore City, Anne Arundel, Baltimore, Calvert, Carroll, Frederick, Harford, Howard, Montgomery and Prince George's Counties and the Tri-County Council for Southern Maryland to promote the use of carpools and vanpools. MTA facilitates federal funds for locally-sponsored projects.	Transit Construction	$115,900	Ongoing
FY 2011-16 CTP	Montgomery County Local Bus Program	Funding for annual bus replacement. The current program funds approximately six to ten buses for replacement of existing Ride On vehicles, fareboxes, and stop annunciators.	Transit Construction	$12,700	Ongoing
FY 2011-16 CTP	Prince George's County Local Bus Program	Annual funding for approximately 3-5 buses per year to replace existing vehicles in the County's "The Bus" fleet.	Transit Construction	$4,120	Ongoing
FY 2011-16 CTP	MARC West Baltimore Station Parking Expansion	Construct additional parking spaces at the West Baltimore MARC Station in Baltimore City.	Transit Construction	$9,755	2013

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
FY 2011-16 CTP	Takoma/Langley Park Transit Center	Construction of an off-street transit center at the intersection of MD 193 and MD 650 in the Takoma/Langley Park community.	Transit Construction	$24,188	2013
FY 2011-16 CTP	Capital Program Support Fund	MTA agency wide improvements – ongoing and FY 2011	System Preservation Minor Projects Program	$3,600	2011, 2012
FY 2011-16 CTP	Charles County-Expansion Buses	Project underway	LOTS	$910	Underway
FY 2011-16 CTP	Harford County Expansion Buses (ARRA)	12 heavy-duty low-floor hybrid expansion buses	LOTS	$4,212	2011
FY 2011-16 CTP	Howard County Expansion Buses (ARRA)	Bus expansion	LOTS	$1,620	2011
FY 2011-16 CTP	Howard Street Revitalization	This project is part of the Main Howard Street Revitalization Project.	Transit Construction	$3,843	2012
FY 2011-16 CTP	Washington Blvd. Improvements		System Preservation Minor Projects Program	$2,162	2011
FY 2011-16 CTP	Light Rail Parking Expansion (ARRA)		System Preservation Minor Projects Program	$3,460	Underway
FY 2011-16 CTP	Real Time Passenger Information Systems		System Preservation Minor Projects Program	$2,570	Underway
FY 2011-16 CTP	WMATA Capital Improvement Program	This program includes Maryland's share of funding for WMATA's CIP.	Transit Construction	$1,027,437	Ongoing
FY 2011-16 CTP	Matching Funds for Passenger Rail Investment and Improvement Act of 2008	The federal legislation authorizes new federal funds to be appropriated over a 10 year period for WMATA. The federal legislation also requires $50.0 million per year from each jurisdiction in matching funds. Maryland has funded the first five years of this match.	Transit Construction	$300,000	Ongoing

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
FY 2011-16 CTP	Rail Cars/Capital Improvement Program	Funds Maryland's share of 48 new rail cars that were ordered in FY 2003. This program also funds Maryland's allocated share of the WMATA development and evaluation program.	Transit Construction	$6,456	Ongoing
FY 2011-16 CTP	WMATA ARRA Capital Program	Capital projects include bus procurement, station improvements, and upgrades to operation systems.	Transit Construction	$18,870	2011
FY 2011-16 CTP	Metro Matters Railcars and Buses	The Metro Matters funding agreement was executed in October, 2004 and outlines an integrated financial plan that will fund the IRP and SAP through FY 2010. The plan will rely on local, state, and federal funding and short and long term debt as necessary. Projects include all system infrastructure, rolling stock, vehicles and equipment.	Transit Construction	$62,712	Ongoing
BRTB 2011-2014 TIP	MARC Aberdeen Station Parking Expansion	Development of Plans and Environmental Documentation for two-phase expansion of parking capacity at the Aberdeen MARC Station on an MTA-owned parcel at Taft Street (Phase I, approximately 65 spaces) and along APG Road below East Bel Air Avenue (Phase II, approximately 90 spaces), opposite the station building.	TERM	$1,741	2012
BRTB 2011-2014 TIP	Local Bus Replacement	Routine replacement of buses past their useful service life with new hybrid electric buses. This project will provide the replacement of three diesel vehicles with three clean diesel hybrid buses for Howard Transit.	TERM	$594	2011
BRTB 2011-2014 TIP	CMAQ Areawide	The BRTB will use a competitive selection process to select $800,000 worth of Congestion Mitigation and Air Quality Improvement Program (CMAQ) projects in FY 2011. CMAQ projects reduce air pollution emissions from the transportation sector.	TERM	$1,700	Ongoing

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
BRTB 2011-2014 TIP	Mobility Bus Implementation	Project includes a mobile command center designed to provide communications and system interfaces that allow for the scheduling and control of paratransit service in case of an emergency and for fleet expansion and replacement	TERM	$5,244	2013
BRTB 2011-2014 TIP	Local Bus & Facilities - Annapolis	Capital assistance to the City of Annapolis for their transit system to purchase vehicles, equipment and facilities.	TERM	$2,680	Ongoing
BRTB 2011-2014 TIP	Rural Transit Systems-Capital	Capital assistance to purchase vehicles, equipment, and facilities. (Anne Arundel, Howard, Baltimore County	LOTS	$198	Ongoing
BRTB 2011-2014 TIP	Job Access and Reverse Commute Program	Develop transportation services designed to transport welfare recipients and low-income individuals to and from jobs and develop transportation services for residents of urban, suburban, and rural areas to suburban employment sites.	Transit	$8,755	Ongoing
BRTB 2011-2014 TIP	Small Urban Transit Systems-Capital	Capital assistance to purchase vehicles, equipment, and facilities. (Harford and Carroll County)	LOTS	$3,730	Ongoing
BRTB 2011-2014 TIP & Transportation Outlook 2035	Bus Replacements	Routine replacement of buses past their useful service life with new hybrid buses. Planned fleet replacement of 50-100 buses to hybrid diesel buses each of the next four years depending on funding.	TERM	$166,694	Ongoing
BRTB Transportation Outlook 2035	Red Line-Regional [1]	Construct an east-west rapid transit system from Social Security area to Bayview Medical Center	Transit	$1,538,750	2015
BRTB Transportation Outlook 2035	MARC-East Baltimore	New station	Transit	$70,000	2015

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
BRTB Transportation Outlook 2035	MARC-Middle River	Relocate with station improvements	Transit	$15,000	2015
BRTB Transportation Outlook 2035	MARC-Aberdeen	Relocate with station improvements	TERM	$15,000	2015
BRTB Transportation Outlook 2035	Expand real-time transit information	Expand accuracy and availability of real-time bus schedules.	Transit Information	$10,000	2013
HEPMPO Draft FY 2010-13 TIP	Small Urban Transit System-Capital	Capital assistance for vehicles and equipment.	Transit	$923	2010
MWCOG 2010 CLRP	Purple Line Transitway [2]	Construction of Bethesda to New Carrollton	Transit	$1,716,000	2020
MWCOG 2010 CLRP	Corridor Cities Transitway (CCT) [3]	Bus rapid transit line along a 14-mile corridor from Rockville through Quince Orchard, Gaithersburg and Germantown to Clarksburg.	Transit	$1,193,000	2020
MWCOG 2010 CLRP	Veirs Mill Road Bus Enhancement	Rockville to Wheaton	Transit	$15,000	2020
MWCOG 2010 CLRP	Four Corners Transit Center	Construct Four Corners Transit Center US 29/MD 193	Transit	$2,565	2015
MWCOG 2010 CLRP	Olney Transit Center	Olney Transit Center, adjacent to or north of MD 108	Transit	$1,000	2015
MWCOG 2010 CLRP	University Blvd Bus Enhancement	Kensington to Silver Spring	Transit	$500	2020
MWCOG 2010 CLRP	Norbeck Road Park and Ride	Norbeck Road Park and Ride, Norbeck Rd. at Georgia Avenue	Transit	$200	2015
MWCOG 2010 CLRP	White Oak Transit Center	Along Lockwood Drive east of New Hampshire Avenue	Transit	$1,791	2010
MWCOG 2010 CLRP	I-95/495: Branch Avenue Metro Access	Construct 8-lane access road to improve access to Branch Avenue METRO Station	Transit	$127,592	2020

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
MWCOG 2011-16 TIP	Bus Purchases - ARRA	This ARRA project provides $6,550,000 for the purchase of one diesel bus and additional hybrid buses.	Transit Improvements	$6,550	Ongoing
MWCOG 2011-16 TIP	Montgomery Mall Transit Center	This project provides for the County portion of the new Montgomery Mall Transit Center.	Transit Improvements	$1,100	2011
MWCOG 2011-16 TIP	Public Transit Systems	Provision of vehicles, equipment and other projects in support of public transportation. Federal and state assistance with local match. Project selection based on application from local providers.	Transit Improvements	$10,000	Ongoing
MWCOG 2011-16 TIP	Bethesda Metro South Entrance [4]	This project provides access from Elm Street west of Wisconsin Avenue to the southern end of the Bethesda Metrorail Station. Currently there is one entrance, near East-West Highway. The Metrorail station was built with accommodations for a future southern entrance.	Transit Improvements	$60,000	2015
MWCOG 2011-16 TIP	Bus Stop Improvement Program	Installation and improvement of capital amenities at bus stops in Montgomery County.	Transit Improvements	$10,000	Ongoing
WILMAPCO FY 2012-2015 TIP	Small Urban Transit System-Capital Assistance	Capital assistance to the Cecil County Department of Aging.	Transit-System Preservation	$313	Ongoing
WILMAPCO 2040 RTP	MARC Extension - Perryville to Elkton	Extend peak period MARC service from Perryville to Elkton	Transit Construction	$22,204	2020
Public Transportation - TOTAL				**$6,962,996**	
FY 2011-16 CTP	I-295/I-495, National Harbor	Construct access improvements and MD 414 Extended.	Highway Capacity	$4,126	2013
FY 2011-16 CTP	MD 295, Baltimore Washington Parkway	Widen from 4 to 6 lanes from I-695 to I-95 (1.50 miles).	Highway Capacity	$4,982	2012
FY 2011-16 CTP	I-95 Ft. McHenry Tunnel (MDTA)	Moravia Road to the Tunnel Modifications. 4 continuous through lanes.	Highway Capacity	$11,716	2011

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
FY 2011-16 CTP	I-70 Baltimore National Pike	Extension of MD 475 (East Street) from South Street to the proposed Monocacy Boulevard. Includes storm water management, urban diamond interchange, and new MD 355 Bridge.	Highway Capacity	$5,236	2011
FY 2011-16 CTP	I-70 Baltimore National Pike	Widen east of MD 85 to east of MD 144, replace the bridge over Reich's Ford Road, reconstruct the ramps at Monocacy/ Reich's Ford Road	Highway Capacity	$48,646	2014
FY 2011-16 CTP	Francis Scott Key Highway (MDTA)	Interchange improvements at MD 695 and Quarantine Road: Interchange and road improvements.	Interchange Capacity	$5,484	2012
FY 2011-16 CTP	I-95/MD 24 Interchange (MDTA)	I-95/MD 24/MD 924: Phase 1 includes minor improvements and a grade-separated interchange.	Interchange Capacity	$29,334	2012
FY 2011-16 CTP	US 40, Pulaski Hwy	Construct interchange improvements at MD 715	Interchange Capacity	$33,103	2013
FY 2011-16 CTP	US 40, Dual Hwy	Widen US 40 at Edgewood Drive intersection.	Interchange Capacity	$2,081	2011
FY 2011-16 CTP	MARC Improvements on Camden, Brunswick, and Penn Lines	Ongoing program of improvements on the MARC Camden, Brunswick, and Penn lines to ensure safety and quality of service.	Transit Construction	$91,225	Ongoing
FY 2011-16 CTP	Freight Line Grade Crossing Rehabilitation	Crossings in Queen Anne's and Caroline County	System preservation and safety enhancement.	$1,990	Ongoing
FY 2011-16 CTP	Baltimore Intercity Bus Terminal	Construction underway	System Preservation Minor Projects Program	$1,930	2011
FY 2011-16 CTP	MD 5, Branch Avenue	Widen from 4 to 6 lanes from north of MD 373 to US 301 (1.07 miles). Bike/pedestrian accommodations where appropriate.	Highway Capacity w Bike/Ped	See bike and pedestrian	2011

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
FY 2011-16 CTP	BRAC Intersections near Fort Meade	Intersection improvements at key locations along access routes to Ft. Meade. Bike/Ped facilities provided where appropriate.	Intersection w Bike/Ped	See bike and pedestrian	2012
FY 2011-16 CTP	BRAC intersections near Bethesda Naval Center	Intersection improvements along access routes to Bethesda Naval Center. Bike/Ped facilities where appropriate.	Intersection w Bike/Ped	See bike and pedestrian	2012
FY 2011-16 CTP	BRAC Intersections near Aberdeen Proving Grounds	Intersection improvements along access routes to Aberdeen Proving Grounds. Bike/Ped facilities where appropriate.	Intersection w Bike/Ped	See bike and pedestrian	2012
FY 2011-16 CTP	High Speed Rail Passenger Rail Grant Funding for B&P Tunnel	ARRA Funding for PE and NEPA	Intercity Rail	$60,000	
FY 2011-16 CTP	SHA Primary Development and Evaluation Programs	Study's to address safety, congestion concerns on selected state highway corridors.	Highway Capacity	$48,370	
BRTB 2011-2014 TIP	Southeast Infrastructure	Support highway access improvements in SE Baltimore. Includes a new 2 lane extension of Danville St. from Clinton St. to Haven St.	Highway Capacity	$5,500	2013
BRTB 2011-2014 TIP	New Vail Street	Extend New Vail St. 1200 feet north from current terminus at Keith Ave. Project will reduce commercial vehicle traffic on Broening Highway, Dundalk Ave., and Holabird Ave.	Highway Capacity	$4,440	2014
BRTB 2011-2014 TIP	Edmonson Avenue Bridge	New bridge will be 23 feet wider than existing bridge to accommodate a dual track light rail line. Increase number of lanes from 8 to 10. Could improve conditions for bikes and pedestrians.	Highway Capacity	$34,500	2013
BRTB 2011-2014 TIP	US 29, Columbia Pike	Widen the northbound section of US 29 from Seneca Drive to MD 175	Highway Capacity	$3,640	2014
BRTB Transportation Outlook 2035	MD 295	I-195 to MD 100: Widen from 4 to 6 lanes, full interchange at Hanover Road.	Highway Capacity	$144,000	2015

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
BRTB Transportation Outlook 2035	I-695	I-95 South to MD 122: Widen from 6 to 8 lanes.	Highway Capacity	$373,300	2015
BRTB Transportation Outlook 2035	I-695	I-83 Harrisburg to I-95 North: Widen from 6 to 8 Lanes.	Highway Capacity	$373,200	2015
BRTB Transportation Outlook 2035	Russell Street Project	I-95 to City Line: Add N/S lanes to ramp and intersection upgrades. Add a lane from Russell Street Gateway I-95 to City Line.	Highway Capacity	$20,000	2015
BRTB Transportation Outlook 2035	MD 32	MD 108 to I-70: 2 to 4 lanes, Full interchanges at Dayton Ship, Rosemary Lane, MD 144 with ramps and upgrade I-70 interchange.	Highway Capacity	$219,000	2015
BRTB Transportation Outlook 2035	I-795	Pleasant Hill Rd/Dolfield Rd: new interchange and improve ramps.	Interchange Capacity	$67,000	2013
BRTB Transportation Outlook 2035	US 1	US 1 at MD 175: new full interchange.	Interchange Capacity	$30,000	2015
HEPMPO LRTP	Halfway Blvd Ext.	Newgate Blvd to MD 63: new 4 lane divided road.	Highway Capacity	$8,911	2020
HEPMPO LRTP	Paul Smith Blvd	US 40 Alt to US 40: new 2 lane connector.	Highway Capacity	$5,025	2020
HEPMPO LRTP	Eastern Blvd	Antietam Drive to MD 60 to Northern Avenue: new 4 lane divided road.	Highway Capacity	$511,356	2020
HEPMPO LRTP	Edgewood Drive	Entire segment Inside Corporate Limits: widen to 4 lanes.	Highway Capacity	$20,093	2020
HEPMPO LRTP	Longmeadow Road	US 11 to Marsh Pike: widen to 5 lanes.	Highway Capacity	$11,186	2020
HEPMPO LRTP	Marsh Pike	MD 60 to Longmeadow Road: widen to 5 lanes with signal.	Highway Capacity	$6,895	2020
HEPMPO LRTP	Newgate Blvd	Halfway Blvd to US 40: new 2 lane road	Highway Capacity	$7,828	2020
HEPMPO LRTP	Professional Court (PH III)	Yale Drive to Varsity Lane: widen to 4 lanes	Highway Capacity	$7,946	2020

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
HEPMPO LRTP	Professional Court (PH IV)	Varsity Lane to Hagerstown Community College: new 4 lane road.	Highway Capacity	$6,835	2020
HEPMPO LRTP	Wesel Blvd.	Burhans Blvd. to existing 4 Lane Segment: widen to 4 lanes.	Highway Capacity	$4,150	2020
HEPMPO LRTP	Maugans Avenue (PH II)	I-81 to Main St in Village of Maugansville: widen to 3 lanes	Highway Capacity	$6,446	2020
HEPMPO LRTP	MD 65 - S Potomac Street	Oak Ridge Drive to Wilson Blvd: widen to 4 lanes.	Highway Capacity	$19,106	2020
HEPMPO LRTP	US 11 - Pennsylvania Avenue	Burhans Blvd to Maugans Avenue - Widen to 4 Lanes plus Auxiliary Lane	Highway Capacity	$27,636	2020
HEPMPO LRTP	Robinwood Drive	Hagerstown CC to MD 64: new 4 lane alignment north of Hagerstown Community College	Highway Capacity	$9,532	2020
HEPMPO LRTP	Professional Court Ext (PH I)	Eastern Blvd to Antietam Creek Bridge: widen to 4 lanes with bridge over Antietam Creek.	Highway Capacity	$6,655	2020
HEPMPO LRTP	Professional Court Ext (PH II)	Antietam Creek Bridge to Yale Drive: new 4 lane divided road.	Highway Capacity	$7,134	2020
MWCOG 2010 CLRP	I 70 Interchange at Meadow Road	Reconstruct the interchange to provide missing ramp movements.	Highway Capacity	$27,000	2016
MWCOG 2010 CLRP	MD 4	Widen to 6 lanes, upgrade with interchanges at Westphalia Rd. and Suitland Pkwy.	Highway Capacity	$460,680	2020
MWCOG 2010 CLRP	I-270	New interchange at Watkins Mill Rd. Ext.	Highway Capacity	$178,530	2016
S/WMPO LRTP	US Route 50 - Ocean Gateway	Vienna Bypass (MD 731A to White Lowe Road) (9.7 miles) Access Control Improvements.	Access Improvements	$64,800	2020

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
S/WMPO LRTP	US Route 50 - Ocean Gateway	Hobbs Road/Walston Switch Road (1.8 Miles)	Interchange Construction	$31,300	2020
WILMAPCO 2040 RTP	MD 272	Widen from 2 to 4 lanes, divided.	Highway Capacity	$32,861	2020
Intercity Passenger and Freight Transportation - TOTAL				**$3,084,708**	
FY 2011-16 CTP	MD 404, Shore Highway	Upgrade from Cemetery Road to east of MD 480. Bike/Ped accommodation included.	Highway Capacity w Bike/Ped	$7,511	2013
FY 2011-16 CTP	MD 124, Woodfield Road	Construct 6 lane divided highway from south of Airpark Road to north of Fieldcrest Road (1.14 miles). Bike/pedestrian accommodations where appropriate.	Highway Capacity w Bike/Ped	$9,281	2011
FY 2011-16 CTP	MD 5, Branch Avenue	Widen from 4 to 6 lanes from north of MD 373 to US 301 (1.07 miles). Bike/pedestrian accommodations where appropriate.	Highway Capacity w Bike/Ped	$7,102	2011
FY 2011-16 CTP	MD 237, Chancellors Run Road	Upgrade and widen MD 237 to a multi-lane highway from Pegg Road to MD 235 (2.80 miles). Bike/Ped accommodations.	Highway Capacity w Bike/Ped	$8,963	2011
FY 2011-16 CTP	US 113, Worcester Highway	Upgrade to a 4 lane divided highway from Goody Hill Road to Massey Branch (1.8 miles). Access control improvements, bike/pedestrian accommodations.	Highway Capacity w Bike/Ped	$12,990	2012
FY 2011-16 CTP	MD 355, Rockville Pike	Construct Interchange at Randolph Road/Montrose Parkway. Bike/pedestrian accommodations where appropriate.	Highway Capacity w Bike/Ped	$5,049	Complete
FY 2011-16 CTP	MD 97: Georgia Avenue	Interchange improvements at Randolph Road. Bike/pedestrian accommodations where appropriate.	Highway Capacity w Bike/Ped	$54,353	2016

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
FY 2011-16 CTP	MD 755	Edgewood Road streetscape	Streetscape w Bike/Ped	$3,961	2011
FY 2011-16 CTP	BRAC Intersections near Fort Meade	Intersection improvements at key locations along access routes to Ft. Meade. Bike/Ped facilities provided where appropriate.	Intersection w Bike/Ped	$44,613	2012
FY 2011-16 CTP	BRAC intersections near Bethesda Naval Center	Intersection improvements along access routes to Bethesda Naval Center. Bike/Ped facilities where appropriate.	Intersection w Bike/Ped	$33,703	2012
FY 2011-16 CTP	BRAC Intersections near Aberdeen Proving Grounds	Intersection improvements along access routes to Aberdeen Proving Grounds. Bike/Ped facilities where appropriate.	Intersection w Bike/Ped	$17,528	2012
FY 2011-16 CTP	Enhancement Projects	College Park Trolley Trail, Melrose Park Access Trail, North Gate Park	Bicycle/ Pedestrian Facility	$1,083	2011
FY 2011-16 CTP	SHA Sidewalk Program	This program will provide matching funds for the construction of sidewalks adjacent to State highways. Fifty percent of project costs will be required from local and municipal project sponsors, except in urban revitalization areas where projects are eligible for 100 percent state funding, and in priority funding areas where projects are eligible for 75 percent state funding.	Bicycle/ Pedestrian Facility	$5,700	Ongoing
FY 2011-16 CTP	Herring Run Greenway	Construct new portions of a 8 foot wide trail between Harford Road and Sinclair Lane, extended to the west to Lake Montebello and Morgan State University, extended to the east to Sinclair Lane.	Bicycle/ Pedestrian Facility	$1,980	2012
FY 2011-16 CTP	Key Highway	Key Highway; from I 95 to Lawrence Street; construct a ten foot wide bicycle pedestrian path	Bicycle/ Pedestrian Facility	$554	2011
FY 2011-16 CTP	Jones Falls Trail	Woodbury Light Rail Station to Cylburn Auditorium	Bicycle/ Pedestrian Facility	$2,000	2012
FY 2011-16 CTP	Broken Land Parkway Pathway	Cradlerock Way to Snowden River Pkwy	Bicycle/ Pedestrian Facility	$386	2011

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
FY 2011-16 CTP	Shady Grove Metro Access	Shady Grove Rd. to Redland Rd. bikepath	Bicycle/ Pedestrian Facility	$1,255	2011
FY 2011-16 CTP	Community Safety and Enhancement Program	SHA element of the Statewide Neighborhood Conservation Program	Bicycle/ Pedestrian Facility	$103,000	Ongoing
BRTB 2011-2014 TIP	Little Pipe Creek Trail & Wakefield Valley Community Trail	Macadam trail that will link two municipalities (Union Bridge and New Windsor); will connect to the Wakefield Valley Community Trail in New Windsor (which links to Westminster; which will result in a continuous 8-mile long trail)	TERM	$400	2014
BRTB 2011-2014 TIP	Areawide Recreational Trails Program	This program is intended to develop and maintain recreational trails for motorized and nonmotorized recreational trail users. It includes projects that provide for the redesign, reconstruction, non-routine maintenance, or relocation of recreational trails to benefit the natural environment.	TERM	$2,500	Ongoing
BRTB 2011-2014 TIP	Areawide Enhancement Projects	Pedestrian/bicycle facilities; acquisition of scenic easements and historic sites; scenic/historic highway programs; landscaping/beautification; historic preservation; rehabilitation/operation of historic transportation facilities, including railroad facilities and canals; preservation of abandoned railway corridors; archeological planning/research; and mitigation of water pollution due to highway runoff.	TERM	$18,500	Ongoing
BRTB 2011-2014 TIP	Areawide Environmental Projects	Non-capacity improvements which include projects dealing with noise abatement, wetlands, reforestation, landscape planting, scenic beautification and pedestrian or bicycle facilities.	TERM	$24,930	Ongoing

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
BRTB 2011-2014 TIP	Charles Street Gateway Rehabilitation	Streetscape and functional improvements on Charles Street from 25th Street to University Parkway including new sidewalks, lighting, crosswalks, ADA ramps, and aesthetic improvements.	TERM	$28,320	2013
BRTB 2011-2014 TIP	West Baltimore MARC Neighborhood Improvements	Sidewalk and street rehabilitation, pedestrian lighting, additional trees and tree pits, new crosswalks, and ADA ramps. Limits are Edmondson Ave. between Benalou and Pulaski, and Pulaski St. between Edmondson and West Saratoga.	TERM	$1,400	2012
BRTB 2011-2014 TIP	Central Avenue Reconstruction	Central Avenue is to be reconstructed between Monument and Lancaster Street. This work will include total reconstruction of the street, including new curbs, sidewalks, roadway sub-base, roadway surface, utility adjustments and other roadway appurtenances such as roadway lighting, signage and lane markings.	TERM	$39,825	2012
Cumberland Area MPO	Allegheny Highlands Trail	Baltimore Avenue in Cumberland to Woodcock Hollow Road (9.3 miles)	Bicycle/ pedestrian	$4,600	2020
MWCOG 2010 CLRP	MD 85, Buckeystown Pike	Upgrade to a four to six-lane divided highway from south of English Muffin Way to north of Grove Road (2.40 miles). Widen MD 85 to a four-lane divided highway from south of English Muffin Way to the State Highway Administration/Westview development complex, then 6 lanes through the I-270 interchange, then 4 lanes from north of Spectrum Drive to Grove Road. The interchange at I-270/MD 85 will be partially reconstructed as part of this line item. Auxiliary lanes where necessary. Bicycles accommodated.	Highway Capacity w Bike/Ped	$245,992	2020
MWCOG 2010 CLRP	MD 97, Georgia Avenue	Interchange improvements at MD 28/Norbeck Road. Bike/Pedestrian accommodations where appropriate	Highway Capacity w Bike/Ped	$139,154	2020

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
MWCOG 2010 CLRP	MD 124	Widen to 6 lanes from Midcounty Hwy to Warfield Rd	Highway Capacity w Bike/Ped	$152,433	2020
MWCOG 2010 CLRP	Century Blvd./Crystal Rock Loop	This project provides for the planning, design, and construction of the extension of Century Blvd. to Crystal Rock Drive. Bike and pedestrian accommodations included.	Highway Capacity w Bike/Ped	$7,000	2011
MWCOG 2010 CLRP	Burtonsville Access Road	MD 198 to entrance to Burtonsville Shopping Center	Highway Capacity w Bike/Ped	$7,949	2013
MWCOG 2010 CLRP	US 1, Baltimore Avenue	College Avenue to Sunnyside Avenue	Highway Capacity w Bike/Ped	$135,008	2020
MWCOG 2010 CLRP	MD 450, Annapolis Road	Widen from Whitfield Chapel Road to MD 3	Highway Capacity w Bike/Ped	$63,504	2020
MWCOG 2010 CLRP	MD 28, Rockville Town Center	MD 586/911	Highway Capacity w Bike/Ped	$5,296	2020
MWCOG 2010 CLRP	MD 118	MD 355 to M 83 Watkins Mill Rd.	Highway Capacity w Bike/Ped	$4,000	2020
MWCOG 2010 CLRP	MD 124 Woodfield Road Extended	MD 108 1200' North of Main Street (MD 108) to MD 27 Ridge Road (MD 27)	Highway Capacity w Bike/Ped	$1,040	2011
MWCOG 2010 CLRP	Dower House Road	MD 223 Woodyard Road to MD 4 Pennsylvania Avenue	Highway Capacity w Bike/Ped	$40,900	2020
MWCOG 2011-2016 TIP	Chapman Avenue Extended	Randolph Road to Old Georgetown Road	Highway Capacity w Bike/Ped	$6,217	2013
MWCOG 2011-2016 TIP	Father Hurley Blvd. Extension	From Wisteria Road to MD 118 as a four-lane divided, closed section highway with future provisions for two additional lanes. Pedestrian improvements.	Highway Capacity w Bike/Ped	$8,422	2011
MWCOG 2011-2016 TIP	Burtonsville Access Road	New roadway between MD 198 and School Access Rd. Includes sidewalks and parallel hiker/biker path.	Highway Capacity w Bike/Ped	$4,236	2013
MWCOG 2011-2016 TIP	Montrose Parkway East	4-lane divided parkway form Parklawn Drive to Veirs Mill Road. Includes bikepath and sidewalk.	Highway Capacity w Bike/Ped	$33,467	2015

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
MWCOG 2011-2016 TIP	Annual Bikeway Program	This program provides funds to design and construct bikeway and trail projects in Montgomery County.	Bicycle/ Pedestrian Facility	$1,650	Ongoing
MWCOG 2011-2016 TIP	Annual Sidewalk Program	This pedestrian access improvement program provides sidewalks and bus pads on County-owned roads and some State-maintained roadways under the Maryland State Highway retrofit sidewalk program.	Bicycle/ Pedestrian Facility	$7,178	Ongoing
MWCOG 2011-2016 TIP	Pedestrian Safety Program	This project provides for the construction of physical structures and/or installation of traffic control devices which include but are not limited to: new crosswalks; pedestrian refuge islands; bus pull-off areas; fencing to channel pedestrians to safer crossing locations; inlaid and/or overhead pedestrian signals or warning beacons; improving signage, etc.	Bicycle/ Pedestrian Facility	$8,000	Ongoing
MWCOG 2011-2016 TIP	Falls Road East Side Hiker/Biker Path	Acquire ROW and construct 4mi path	Bicycle/ Pedestrian Facility	$7,730	2015
S/WMPO LRTP	Northeast Collector Phase III	College Avenue and Beaglin Park Drive/Kelly Road and Zion Road.	Highway Capacity w Bike/Ped	$2,990	2015
S/WMPO LRTP	Pemberton Drive Widening	Parsons Road to Crooked Oak Lane (including bike path).	Highway Capacity w Bike/Ped	$3,830	2015
S/WMPO LRTP	Riverside Drive Roundabout	Intersection of Riverside Drive, Mill Street, Carroll Street, and Camden Avenue.	Highway Capacity w Bike/Ped	$6,500	2015
S/WMPO LRTP	US Route 13 - North Salisbury Boulevard/ Ocean Highway	Salisbury Bypass to Delaware State Line (4.0 miles) - Divided highway reconstruct with access control improvements.	Highway Capacity w Bike/Ped	$50,800	2015
Bike and Pedestrian - TOTAL				**$1,384,783**	

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
FY 2011-16 CTP	I-95 John F. Kennedy Memorial Highway	Express Toll Lanes (ETL) Construction: Improve the I-95 interchanges with I-895, I-695 and MD 43 and construct two Express Toll Lanes in each direction on I-95 from I-895 North to north of MD 43 (9.63 miles).	Highway Capacity	$360,101	2014
FY 2011-16 CTP	InterCounty Connector*	Construct new East-West multi-modal highway in Montgomery and Prince George's counties between I-270 and I-95/US 1.	Highway Capacity	$1,014,651	2014
BRTB Transportation Outlook 2035	Baltimore Region Rideshare Program - 2006 (Baltimore City, Carroll, Baltimore, Harford, Howard, Anne Arundel)	Provides funding support to local rideshare coordinators to strengthen ridematching and ridesharing coordination services to both commuters and employers	TERM	$4,325	Ongoing
MWCOG 2011-16 TIP	Commuter Connections Program	Commuter Operations Center, Guaranteed Ride Home, Marketing, Monitoring and Evaluation, Employer Outreach, Telecommute Project	TERM	$12,681	Ongoing
MWCOG 2011-16 TIP	Commuter Connections Program	Ridesharing - Regional element for Frederick, Montgomery and Prince Georges	TERM	$4,405	Ongoing
MWCOG 2011-16 TIP	Commuter Connections Program	Expanded guaranteed ride home to Baltimore region and St. Mary's County	TERM	$770	Ongoing
Transportation Pricing and Travel Demand Management - TOTAL				**$1,396,933**	
FY 2011-16 CTP	Transportation Emission Reduction Measures (TERMS)	Fifteen counties are in air quality non-attainment or maintenance status. This program will help address CAA requirements by implementing projects that will achieve measurable reductions in mobile source emissions.	TERM	$24,683	Ongoing
FY 2011-16 CTP	CHART	Transportation Emission Reduction Measures (TERMS)	TERM	$90,600	Ongoing
FY 2011-16 CTP	US 29	MD 410 to Wayne Avenue signals	Signal Systems	$1,104	Ongoing
FY 2011-16 CTP	MD 650	Sheridan Street to Metzerott Rd.	Signal Systems	$1,840	2011
FY 2011-16 CTP	MD 2 and MD 710	Signal reconstruction (ARRA)	Signal Systems	$1,621	Ongoing
FY 2011-16 CTP	Baltimore County	Signal reconstruction (ARRA)	Signal Systems	$1,721	Ongoing

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
FY 2011-16 CTP	Bus Procurement	Annual purchase of 40-foot hybrid buses to replace those that have been in service for 12 or more years.	Transit Construction	$202,049	Ongoing
FY 2011-16 CTP	CAD/AVL Systems	Provides radio data channel expansion to improve the bus fleet's voice and data communication. Will improve customer service by providing real time management and schedule adherence.	Transit Operations	$1,106	2011
FY 2011-16 CTP	LED Signals	Replace dynamic message signs and lane use signals with LED technology (Baltimore Harbor and Ft. McHenry Tunnel)	Signal Systems	$3,744	2011
FY 2011-16 CTP	SHA Signalization Projects	District traffic management projects, ARRA LED and traffic detection projects.	Signal Systems	$29,114	2012
BRTB 2011-2014 TIP	Variable Message Signs	Repair and replace Variable Message Signs. Variable Message Signs report traffic activities, accidents, and detours throughout the city. Providing up to date information to drivers will help manage congestion.	TERM	$1,000	Ongoing
BRTB 2011-2014 TIP	Areawide Congestion Management	The employment of variable message signs, video for traffic management (CCTV), traffic movement detectors, signal system coordination and remote timing, permanent congestion monitoring systems employed by the CHART program, deployment of local jurisdiction intelligent transportation system (ITS) projects, and the development of park and ride facilities.	TERM	$15,900	Ongoing
BRTB 2011-2014 TIP	CMAQ Areawide	The BRTB will use a competitive selection process to select $800,000 worth of Congestion Mitigation and Air Quality Improvement Program (CMAQ) projects in FY 2011. CMAQ projects reduce air pollution emissions from the transportation sector.	TERM	$1,700	Ongoing
BRTB 2011-2014 TIP	PA/LED Sign Replacement-LRT and Metro	This project will develop specifications and construct enhancements or additions of ADA compliant public address and LED sign systems for LRT and Metro.	Transit Facility	$7,391	2014

Source	Project/Facility	Description	Project Type	Updated Costs (in 000$)	Updated Year Open/ Completion
MWCOG 2011-16 TIP	Congestion Management	Congestion management program includes projects associated with the following: traffic management - new or reconstruct signals, signing and lighting; signal systemization; commuter action - engineering and construction of Park-n-Ride facilities; CHART - engineering and construction of ITS projects; and intersection capacity improvement - engineering and construction of intersection improvements.	TERM	$4,500	Ongoing
MWCOG 2011-16 TIP	Clean Air Partners	Air Quality Public Education Project	TERM	$1,000	Ongoing
MWCOG 2011-16 TIP	Fiber Optics: Advanced Transportation Management System	US 39 - Briggs Chaney Road to Howard County Line	System Management	$600	2012
Transportation Technologies - TOTAL				**$389,673**	

Funded and Committed Maryland Plans, Programs, and TERMs - TOTAL	**$13,219,093**	

Notes:

1) The BRTB Outlook 2035 estimated a total Red Line implementation cost of $1.539 billion. The 2011-2016 CTP identifies $200.7 million in planning, engineering and ROW costs for this project.

2) The MWCOG 2010 CLRP estimated a total Purple Line implementation cost of $1.716 billion. The 2011-2016 CTP identifies $237.0 million in planning, engineering and ROW costs for this project.

3) The MWCOG 2010 CLRP estimated a total Corridor Cities Transitway implementation cost of $1.193 billion. The 2011-2016 CTP identifies $36.5 million in planning, engineering and ROW costs for this project.

4) The MWCOG 2010 CLRP estimated a total Bethesda METRO South Entrance implementation cost of $60 million. The 2011-2016 CTP identifies $2.4 million in planning and engineering costs for this project.

C. TERM Analysis Assumptions, Costs, and Results

TERMs identified in the 2010-16 CTP and MPO TIP and CLRPs as well as continuation of current programs such as Commuter Connections, CHART, Metropolitan Area Transportation Operations Coordination (MATOC) are assessed to determine estimates of GHG emission reductions and costs through 2020.

The air quality benefits of a large share of these strategies have been analyzed through BMC's and MWCOG's air quality conformity process. For these strategies, reductions in VMT or fuel consumption as estimated by BMC, MWCOG, MDOT and MDE are adjusted to reflect 2020 conditions and converted to GHG emission savings. For the strategies where a prior analysis has not been completed, observed data on the benefits of these strategies in other locations or research reports were utilized to determine potential 2020 benefits.

Maryland Statewide TERMs

These TERMs span both the MWCOG and BMC metropolitan regions and are operated through multiple partnerships between the MPOs and State agencies including SHA and MTA. The annual emission reduction benefits of these programs are tracked by MDOT through the Annual Attainment Report. Table C.1 lists these TERMs and details the assumption required to translate 2008 and 2009 observed benefits in terms of reduced fuel consumption or VMT to 2020 GHG emission reductions.

Table C.1 Maryland Statewide TERMs

TERM Description	Assumptions
CHART	Multiply vehicle hours of delay by MOVES idle emission factor
Signal Systemization Total	Multiply vehicle hours of delay by MOVES idle emission factor
Metropolitan Area Transportation Operations Coordination (MATOC)*	Multiply fuel savings by carbon content of fuel. Assume carbon content of fuel at 0.0088 tons/gallon (EPA)
Guaranteed Ride Home	Apply 1.4 % annual VMT growth rate to 2011 Attainment Report[1] VMT reduction. Assume 2 minutes idling per trip.

[1] MDOT 2011 Annual Attainment Report on Transportation System Performance, 2011.

TERM Description	Assumptions
Employer Outreach (inc. for bicycles)	Apply 1.4 % annual VMT growth rate to 2011 Attainment Report VMT reduction. Assume 2 minutes idling per trip.
Integrated Rideshare	Apply 1.4 % annual VMT growth rate to 2011 Attainment Report VMT reduction. Assume 2 minutes idling per trip.
Commuter Operations and Ridesharing Center	Apply 1.4 % annual VMT growth rate to 2011 Attainment Report VMT reduction. Assume 2 minutes idling per trip.
Telework Resource Center	Apply 1.4 % annual VMT growth rate to 2011 Attainment Report VMT reduction. Assume 2 minutes idling per trip.
Mass Marketing	Apply 1.4 % annual VMT growth rate to 2011 Attainment Report VMT reduction. Assume 2 minutes idling per trip.
MTA College Pass	Apply 1.4 % annual VMT growth rate to 2011 Attainment Report VMT reduction. Assume 2 minutes idling per trip.
MTA Commuter Choice Maryland Pass	Apply 1.4 % annual VMT growth rate to 2011 Attainment Report VMT reduction. Assume 2 minutes idling per trip.
Transit Store in Baltimore	Apply 1.4 % annual VMT growth rate to 2011 Attainment Report VMT reduction. Assume 2 minutes idling per trip.

Baltimore Regional Transportation Board

In order to determine the emission reductions associated with the Transportation Emission Reduction Measures (TERMs) for the Baltimore Region, VMT and fuel consumption data, obtained from the Baltimore Regional Transportation Board (BRTB) TIPs, LRPs, and conformity documentation, were used to determine a reduction in GHG emissions in 2020. VMT and fuel consumption data were projected to 2020 utilizing local data obtained from the documentation and the MAQONE 5.1 Model, including: VMT growth rates; cooperative forecasts; and average trip lengths, speeds, and vehicle occupancy rates. Emission factors were generated using MOVES 2010a. Where VMT or fuel consumption data were not readily available, project-specific data, obtained from the documentation, was used as an input to conduct independent, off-network analyses. These analyses utilized proven methodologies including recent research and off-network tools, such as MAQONE 5.1 or the COMMUTER Model, in order to calculate a 2020 VMT or fuel consumption reduction. Emission factors were then applied to determine an emissions benefit. Table C.1 outlines the assumptions utilized in the independent, off-network analysis of the BRTB TERM projects.

Table C.2 BRTB TERM Analysis Assumptions

Project Type	Description	Assumptions
Clean Technology	Hybrid Bus Replacements	Avg. annual revenue mileage = 30,472.85 (MAQONE5.1) Percent deadhead = 15% Avg. fuel economy of standard diesel = 3.860 mpg[1] Avg. fuel economy of hybrid = 4.580 mpg[1] Carbon content of diesel = 10.5 kg/gal
Commute Alternatives Incentive	Provide matching grant money to employees moving near their work	Participants = 1,260 Avg. work-trip length = 7.69 mi. 250 commute days Avg. trips/day = 1.8
Commute Alternatives Incentive	Johns Hopkins University FlexCar – car-sharing service to JHU students and people in the surrounding neighborhoods	Annual Flexcar fleet growth rate = 12.5% (based on 2007-2009 observed data) 31 cars available in 2020 Car ownership reduced per Flexcar = 15[2] Average annual VMT reduced/ownership reduced = 4,227[3]
Commute Alternatives Incentive	Park & Ride Lots	Avg. trip lengths based on county defaults from MAQONE 5.1. 250 days / year Statewide annual VMT growth = 1.35% 31 mph light-duty emission factors from MOVES
Outreach/ Education	Clean Air Partners – Ozone Action Days	2020 employment forecast from BMC 2035 LRP MAQONE 5.1. defaults used for average auto trip lengths by jurisdiction 3% of drivers participate (based on Sacramento, CA survey data) Average trips reduced = 1.04 / Ozone Action Day Number of ozone action days = 20 based on Clean Air Partners FY2008 Annual Report
Bicycle & Pedestrian	All trail, sidewalk, and bike/ped improvements	VMT estimated by BRTB Avg. trip length = 2.5 mile 250 days/year 31 mph light-duty emission factor Statewide annual VMT growth = 1.35%
Public Transit Improvement	Purchase and use 50 bi-level coaches	2020 employment forecast from BMC 2035 LRP MAQONE 5.1. defaults used for average auto trip lengths by jurisdiction Avg. ridership increase / coach/day = 200 260 operating days/year
Public Transit Improvement	Hampden neighborhood shuttle	Ridership / day = 250 (Based on 2010-2013 Conformity) Avg. trip length = 2 miles 260 operating days/year
Public Transit Improvement	Provide free service to state employees for MTA bus, light rail, some commuter buses, and Metro subway systems.	Off-network analysis tool – Commuter Model: Financial Incentives 100% employer participation rate State workers in 2020 = 70,527[4] Potential market = 28% of total state worker employment

Project Type	Description	Assumptions
Traffic Control	Traditional traffic signal heads are replaced with LED signal heads.	39,000 signals in Baltimore City Traditional signal power consumption = 150 (W) LED power savings = 90%

[1] Based on FTA Report: Transit Bus Lifecycle Cost: http://www.fta.dot.gov/documents/WVU_FTA_LCC_Final_Report_07-23-2007.pdf

[2] Based on white paper: *Go To 2040 Regional Comprehensive Plan Strategy Analysis: CARSHARING*, Chicago Metropolitan Agency for Planning.

[3] Based on forecast of average miles traveled per vehicle data available on the Research and Innovative Technology Administration's Bureau of Transportation Statistics website: http://www.bts.gov/publications/national_transportation_statistics/html/table_04_11.html

[4] Forecast from *Employment and Payrolls First Quarter 2008*, Maryland Department of Labor Licensing and Regulation to 2020 based on Cooperative Forecasts in the BRTB's Conformity Determination of Transportation Outlook 2035 and the 2010-2013 Transportation Improvement Program.

Maryland Aviation Administration

The *BWI, Thurgood Marshall Airport Greenhouse Gas Baseline Emissions Inventory* document, dated March 2008 was utilized in order to identify the key on-going GHG emission reduction activities conducted by MAA. The emission reduction strategies were categorized into four groups: aircraft, surface transportation; ground service equipment (GSE) / auxiliary power units (APUs), and electrical usage.

The 2006 CO_2 baseline contained in the 2008 emissions inventory document was utilized in combination with the FAA's Terminal Area Forecast, issued in December 2008, in order to determine forecast 2020 CO_2 emissions. This 2020 forecast was used as a benchmark from which to measure emissions reductions from the airport strategies. The following assumptions, organized by strategy group, were employed to calculate emissions benefits.

Aircraft emission reductions

- Based on the 2020 forecast, annual 2020 CO_2 emissions from aircraft in 2020 are equal to 142,766 metric tons (MT) per year.
- Taxi/idle/delay accounts for 4 percent of total CO2 emissions from aircraft operations, based on methodology from the *Port of Seattle Seattle-Tacoma International Airport Greenhouse Gas Emissions Inventory - 2006* (October, 2007).
- All measures result in 10 percent reduction in air taxi or aircraft turnaround idling/delay

Surface Transportation

Alternative Fuels - MAA Vehicles

- Based on the 2020 forecast, annual 2020 CO_2 emissions from surface transportation are equal to 84,367 mt/yr.
- 28 percent of MAA vehicles use alternative fuels

- MAA vehicles accounts for 12 percent of total CO_2 emissions from surface transportation, based on methodology from the *Port of Seattle Seattle-Tacoma International Airport Greenhouse Gas Emissions Inventory - 2006* (October, 2007).
- 70 percent of MAA vehicles using alternative fuels are gasoline-powered, and 30 percent are diesel-powered.
- 30 CNG shuttle buses in use in place of traditional diesel buses, resulting in 20 percent reduction in emissions.
- Gasoline vehicles will use E85, resulting in a 15 percent CO_2 emissions reduction, based on *Alternative Fuels: E85 and Flex Fuel Vehicles. EPA420-F-06-047* (October, 2006).
- Emission benefits from diesel vehicles utilizing B20, were not quantified in this report. MAA reported experiencing several problems with the implementation of biodiesel due to the fact that much of the fleet utilizing B20 can sit idle for extended periods of time during which the biodiesel became fouled.

Buses & Vans Congestion Reduction

- Buses & vans account for 1 percent of total CO_2 emissions from surface transportation, based on methodology from the *Port of Seattle Seattle-Tacoma International Airport Greenhouse Gas Emissions Inventory - 2006* (October, 2007).
- 5 percent of CO2 emissions reductions are attributable to reduced congestion

Vehicle Idling/Delay/VMT Reduction at Parking

- CO_2 emissions associated with vehicle parking account for 10 percent of total CO_2 emissions from surface transportation.
- A 30 percent reduction in parking time can be attributed to parking management measures, such as use of automated navigational signs or an increase in parking capacity, based on methodology from *Evaluating ITS Parking management Strategies: A Systems Approach* (May, 2000).

Ground Service Equipment (GSE) / Auxiliary Power Units (APUs)

All strategies under this group will result in a 10 percent reduction of GSE/APU usage.

Electrical Usage

Total electrical consumption is reduced by 20 percent, including: a state initiative to reduce electrical consumption by 15 percent from 2007, by 2015, and purchasing 5 percent of electricity from renewable energy sources.

Maryland Port Administration

The Port of Baltimore was recently awarded $3.5 million in Recovery Act funding to help clean the air in and around the Port. The funds will be used primarily for clean diesel technologies, but it is anticipated that anti-idling devices, vehicle replacements, and engine repowers will result in GHG emissions reductions.

MPA provided data regarding the current and replacement equipment including type, average age of current engines and replacement engines, average use and remaining life. CO_2 emission factors were calculated for each operating piece of equipment based on EPA's, NONROAD technical guidance document, EPA420-P-04-009, dated April 2004. It was estimated that the replacement equipment (vehicles and engines) would result in a 5percent improvement in fuel efficiency. The following set of equipment assumptions was utilized in order to quantify GHG emission reductions associated with the anticipated use of the Recovery Act funding:

- 15 truck engines (average model year 1990, average HP 150) will be replaced with MY 2004 engines.
- 10 truck engines (average model year 1992, average HP 150) will be replaced with MY 2004 engines.
- 5 truck engines (average model year 1996, average HP 150) will be replaced with MY 2007 engines.
- 65 truck engines (average model year 1996, average HP 150) will be replaced with MY 2007 engines, which will include auto engine start stop (AESS) technology preventing idling for longer than 10 minutes.
- 7 locomotives will be equipped with auto engine start stop (AESS) technology.
- 7 Forklifts, MY 1991-1997 will be repowered / replaced.
- Replace 1 MY 2000 rough terrain forklift
- Replace 1 MY 2000 crawler tractor
- Replace 5 MY 1994 and 3 MY 2001 terminal tractors
- Repower 3 MY 1992 terminal tractors

Metropolitan Washington Council of Governments

In order to determine the emission reductions associated with the TERMs for the Washington DC Region, project-specific data, obtained from TIPs, LRPs, and conformity documentation, was used to determine a reduction in VMT or fuel consumption.

Table C.2 presents the assumptions required to translate 2008 and 2009 reductions as estimated by MWCOG for the entire Washington DC region, into Maryland specific impacts, annually in 2020.

Table C.3 MWCOG TERM Analysis Assumptions

Project Type	Description	Source	Assumptions / Methodology (1) (2)
Clean Technology	Bose Automobile Anti-Air Pollutant and Energy Conservation System	1	Use running emissions factor for transit bus Avg. bus speed: 15 mph Assume fuel economy increases 15%, 500 buses Avg. bus mileage: 140 mi/day-bus Annual operation days: 312
Clean Technology	Truck Idling (Truck Stops and Auxiliary Power Unit)	1	Use idle emissions factor for HDT 500 engines, Avg. truck idle: 8 hrs/day Annual operation days: 312
Clean Technology	100 CNG Buses in place of old Diesel Buses (2010)	1	Avg. bus VMT: 40,000 miles/yr, Avg. bus speed: 15 mph CNG bus consumes 9% less fuel compared to old diesel bus
Clean Technology	100 Hybrid Buses in place of old Diesel Buses (2010)	1	Avg. bus VMT = 40k miles per year, avg speed = 15mph, hybrid bus consumes 36% less fuel compared to diesel, Hybrid and Alternative Fueled Vehicles: (http://www.kingcounty.gov/operations/procurement/Services/Environmental_Purchasing.aspx)
Commute Alternatives/ Incentives	Glenmont METRO Parking Garage Expansion	1	Use statewide avg. EF for LDV Avg. trip length: 15.5 miles Cold start idle time: 2 mins/start, 300 days/yr
Clean Technology	Purchase 185 Buses to Accommodate Ridership Growth	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Commute Alternatives/ Incentives	Employer Outreach for Public Sector Agencies	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Commute Alternatives/ Incentives	Expanded Employer Outreach for Private Sector Employers	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Commute Alternatives/ Incentives	Expansion of Car Sharing Program	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Public Transit Improvement	Improve Pedestrian Facilities Near Rail Stations	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Commute Alternatives/ Incentives	Implement 10 Neighborhood Circulator Bus Service to Metrorail	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Commute Alternatives/ Incentives	Transit Stores in Maryland	2	Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).

Project Type	Description	Source	Assumptions / Methodology (1) (2)
Commute Alternatives/ Incentives	6 Kiosks in Maryland	2	Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Public Transit Improvement	Park-and-ride lots (Germantown Transit Center, MD 210/MD 733, Southern Maryland, Frederick County, US 340, I 70/MD 355, I 270/MD 80	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Commute Alternatives/ Incentives	MD/DC Vanpool Incentive Program	1	Use statewide avg. EF for LDV Avg. trip length: 15.5 miles Cold start idle time: 2 mins/start 300 days/yr
Commute Alternatives/ Incentives	Voluntary Employer Parking Cash-Out Subsidy	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Public Transit Improvement	Bus Information Displays with Maps at Bus Stops	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Public Transit Improvement	Construction of 1000 Additional Parking at WMATA Metrorail Stations	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Public Transit Improvement	Enhance Commuter Services on Major Corridors in Maryland	2	Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Public Transit Improvement	Enhanced Commuter Services on Major Corridors in (Reverse Commute)	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Public Transit Improvement	Free Bus Service Off-Peak (10:00 AM –2:00 PM Mid-Day and Weekends)	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Public Transit Improvement	Free Bus-to-Rail/Rail-to Bus Transfer (Similar to NYC Pricing Structure)	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Public Transit Improvement	Parking Impact Fees	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).
Public Transit Improvement	Real Time Bus Schedule Information	2	Apply 49 percent MWCOG region VMT in Maryland (per travel demand model, 2000 model calibration report). Apply updated MOVES derived 2020 g CO2e/mile (344 g/mi) compared to TPB emissions factor (358.78 g/mi).

Notes: (1) Unless noted otherwise, to obtain 2020 estimate, annual VMT growth rate (1.4 percent) is applied to 2008/2010 MWCOG TERM estimates.

(2) Annualization factor for commute alternatives/incentives and transit TERMs is 250 days.

Sources:(1) Analysis Of Potential Transportation Emissions Reductions Measures (TERMs) Under Consideration For The Conformity Of The 2009 CLRP & FY 2010-2015 TIP, Transportation Planning Board, June 2009.

(2) GHG emission reductions in 2020 calculated by MWCOG. Refer to: Preliminary Analysis of Potential Transportation-Related GHG Reduction Strategies for the Washington D.C. Region, Transportation Planning Board, May 2010.

Table C.4 presents the complete 2020 TERM listing with source, description, and estimated GHG reduction.

Table C.4 Transportation Emission Reduction Measures (TERMs) Project Listing

Project Type	Agency	Source	Project	Description	2020 GHG Reduction (mmt CO2e)
Clean Technology	Office of the Secretary	BRTB Outlook 2035 & TIP Conformity Report	IdleAire Advanced Truckstop Electrification System	This project involves the installation of up to 190 Advanced Truckstop Electrification (ATE) units at truck stops in Jessup and Baltimore City. The ATE units provide individual electric service to trucks utilizing parking spaces.	**0.0031**
Commute Alternatives Incentive	ARTMA/ Annapolis Transit	BRTB Outlook 2035 & TIP Conformity Report	Fare-less Cab	When a company participates in Fare-less Cab, an employee who participates in the program can get a free cab ride home in the event of illness (personal or family) or unscheduled overtime. Clean Commute Annapolis will invoice the participating company.	**0.0000**
Commute Alternatives Incentive	Baltimore City	BRTB Outlook 2035 & TIP Conformity Report	Live Near Your Work	Provide matching grant money to employees moving near their work.	**0.0021**
Commute Alternatives Incentive	Howard County	BRTB Outlook 2035 & TIP Conformity Report	Park & Ride at MD 32/MD 108	Funds for land acquisition for Park & Ride MD 32/MD 108 is included in this project. New roadway construction in Howard County - Sharing Costs with SHA.	**0.0002**
Commute Alternatives Incentive	JHU Sustainability Initiative	BRTB Outlook 2035 & TIP Conformity Report	Car Sharing Program - JHU Sustainability Initiative	Johns Hopkins University Sustainability Initiative has partnered with FlexCar to offer car-sharing service to JHU students and people in the surrounding neighborhoods. Car-sharing is a service in which members can get online and rent a car by the hour.	**0.0008**
Commute Alternatives Incentive	MDOT	BRTB Outlook 2035 & TIP Conformity Report	I-95 at MD 543 Park-n-ride lot	128 new spaces	**0.0001**
Commute Alternatives Incentive	MDOT	BRTB Outlook 2035 & TIP Conformity Report	US 1 at MD 23 Park-n-Ride Lot	60 new spaces	**0.0000**
Commute Alternatives Incentive	MDOT	BRTB Outlook 2035 & TIP Conformity Report	MARC BWI Rail Station Parking Garage	1790 Spaces	**0.0024**

Project Type	Agency	Source	Project	Description	2020 GHG Reduction (mmt CO2e)
Commute Alternatives Incentive	MDOT	BRTB Outlook 2035 & TIP Conformity Report	MARC Halethorpe Station Parking Expansion	Expand surface parking and investigate future parking at the Halethorpe MARC Station. Parking spaces will be added. The scope of the proposed work also includes high level platforms, new shelters, improved accessibility for persons with disabilities, lighting improvements.	**0.0001**
Commute Alternatives Incentive	MDOT	BRTB Outlook 2035 & TIP Conformity Report	MARC Odenton Parking Expansion	A 700-space parking lot, and a facility study for structured parking (garage or parking deck)	**0.0002**
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Gwynns Falls Trail - Phase II and III	5.5 miles. Develop a linear park and recreational trail along the Gwynns Falls, linking Leakin Park to Middle Branch Park. Phase 3 will link Carroll and Middle Branch Parks to the Inner Harbor.	**0.0002**
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Star Spangled Heritage Trail - Phase II	Complete design and Installation of Phase II of the Star Spangled Heritage Trail, a system of interpretive kiosk signs, site signs, and sidewalk markers, integrated with the Downtown Pedestrian Wayfinding System, from monument Square to Penn Station.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Druid Hill Park: Jones Falls Greenway Extension	The pedestrian/bicycle path system in Druid Hill Park will be renovated to extend the Jones Falls Greenway through Druid Hill Park. The project is also to include resurfacing existing walks and making new connections for safe crossings at park roads.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Govans Area Streetscape Improvements	Install brick sidewalks along the fronts of the businesses on Dock Street from Randall Street to Susan Campbell Park and installation of landscaped island between Randall and Craig Street.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Abington Road/Route 924/Box Hill S. Pkwy (Phase I)	Abington Rd. between existing MD Rte. 924 and Box Hill South Pkwy. to be improved to adequately handle existing and projected traffic loads. 4,400 LF of closed section road is to be built. Sidewalks will also be constructed to improve pedestrian access from the communities of Box Hill to commercial sites along MD Rte. 924	

Project Type	Agency	Source	Project	Description	2020 GHG Reduction (mmt CO2e)
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Howard County Pathway System	A project to develop a 30-mile spinal pathway system linking Alpha Ridge Park, David Force Park, Centennial Park, Lake Elkhom, King's Contrivance, and follow Little Patexent River to Savage Park.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Columbia - 100 Parkway Area Sidewalks	Construction of approximately 4000 ft. of pedestrian sidewalks to connect residential communities along Columbia 100 Parkway to restaurant/shopping areas and Howard High School.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Broken Land Parkway Sidewalks	A project for the design and construction of a sidewalk along the east side of Brokenland Parkway between the two intersections with Cradlerock Way.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Hunt Club Sidewalk	Construction of approximately 4000 LF of sidewalk along Hunt Club Rd. from US 1 to Bauman Dr.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Snowden River Parkway Sidewalks	Construction of approximately 4000 ft. of sidewalks from Dobbin Road to Tamar Drive.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Broadneck Peninsula Trail - Phase II	This is part of a larger project to develop a multi-use trail to connect Bay Bridge and Sandy Point State Park with B&A Trail. Phase II goes from Bay Dale to Green Holly.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	South Shore Trail - Phase II	This is a portion of a larger trail project which involves acquiring property, design and construction of a trail between Annapolis and Odenton on WB&A.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Herring Run Greenway - Phase II and III	Phase II (Morgan State to Northern Parkway) and Phase III (Sinclair Lane to Armistead Gardens) of the Herring Run Greenway. The Herring Run Greenway Trail will add to the recreational and commuting opportunities for citizens of Baltimore City and the region.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Jones Falls Trail - Phase II	Creation of bike/ped trail from the Penn Station area south to the Maryland Science Center at the Inner Harbor.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Taylor Avenue Bike/Ped Facilities	Build a new bike/ped trail along Taylor Avenue	

Project Type	Agency	Source	Project	Description	2020 GHG Reduction (mmt CO2e)
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Long Gate Sidewalk	The project is for the reconstruction of approximately 1500 LF Concrete curb storm drain inlets and sidewalk along Long Gate Parkway, including the bridge over MD 100.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Ilchester Road Walkways	A project for the construction of a sidewalk in Ilchester Rd. from Crestwood Ln. to Wharf Ln.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Robert Fulton Sidewalks	A project to construct approximately 4000 LF of sidewalk along Robert Fulton Drive from Solar Walk Way to Columbia Gateway Drive.	
Bicycle and Pedestrian	MDOT	BRTB Outlook 2035 & TIP Conformity Report	St. John's Lane Sidewalk	Project to construct sidewalk and pathway improvements along St. Johns Lane to link Mt. Hebron High School to US 40.	
Public Transit Amenities Improvement		BRTB Outlook 2035 & TIP Conformity Report	Public Transit Amenities Improvement Total - shelters, sidewalks, lightning and signage		**0.0013**
Public Transit Improvement	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Charles Street Improvements	Construct sidewalk	**0.0001**
Public Transit Improvement	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Local Bus Replacement	Purchase 4 new vehicles	**0.0001**
Public Transit Improvement	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Bus Replacements	Purchase 100 buses in Contract Year - 1	**0.0016**
Public Transit Improvement	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Bus Replacements	Purchase 125 buses in Contract Year - 2	**0.0020**
Public Transit Improvement	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Bus Replacements	Purchase 107 buses in Contract Year 3: 94 - 40 ft. Low-floor diesel buses; 3 - 30 ft. Low-floor diesel buses; 10 - 40ft. Hybrid Electric Buses	**0.0017**
Public Transit Improvement	MDOT	BRTB Outlook 2035 & TIP Conformity Report	MARC New Bi-level Coach Purchase	Purchase and use 50 bi-level coaches	**0.0146**
Public Transit Improvement	MDOT	BRTB Outlook 2035 & TIP Conformity Report	Hampden Shuttle	Neighborhood shuttle in Hampden, including connection to Woodberry Light Rail Station (Bus Route #98) and MTA bus routes #22 and #27	**0.0001**

Project Type	Agency	Source	Project	Description	2020 GHG Reduction (mmt CO2e)
Public Transit Improvement	MDOT	BRTB Outlook 2035 & TIP Conformity Report	State Worker Free Transit Program	Provide free service to state employees for MTA bus, light rail, some commuter buses, and Metro subway systems.	**0.0053**
Traffic Control	Baltimore City	BRTB Outlook 2035 & TIP Conformity Report	Traffic Signal LED Upgrades	Traditional traffic signal heads are to be replaced with LED signal heads.	**0.0260**
Commute Alternatives Incentive		MWCOG TERMs Analysis, 2009 CLRP	Employer Outreach for Public Sector Agencies	Marketing and implementing employer based TDM programs	**0.0079**
Commute Alternatives Incentive		MWCOG TERMs Analysis, 2009 CLRP	Expanded Employer Outreach for Private Sector Employers	Marketing and implementing employer based TDM programs	**0.0010**
Commute Alternatives Incentive	WMATA	MWCOG TERMs Analysis, 2009 CLRP	Expansion of Car Sharing Program	Funds incentives for1000 new car sharing customers. Car sharing customers typically increase their transit ridership and decrease driving. Started sponsorship in 2005.	**0.0002**
Public Transit Improvement		MWCOG TERMs Analysis, 2009 CLRP	Improve Pedestrian Facilities Near Rail Stations	Assumes improvements to sidewalks curb ramps, crosswalks, and lighting in order to improve pedestrian access to 11 MARC stations and 12 Metrorail stations in Montgomery County.	**0.0010**
Public Transit Improvement		MWCOG TERMs Analysis, 2009 CLRP	Construction of 1000 Additional Parking at WMATA Metrorail Stations	A total of 1000 parking spaces will be added at different Metrorail Stations	**0.0010**
Clean Technology	WMATA	MWCOG TERMs Analysis, 2009 CLRP	Purchase of 185 Buses to Accommodate Ridership Growth	WMATA will purchase 185 new CNG buses in the District of Columbia and deploy them on 36 crowded routes resulting in increased frequency. (assume 1/4 of benefit to Maryland)	**0.0136**
Commute Alternatives Incentive		MWCOG TERMs Analysis, 2009 CLRP	Implement Neighborhood Circulator Buses	The circulator bus service would operate over an expanded period from 5:30 am to 10:00 am and from 3:00 pm to 8:00 pm on weekdays. (assume half of benefit in Maryland)	**0.0022**
Commute Alternatives Incentive		MWCOG TERMs Analysis, 2009 CLRP	Voluntary Employer Parking Cash-Out Subsidy	A program that gives equal compensation "cash-out" to employees who choose not to use free parking provided by employers and use alternative modes of travel instead.	**0.0120**

Project Type	Agency	Source	Project	Description	2020 GHG Reduction (mmt CO2e)
Commute Alternatives Incentive		MWCOG TERMs Analysis, 2009 CLRP	Transit Stores in Maryland	Establish 10 transit stores in MD.	**0.0062**
Commute Alternatives Incentive		MWCOG TERMs Analysis, 2009 CLRP	6 Kiosks in Maryland	Establish 6 Transportation Information Kiosks in Maryland similar to those being placed in Virginia and DC	**0.0000**
Commute Alternatives Incentive		MWCOG TERMs Analysis, 2009 CLRP	Parking Impact Fees	This measure would consist of a parking impact fee administered by local governments throughout the region. The fees would allow governments to recoup some of the costs associated with maintaining the roadway infrastructure and mitigating the adverse effects on traffic.	**0.0877**
Public Transit Improvement	WMATA	MWCOG TERMs Analysis, 2009 CLRP	Bus Information Displays with Maps at Bus Stops	Provide more information at 2,000 Metrobus locations (assume 1/3 of benefit in Maryland).	**0.0016**
Public Transit Improvement		MWCOG TERMs Analysis, 2009 CLRP	Real Time Bus Schedule Information	Provide real time bus schedule information to the transit riders through internet and at bus shelter display units. Satellite technology would track buses and customers would determine real-time location and arrival time of a specific bus.	**0.0009**
Public Transit Improvement		MWCOG TERMs Analysis, 2009 CLRP	Free Bus-to-Rail/Rail-to-Bus Transfer (Similar to NYC Pricing Structure)	This program would institute a free bus to rail transfer similar to the reduced fare rail to bus transfer.	**0.0037**
Public Transit Improvement		MWCOG TERMs Analysis, 2009 CLRP	Free Bus Service Off-Peak (10:00 AM - 2:00 PM Mid-Day and Weekends)	Free bus service (10:00AM-2:00PM mi-day, weekends): Free service during the mid day and all day on weekends.	**0.0031**
Public Transit Improvement		MWCOG TERMs Analysis, 2009 CLRP	Enhanced Commuter Services on Major Corridors in Maryland (HOV Facilities)	Bus service on corridors with HOV facilities and bus lanes such as US 50, I-270, and US 29. Commuters would be picked up at Metrorail Park & Ride facilities close to Metro stations and transported to major work centers	**0.0049**
Public Transit Improvement		MWCOG TERMs Analysis, 2009 CLRP	Enhanced Commuter Services on Major Corridors (Reverse Commute)	Proposes bus service to Potomac Mills and Arundel Mills shopping centers from Metrorail stations. The service would benefit reverse commuters whose work place is in Prince William and Anne Arundel Counties.	**0.0014**

Project Type	Agency	Source	Project	Description	2020 GHG Reduction (mmt CO2e)
Public Transit Improvement		MWCOG TERMs Analysis, 2009 CLRP	Metrorail Feeder Bus Service	Improve Metrorail feeder bus service at two underutilized park and ride lots and implement a fare buydown program.	**0.0003**
Clean Technology		MWCOG TERMs Analysis, 2009 CLRP	Bose Automobile Anti-Air Pollutant and Energy Conservation System	The Bose Automobile Anti- Air Pollutant and Energy Conservation System is a mechanical, gas turbine operated system with no platinum catalysts involved as in catalytic converter systems. This system can be used with all types of fuel. It is expected to	**0.0057**
Clean Technology		MWCOG TERMs Analysis, 2009 CLRP	Truck Idling (Truck Stops and Auxiliary Power Units)	This is a voluntary program designed to install pollution-reduction technology on existing diesel vehicles and equipment. Under this program it is proposed to use a small diesel auxiliary power unit (APU), which will be mounted on the truck chassis to pr	**0.0109**
Clean Technology		MWCOG TERMs Analysis, 2009 CLRP	100 CNG Buses in place of Old Diesel Buses	The 100 oldest remaining buses in the fleet will be replaced in 2010 with CNG buses.	**0.0006**
Clean Technology		MWCOG TERMs Analysis, 2009 CLRP	100 Hybrid Buses in place of Old Diesel Buses	The 100 old diesel buses in the fleet will be replaced in 2010 with Hybrid Buses	**0.0010**
Commute Alternatives Incentive		MWCOG TERMs Analysis, 2009 CLRP	MD/DC Vanpool Incentive Program	This measure is a package of programs and incentives designed to increase the number of vanpools in the region. Expansion of existing Virginia program.	**0.0037**
Public Transit Improvement	WMATA		Glenmont Metro Parking Garage Expansion	Provides for the design and construction of 1200 additional garaged parking spaces at the Glenmont Metrorail Station on the west side of Georgia Ave. The project will be designed and constructed by WMAA.	**0.0033**
Clean Technology	MDOT	MWCOG 2010 CLRP CDR	Fleet Replacement	MDOT auto fleet, gas to hybrid, 250 vehicles	**0.0014**
Bike and pedestrian	Montgomery County	MWCOG 2010 CLRP CDR	Bicycle Facilities	Ongoing	**0.0000**
Bike and pedestrian	Region	MWCOG 2010 CLRP CDR	Bicycle Parking	Ongoing	**0.0000**
Bike and pedestrian	MDOT	MWCOG 2010 CLRP CDR	Bike Facilities at Park and Ride Lots	Ongoing	**0.0001**

Project Type	Agency	Source	Project	Description	2020 GHG Reduction (mmt CO2e)
Bike and pedestrian	MDOT	MWCOG 2010 CLRP CDR	Sidewalks at/near rail stations	Ongoing	**0.0000**
Bike and pedestrian	MDOT	MWCOG 2010 CLRP CDR	Neighborhood Conservation Program	Ongoing	**0.0001**
Public Transit Improvement	Montgomery County	MWCOG 2010 CLRP CDR	Germantown Transit Center	Completed 2005	**0.0007**
Public Transit Improvement	MDOT	MWCOG 2010 CLRP CDR	Park and ride lot - MD 210/MD 373	Completed 2003	
Public Transit Improvement	MDOT	MWCOG 2010 CLRP CDR	Various Park and Ride lots (including Southern Maryland)	Completed 2001, 2003, 2005	
Public Transit Improvement	MDOT	MWCOG 2010 CLRP CDR	New surface parking at transit centers	Ongoing	
Public Transit Improvement	MDOT	MWCOG 2010 CLRP CDR	Frederick County park and ride lots	2 new/expanded lots, completed 2005, 2008	
Public Transit Improvement	MDOT	MWCOG 2010 CLRP CDR	Park and ride lot - US 340/Mt. Zion Road	Opened 2008, expanded 2011	
Public Transit Improvement	MDOT	MWCOG 2010 CLRP CDR	Park and ride lot - I 70/MD 355	Completed 2010	
Public Transit Improvement	MDOT	MWCOG 2010 CLRP CDR	Park and ride lot - I 270/MD 80	Completed 2009	
Public Transit Improvement	MDOT	MWCOG 2010 CLRP CDR	Grosvenor Metro Station Parking	2004	**0.0035**
Public Transit Improvement	MDOT	MWCOG 2010 CLRP CDR	Bethesda Shuttle Bus Services	2004	**0.0000**
Public Transit Improvement	MDOT	MWCOG 2010 CLRP CDR	Bike Racks on Ride-On Buses	2004	**0.0000**

Project Type	Agency	Source	Project	Description	2020 GHG Reduction (mmt CO2e)
Outreach/ Education	SHA	BRTB Outlook 2035 CDR, MWCOG 2009 CLRP	Clean Air Partners	A public/private consortium that carries out a public education campaign in the Baltimore and Washington D.C. regions, to encourage individuals to take actions to reduce air emissions and protect their health from air pollution.	**0.0065**
ITS	SHA	MDOT 2011 AR	CHART	Statewide CHART program	**0.1639**
ITS	SHA	MDOT 2011 AR	Signal Systemization Total	Statewide signal system optimization	**0.0045**
ITS	SHA	2009 MDOT CAP Implementation Status Report	Metropolitan Area Transportation Operations Coordination (MATOC)*	The MATOC program coordinates and supports regional sharing of transportation systems' conditions and info management during regional incidents.	**0.0665**
Commute Alternatives Incentive	MDOT	MDOT 2011 AR	Guaranteed Ride Home	Statewide (includes all Commuter Connection program benefits)	**0.0236**
Commute Alternatives Incentive	MDOT	MDOT 2011 AR	Employer Outreach (inc. for bicycles)	Statewide (includes all Commuter Connection program benefits)	**0.1007**
Commute Alternatives Incentive	MDOT	MDOT 2011 AR	Integrated Rideshare	Statewide (includes all Commuter Connection program benefits)	**0.0207**
Commute Alternatives Incentive	MDOT	MDOT 2011 AR	Commuter Operations and Ridesharing Center	Statewide (includes all Commuter Connection program benefits)	**0.0597**
Commute Alternatives Incentive	MDOT	MDOT 2011 AR	Telework Resource Center	Statewide (includes all Commuter Connection program benefits)	**0.0429**
Commute Alternatives Incentive	MDOT	MDOT 2011 AR	Mass Marketing	Statewide (includes all Commuter Connection program benefits)	**0.0072**
Public Transit Improvement	MTA	MDOT 2011 AR	MTA College Pass	Discounted monthly transit passes to university/college students.	**0.0029**
Commute Alternatives Incentive	MTA	MDOT 2011 AR	MTA Commuter Choice Maryland Pass		**0.0157**
Public Transit Improvement	MTA	MDOT 2011 AR	Transit Store in Baltimore		**0.0055**
TOTAL					**0.7618**

D. Unfunded GHG Reduction Strategy Emission Reduction and Cost Assumptions

Public Transportation

The GHG reduction benefits of the funded public transportation policy option strategies identified in the CTP and MPO plans through 2020 are estimated as part of the emissions analysis of the funded plans and programs project bundle. The unfunded public transportation strategy approach is detailed below.

The 2008 Climate Action Plan refers to MTA's 2001 Maryland Comprehensive Transit Plan (MCTP) goal of doubling transit ridership by 2020 from a 2000 baseline by increasing transit funding 42 percent. The strategies identified by the TLU-3 working group and the coordinating committee in 2009 fell into three distinct strategy groups, all supporting the MCTP goal. These strategy groups are: (1) increased capacity and revenue miles across all transit modes, (2) enhanced transit level of service, and (3) improved access and increased development adjacent to stations.

To quantify the incremental increase in ridership required to meet the MCTP ridership goal, and the associated GHG reductions along with the investment required to get there, a trend in ridership growth projected to 2020 is developed. The trend include the system expansion projects in the fiscally constrained plans and programs through 2020. The transit ridership trend is included in the GHG reduction benefits calculated for the Maryland plans and programs.

GHG Emission Reduction - Data and Assumptions

There are two primary sources in Maryland for tracking transit ridership data: the National Transit Database administered by FTA and the Maryland Annual Attainment Report. Data for both of these sources are obtained by operator tracking of daily system use. Future ridership projections are generated by transit agencies and modeled by MPO's based on socioeconomic assumptions and expansion of the transit system.

To develop a ridership forecast for Maryland through 2020 the following information is used:

- From 2001 to 2010, the Maryland Annual Attainment Report (AAR) indicates an average annual ridership growth rate of 1.44 percent. This includes an annual growth rate outside of Baltimore of 4.04 percent, and inside Baltimore of -0.16 percent (services inside Baltimore include MTA bus, metro rail, and light rail). The flat ridership growth over the past decade in Baltimore is partly due to light rail system closures due to the double tracking project and service cuts to the local bus system.

- From 2007 to 2010, transit ridership in Baltimore has shown a rebound, increasing at a rate of 1.79 percent per year.
- The BRTB and MWCOG constrained long range plans indicate average annual ridership growth rates through 2030 of 0.64 percent in the Baltimore region and 2.17 percent in the Washington region. These modeled growth rates account for changes in land use and transit system expansion. This equates to an average urbanized area growth rate (weighted based on total ridership) in Maryland of 1.82 percent annually.

Table D.1 summarizes four alternative transit ridership growth trends and forecasts in Maryland.

Table D.1 Maryland Transit Ridership Trends

Scenario	Annual Growth Rate	2020 Ridership Forecast (million unlinked trips)	MCTP 2020 Goal Differential (million unlinked trips)
AR (2001-2010)	1.44%	305.7	146.8
AR Adjusted 1 [1]	2.72%	346.4	106.1
AR Adjusted 2 [2]	3.02%	356.8	95.7
MPO Forecasts (2010 – 2020)	1.82%	341.0	111.6
CAP 2020 Goal [3]	5.00%	452.5	--

Notes:

1) Adjustment assumes Baltimore region ridership maintains a 0.64 percent annual growth rate (per BMC forecasts).

2) Adjustment assumes Baltimore region ridership will maintain a 1.79 percent annual growth rate (consistent with growth 2007 to 2010).

3) MTA's 2001 Maryland Comprehensive Transit Plan (MCTP) calls for a doubling of transit ridership by 2020 from a 2000 baseline by increasing funding 42 percent.

The MCTP goal (doubling 2000 ridership by 2020) results in a target ridership in 2020 of 452.5 million. To achieve the 2020 goal requires an average annual ridership growth of 5.00 percent from 2010 to 2020.

The ridership growth rate representing transit projects and programs funded through 2020 in the CTP and MPO long range plans equals a 2.45 percent annual increase. This growth rate represents the average of the four alternatives presented in Table 1. The logic supporting use of this growth rate instead of the MPO based growth rate (1.82 percent) is tied to MPO model limitations with regard measuring the impacts of short term fluctuations in gasoline prices and economic growth.

This growth rate includes the ridership impact of implementation of all 2011-2016 CTP transit projects and TERMs, and MPO long range transit projects included in modeling assumptions by 2020 (includes Purple Line, Corridor Cities Transitway, Red Line).

The public transportation policy option focus is on the difference between the 452.5 million 2020 goal from the CAP and the 2020 transit ridership forecast of 337.5 million (based on the 2.45 percent annual growth rate). The difference represents 115.0 million unlinked transit trips. This approach ensures no overlap or double counting of transit trips or GHG emission reductions and strictly accounts for the incremental growth required to achieve the MCTP goal.

GHG Emission Reduction – Results

There are three elements to the GHG reduction calculation for public transit expansion: VMT reduction, highway delay reduction, and land use and development interaction impacts. The GHG emission reduction from each element is added together to estimate the total estimated 2020 reduction.

VMT Reduction Element

To translate unlinked transit trips to VMT, an average vehicle occupancy and average transit trip length is required. The average auto occupancy in Maryland is 1.34 persons per vehicle from the 2007-2008 BRTB/TPB household travel survey. The average transit trip length of all Maryland transit trips is 13 miles per data from the 2007-2008 BRTB/TPB household travel survey.

The VMT reduction is translated to a GHG emissions based on the following equation:

$$mmt\ CO_2e = [VMT * EF_R] + [VMT/TL * IDLE * EF_I] + [VMT/TL * EF_S]$$

where:

EF_R = 2020 Running emissions factor = 344 grams/mile

TL = average trip length = 13 miles

IDLE = average idling time per trip = 2 minutes

EF_I = 2020 Idling emission factor = 4678 grams/hour

EF_S = 2020 Start emissions factor = 111 grams/start

Delay Reduction Element

Based on data from Texas Transportation Institute Urban Mobility Report (2009), on average 0.0594 gallons of gasoline are saved for every transit passenger trip in major metropolitan areas, including Baltimore and Washington D.C. One gallon of gas equals 0.0088 metric ton CO_2, and 83 percent of MD population is located in an urbanized area as defined by the 2000 US Census. Based on these relationships, the GHG emissions savings resulting from reduced highway system delay due to mode shift is calculated as follows:

$$mmt\ CO_2e = Tpt * Gpt * G_{CO2} * S * 1.05$$

where:

Tpt = transit passenger trips

Gpt = gallons of gasoline saved per transit passenger trip (0.0594 gallons/trip)

G_{CO2} = 0.0088 mt CO_2/gallon

S = share of population in urban areas (83 percent)

1.05 = EPA factor to convert from CO_2 to CO_2e

Land Use and Development Interaction Element

Accounting for the interaction between expanded transit and redevelopment adjacent to new transit stations is a significant synergy to account for in estimating potential GHG reductions from transit expansion. The process to account for this interaction is as follows:

Step 1: Estimate existing population accessibility to transit (Table D.2)

Table D.2 Existing Population Accessibility to Transit

Population	Access to Premium Transit Service (1/2 mile)	Access to All Urban Transit Service (1/2 - 1/4 mile)
Maryland Population (2007 ACS)	332,839 (6.1%)	1,991,580 (36.5%)

Source: 2007 American Community Survey, population by census tract

Step 2: Share of population in census tracts with supportive population density

Based on policy goals for PlanMaryland, MDP will seek to achieve 75 percent of Maryland's new development as compact development (4 units per acre for residential developments) in 2020. Assuming that 4 units per acre is the minimum density threshold for transit supportive density, based on 2010 census data, 23.6 percent of Maryland's population lives in census tracts with a residential density of 4 units per acre or greater. Based on the MDP growth target, in 2020 28.6 percent of the population will live in a census tract with a residential density of 4 units per acre or greater.

Step 3: Estimate 2020 population accessibility to transit (Table D.3)

Table D.3 2020 Population Accessibility to Transit

Scenario	Percent Access to Premium Transit
2010	6.1%
2020 Baseline (PlanMaryland Goal)	7.4%
2020 Baseline plus Unfunded Public Transit Expansion Goal	9.4% - 10.9%

Note: Premium transit is any transit mode that is on a fixed guideway.

Step 4: Estimate 2020 GHG reduction

Based on an estimate of 2.70 million households in 2020, the total VMT reduction is estimated as follows:

$$VMT_{LU} = HH * P_{acc} * VMT_{red}$$

where:

HH = 2020 Maryland households (2.7 million)

P_{acc} = 2020 accessibility (9.4% - 10.9%)

VMT_{red} = 6.5 daily vehicle miles less per household accessible to transit[2]

On-Road Transit Emissions

Added revenue miles result in additional emissions from on-road transit vehicles compared to the transit baseline in the MPO plans and programs. Based on data in the Maryland Attainment Report, total revenue miles by transit mode can be estimated from new transit passenger trips. Total emissions from revenue miles for local and commuter buses are calculated as follows:

$$mmt\ CO_2e = ([Rev * EF_R] + [Rev/TL * IDLE * EF_I] + [Rev/TL * EF_S])*HY_{adj}$$

where:

Rev = bus revenue miles

EF_R = 2020 Running emissions factor = 1342 grams/mile

TL = average transit trip length = 12.9 miles

IDLE = average idling time per trip = 4 minutes

EF_I = 2020 Idling emission factor = 12271 grams/hour

EF_S = 2020 Start emissions factor = 109 grams/start

HY_{adj} = Emission factor adjustment for hybrid diesel-electric buses (64 percent)[3]

Results

Example results for the average ridership growth rate scenario (average of the four alternative growth rates presented in Table 4.1) is presented in Table D.4.

Table D.4 GHG Emission Reductions

Average Ridership Growth Rate Scenario	VMT Reduction (mmt CO_2e)	Delay Reduction (mmt CO_2e)	Land Use Interaction (mmt CO_2e)	Added On-Road Emissions (mmt CO_2e)	TOTAL
2.45%	0.40	0.05	0.08	-0.017	0.51

[2] The secondary or indirect effects of transit expansion include long-term land use changes that redistribute growth focused on fixed-guideway transit stations. *The Broader Connection between Public Transportation, Energy Conservation and Greenhouse Gas Reduction* transit and land use analysis (Transit Cooperative Research Program Project J-11) estimated the average reduction of VMT per household by level of transit availability based on household trip survey data from the 2001 National Household Travel Survey. The model estimation from this study resulted in an average daily reduction of VMT per household of 6.5 for households with access to transit.

[3] Assume new buses in 2020 are 36% cleaner than forecast fleet average: (http://www.kingcounty.gov/operations/procurement/Services/Environmental_Purchasing.aspx).

Cost Estimation Assumptions

The method for estimating the costs associated with these strategies is based on the incremental investment needed to increase annual transit ridership growth from the plans and programs to achieve the MCTP goal.

Revenue Mile Expansion Cost

The additional revenue miles required to accommodate the ridership growth by mode to reach the 2020 goal were estimated by using existing transit trip rates per revenue mile (based on Maryland specific 2009 data from the National Transit Database). These trip rates are:

- Heavy rail (Baltimore METRO, WMATA METRO Rail) – 3.2 passenger trips per revenue mile
- Commuter rail (MARC) – 1.3 passenger trips per revenue mile
- Light rail (MTA light rail) – 2.1 passenger trips per revenue mile
- Local bus (MTA, LOTS, WMATA) – 3.6 passenger trips per revenue mile (only includes WMATA bus service in Maryland)
- Commuter bus (MTA) – 0.7 passenger trips per revenue mile

The 2009 revenue miles per vehicle for each mode was used to determine the additional number of vehicles needed to accommodate the ridership growth for each mode (Table D.5). The revenue miles per vehicle for each mode were calculated using 2009 revenue miles and numbers of vehicles available for maximum service. The capital cost per mode was calculated using standard costs per vehicle type (also see Table D.5). Note that the costs for the local and commuter buses represent estimates for hybrid-electric transit buses. Data sources for this information included 2009 NTD data and documentation from ongoing WMATA and MTA plans and projects.

Table D.5 Revenue Miles per Vehicle and Cost per Vehicle

Mode	2009 Annual Revenue Miles per Vehicle	Cost per Vehicle
Heavy Rail	138,905	$3,000,000
Light Rail	41,381	$3,870,000
Commuter Rail	73,837	$2,800,000
Local Bus	24,493	$650,000
Commuter Bus	21,519	$650,000

The estimated incremental costs to achieve the MCTP goal were calculated based on the range of 2020 MCTP ridership differentials presented in Table D.1 and two alternative assumptions for mode share by transit mode. The first calculation assumption for mode share was based on maintaining 2009 actual transit passenger trip mode share in 2020.[4] The second calculation assumption used 2020 forecasted transit passenger trip mode splits.[5] The steps to estimate the total cost are as follows:

1. The transit passenger mode splits were multiplied by the total increment of new transit passenger trips required to achieve the 2020 goal (95.7 to 146.8 million) and then multiplied by the passenger trips per revenue mile in order to estimate total new revenue miles by transit mode needed (see Table D.6)

Table D.6 Range of Incremental Revenue Miles Needed to Achieve Goal

Mode	High Need Estimate (million revenue miles	Low Need Estimate (million revenue miles)
Heavy Rail	13.82	9.38
Light Rail	2.00	1.04
Commuter Rail	3.09	2.51
Local Bus	23.10	15.52
Commuter Bus	2.74	2.79

2. The needed revenue miles were then divided by the annual revenue miles per vehicle data in Table D.5 to estimate the number of new vehicles required.
3. The total number of vehicles required was multiplied by the unit cost per vehicle to estimate total implementation cost.

This costing methodology does not estimate costs associated with the purchase of new ROW or construction of new fixed guideway transit systems (above the funded plans and programs) before 2020, or the annual operations and maintenance costs required to support the expanded transit system. The total cost estimate for expanded revenue miles above and beyond the plans and programs through 2020 ranges from $915 million to $1.298 billion.

Park-and-Ride Expansion Cost

To support this expansion in revenue miles, cost for additional park-and-ride lot spaces needed by 2020 were also estimated. Based on research data from METRA (Chicago region commuter rail system) detailed in Transit Research Cooperative Program Report 95, Chapter 3, for every

[4] The 2009 mode splits, based on NTD and MWCOG model data, were 32.7 percent heavy rail, 3.0 percent light rail, 3.0 percent commuter rail, 59.9 percent local bus, and 1.4 percent commuter bus.

[5] The 2020 mode splits, forecasted based on 2001 to 2009 NTD and MWCOG model data, were 32.7 percent heavy rail, 3.0 percent light rail, 3.6 percent commuter rail, 58.6 percent local bus, and 2.1 percent commuter bus. The 2020 light rail mode share was adjusted to maintain the 2001 percentage (since the share actually decreased between 2001 and 2007), and the local bus mode share was accordingly decreased.

25 percent increase in parking spaces there is an associated 15 percent increase in transit ridership. Current data from SHA and MTA indicate approximately 45,000 park-and-ride lot spaces in Maryland. In 2020, a 25 - 45 percent increase in ridership is estimated in order to achieve the 2020 targeted ridership goal. Based on the relationship detailed above, this increase would require between an additional 11,500 and 20,700 park-and-ride spaces in Maryland.

Assuming that the mix of locations of the park and ride lots stay the same as they are now, based on SHA general guidance total cost per space assumes $8,000 in construction and $2,000 in design and PE costs totaling $10,000 per space in capital costs (this does not include information on ROW acquisition costs). The total cost for new park-and-ride spaces above the plans and programs by 2020 ranges from $115.1 million to $207.2 million.

Results

Based on the assumptions outlined above, the unfunded TLU-3 strategies will yield an average 0.50 mmt reduction in GHG emissions in 2020 at an additional capital cost of approximately $1.214 – $1.765 billion.

Intercity Passenger and Freight Transportation

The GHG reduction benefits of the funded intercity passenger and freight strategies identified in the CTP and MPO plans through 2020 are estimated as part of the emissions analysis of the funded plans and programs project bundle. The unfunded strategy approach is detailed below.

The analysis for greenhouse gas reductions in Maryland by 2020 for unfunded strategies focuses on improving the transit mode share for trips to/from BWI Marshall Airport, and increasing ridership on Amtrak/MARC intercity rail service with an origin or destination in Maryland.

The intercity transportation working group did not specify any unfunded freight strategies for potential implementation prior to 2020. However, given Maryland's recent involvement and commitment to the National Gateway initiative, analysis of the truck VMT savings and associated GHG emission reductions in Maryland are estimated as an unfunded intercity transportation strategy.

GHG Emission Reduction Estimates - Data and Assumptions

Increased Transit Mode Share to/from BWI Marshall

Passenger miles for access trips to and from BWI Marshall total 377.97 million in 2007. Passenger miles for 2020 are obtained by extrapolating historic growth trends in total annual enplanements, which yielded an annual 2 percent growth rate (based on 2002 - 2007).[6] Total

[6] Obtained from Table 4 of 2007 Washington-Baltimore Regional Air Passenger Survey by National Capital Region Transportation Planning Board, et al.

passenger miles to/from BWI Marshall are then broken down into the current and target mode splits between private and public modes.

To quantify the greenhouse gas reduction associated with improved passenger connections at BWI Marshall, it is assumed that the transit mode share can be increased from 11.4 percent in 2007 to 20 percent by 2020. The mode share assumptions are based on:

- 12 percent is the existing public access mode share at BWI Marshall according to a 2008 ACRP Report.[7] Public transportation is defined in this report as rail, bus and shared ride vans, but excludes single-party limousines, courtesy shuttles, and charter operations.
- Table 10 in the 2007 Washington-Baltimore Regional Air Passenger Survey indicates that the average share of public mode of access in 2002, 2005, and 2007 is 11.4 percent.[8] Public mode of access includes rail services and airport bus, van or limo.
- San Francisco International Airport's (SFO) public access mode share of 23 percent, which is currently the highest in the U.S. based on 2005 data included in the referenced ACRP report. SFO has access from multiple rail transit modes, and has on average slightly more expensive daily/long-term parking fees of $14 per day.

20 percent is chosen as a reasonable target mode share for BWI Marshall in 2020, in order to estimate the potential for GHG reductions. This represents an increase over existing conditions and puts BWI Marshall at a transit access share similar to Washington National, Boston Logan, and New York JFK.

The difference between current transit access mode share at BWI Marshall and a mode share in 2020 of 20 percent results in GHG emission savings through a reduction in total passenger miles in a private vehicle. The passenger mile reduction estimates are presented in Table D.7.

Table D.7 Estimated Passenger Mile Reductions from Increased Transit Mode Share at BWI Marshall

BWI Marshall Access Trips	2020
Total Passenger-Miles (millions)	494.71
Current Mode Split	
Private Vehicle (88.6%)	438.31
Transit (11.4%)	56.40
Target Mode Split	
Private Vehicle (80%)	395.77
Transit (20%)	98.94
Private Vehicle Passenger Miles Reduced	**42.54**

[7] Airport Cooperative Research Program (ACRP) Report 4: Ground Access to Major Airports by Public Transportation. 2008.

[8] http://www.mwcog.org/uploads/committeedocuments/lF5dXlhf20081003124339.pdf

The passenger mile reduction estimate is translated to a VMT reduction based on an average occupancy (1.34 passengers per vehicle), and to GHG emission based on the calculation detailed on page D.3 of this Appendix.

Increased Ridership on Amtrak/MARC

Based on Amtrak projections, from 2010 to 2030, daily maximum ridership is expected to grow from 11,500 daily to 24,670 daily, or 3.9 percent annually on the Northeast Corridor (Amtrak Acela and NE Regional services, and MARC Penn line). This is based on implementation of capital elements of the Northeast Corridor Master Plan, which by 2030 identifies $8.014 billion in currently unfunded capital investment in Maryland (including improvements at Washington Union Station).

Annual passenger miles in Maryland on the Northeast Corridor in 2008 are 159.4 million on the MARC Penn Line, and 119.6 million on Amtrak. The 3.9 percent growth rate is compared to a baseline growth rate of 1 percent annually (consistent with growth 2000 – 2010) to estimate the increase in passenger miles in 2020.

Daily NEC Passenger Miles in Maryland (2010) = 279.1 million

Daily NEC Passenger Miles in Maryland (2020 – Baseline growth) = 308.2 million

Daily NEC Passenger Miles in Maryland (2020 – NEC Master Plan) = 407.9 million

2020 Added Passenger Miles = 99.7 million

The passenger mile increase estimate is translated to a VMT reduction based on an average occupancy (1.34 passengers per vehicle), and to GHG emissions based on the calculation detailed on page D.3 of this Appendix.

National Gateway

Based on analysis completed by CSX Transportation, for the moderate diversion scenario, the estimated truck VMT reduction in Maryland in 2020 is 23.0 million. The VMT reduction is translated to a GHG emission reduction based on the 2020 composite grams CO2e/mile running emissions factor for heavy duty vehicles (1342 g CO_2e/mile)

Cost Estimation Assumptions

Increased Transit Mode Share to/from BWI Marshall

Costs for the deployment of improved traveler information and enhanced convenience at BWI Marshall from 2011 to 2020 are variable based on the exact strategies chosen and the level of new infrastructure required.

Examples of the costs associated with providing in-terminal/in-station kiosks or other display boards of real-time transit arrival information are available via a number of recent studies through FHWAs Research and Innovative Technology Administration (RITA). In 2006, the Federal Transit Administration (FTA) sponsored a study to analyze the return-on-investment for real-time bus arrival time information systems. The Transit Tracker system deployed in the Tri-County Metropolitan Transportation District of Oregon (TriMet), deployed in 2001, was evaluated. The system provides riders with a real-time estimate of the expected time the next transit vehicle will arrive at a specific bus stop or rail station. Information is provided to riders via electronic information displays, a dedicated phone line, and a Web site.

An estimate of the cost of the field equipment (designing, purchasing, and installing the dynamic message signs at 13 bus stops and all rail stations), servers, and Web development was $1.075 million. Operating and maintenance costs for Transit Tracker are estimated to be roughly $94,300 per year.[9]

This level of investment at the scale of the Baltimore light rail system would be significantly higher (TriMet example is deployed to all 12 light rail stations in the Portland system). Software development costs could go also support expansion of the existing BWI Ground Access Information System to include all modes of access to BWI., including Amtrak and MTA bus and light rail in Baltimore.

An estimate for full deployment of this technology in all 32 light rail stations and at BWI Marshall totals 2.87 million in capital costs and $250,000 in annual operations and maintenance costs.

Maryland received a $10 million grant as part of the American Recovery and Reinvestment Act High Speed Intercity Passenger Rail Program, for planning and engineering for the new BWI station project, which includes the addition of a fourth track along a 9-mile segment and additional platform space. Maryland is applying for additional federal high speed rail funds to complete the BWI Station reconstruction and new track project estimated at $250 million. This project is assumed to be completed by 2020 if funding becomes available.

Increased Ridership on Amtrak/MARC

Full deployment of the Northeast Corridor Master Plan required $8.014 billion in capital investment in Maryland through 2030. Near term projects on which Maryland has applied for federal high speed rail funds include preliminary engineering and environmental analysis for Northeast Corridor bridges over Bush, Gunpowder, and Susquehanna Rivers ($200 million).[10] Construction of the three bridges is estimated to ultimately cost $2.1 billion.

The majority of the funding for the Northeast Corridor Master Plan is anticipated to be through federal apportionments to Amtrak and the States. Assuming a 20 percent state match for the three bridges would bring Maryland's total commitment to $420 million for construction.

National Gateway

The National Gateway Project is a package of rail infrastructure and intermodal terminal projects that will enhance transportation service options along three major freight rail corridors

[9] http://www.itscosts.its.dot.gov/its/benecost.nsf/SingleCostTax?OpenForm&Query=Transit%20Management

[10] Maryland Seeks High-Speed Rail Money That Florida Spurned. The Baltimore Sun, March 15, 2011. http://articles.baltimoresun.com/2011-03-15/news/bs-md-rail-funds-20110315_1_high-speed-rail-bwi-station-rick-scott

owned and operated by CSX through the Midwest and along the Atlantic coast. The improvements will allow trains to carry double-stacked containers, increase freight capacity and make the corridor more marketable to major East Coast ports and shippers. In 2010, $98 million in TIGER funds were awarded to help complete the first corridor project, from Northwest Ohio to Chambersburg, Pennsylvania, through West Virginia and Maryland. Based on the National Gateway TIGER Grant Application, states are planning to commit 23 percent of the funding to complete the project ($189 million), with Maryland slated to commit $75 million.

Results

Based on the assumptions outlined above, the unfunded intercity passenger and freight strategies will yield a 0.11 mmt reduction in GHG emissions in 2020, with a draft estimated implementation cost of Table D.8 illustrates the GHG emission benefits and total cost of the TLU-5 unfunded strategies.

Table D.8 Estimated GHG Emission Reduction and Costs for Unfunded Strategies

Intercity Passenger and Freight Transportation	GHG Reduction (mmt CO_2e)	Total Cost 2010 - 2020 (million $)
Increased transit mode share to/from BWI Marshall	0.015	$253.12
Implement Northeast Corridor Master Plan	0.024	$420.0
CSX National Gateway	0.044	$75.0

Bike and Pedestrian

The GHG reduction benefits of the funded TLU-8 strategies identified in the CTP and MPO plans through 2020 are estimated as part of the emissions analysis of the funded plans and programs project bundle. The unfunded TLU-8 strategy approach is detailed below.

According to the MDOT Annual Attainment Report, bicycle and walking mode share for commute trips statewide in 2009 is 3.0 percent (0.4 percent biking, 2.6 percent walking). Per the 2007-2008 TPB/BMC Household Travel Survey, for the combined Baltimore and Washington metropolitan area, combined bicycling and walking mode share for commute trips is approximately 6.0 percent.

The focus of the analysis of TLU-8 strategies is to determine the mode shift and resulting GHG emission reductions of building out the *Maryland Trails* plan. A secondary analysis considers the mode shift and resulting GHG emission reductions from a comprehensive improvement in pedestrian infrastructure on urban roadways in areas adjacent to activity centers, transit stations and schools.

Maryland Trails: A Greener Way to Go is Maryland's coordinated approach to developing a comprehensive and connected statewide, shared-use trail network. This plan focuses on creating a state-wide *transportation trails* network. The *Maryland Trails* plan identifies approximately 820 miles of existing *transportation trails* and 770 miles of priority *missing links* (160 trail segments) that, when completed will result in a statewide trails network providing travelers a non-motorized option for making trips to and from work, transit, shopping, schools and other destinations.

GHG Emission Reduction Estimates - Data and Assumptions

Buildout of the Maryland Trails Strategic Implementation Plan

The 2001 Baltimore Metropolitan Commission (BMC) Household Travel (HHT) Survey was analyzed to ascertain the potential impact of trail availability on travel modes in the study area. Whereas the Travel to Work data gathered by the US Census captures only trips to work, the HHT Survey asks respondents to record data on all trips, including work, shopping, recreation and leisure.

To calculate the VMT reduction potential of building out the statewide strategic trails plan, the mode share percentages across the BMC planning area within one mile of an existing transportation trail and within one mile of a priority missing link is estimated. This mode share data is extrapolated to all urban areas statewide to calculate the VMT shift potential of building out the state's transportation trails network.

Throughout the BMC planning area, 9.7 percent of all trips are taken by walking alone. The percentage of trips taken by foot almost doubles to 17.3 percent in areas that are within one mile of an existing transportation trail (see Table D.9).

Table D.9 BRTB Household Travel Survey Walk and Bike Mode Shares

Area	% Walk	% Walk to Transit	% Bicycle	% Bike to Transit	% Other
Within 1 Mile of Existing Trail	17.3	6.4	0.5	0.0	75.8
Within 1 mile of Priority *Missing Link*	6.0	1.2	0.4	0.0	92.4

The potential for capturing trips currently taken by car becomes more pronounced when comparing areas with existing access to a trail to areas within one mile of a priority missing link. According to the data, 92 percent of all reported trips in these areas were taken by car and only 6 percent were taken by walking (7.2 percent when combined with walk to transit trips).

The analysis was performed by applying the mode split percentages calculated for areas within one mile of an existing *transportation trail* to the areas within one mile of a priority *missing link.* By building out the *transportation trail* network, in 2020 up to 400.4 million vehicle miles could be shifted from car to nonmotorized modes of transportation, or a combination of walking or bicycling with transit (see Table D.10). .

Table D.10 2020 Greenhouse Gas Reductions from Buildout of Trail Plan

	Passenger Miles Adjacent to Missing Links	
Mode	Pre-Trail Plan Buildout (millions) [1]	Post-Trail Plan Buildout (millions) [2]
Walk	8.94	25.83
Walk & Transit	1.77	9.56
Bike	1.64	2.23
Bike & Transit	0	0.03
Other	2,176.06	1,783.71
VMT Shift (millions) [3]		**(60.70)**
GHG Reduction (mmt CO_2e)		**0.02**

Notes:

(1) 2020 PMT by mode derived by applying 1.4 percent annual VMT growth rate to 2001 household travel survey data in areas within 1 mile of a priority *missing link*.
(2) 2020 PMT by mode derived by applying 1.4 percent annual VMT growth rate to 2001 household travel survey data in areas within 1 mile of an existing *transportation trail*.
(3) VMT shift by mode extracts the VMT shift associated **only** with the provision of new transportation trails, not the impact of land use change. The assumption is that 15 percent of the mode shift is attributed to the provision of trail infrastructure, while the remainder is predominantly a result of land use change.

The VMT reduction is multiplied by a composite 2020 CO2e emissions factor using the equation detailed on page D-3 of this Appendix to obtain GHG emissions reductions.

It should be acknowledged that these mode share percentages cannot be entirely attributed to the presence or absence of a transportation trail. Other elements, such as distance between origins and destinations (i.e. the mix of uses or density), the relative bike or pedestrian "friendliness" of an area, access to transit, local encouragement efforts, and other factors contribute to travel mode choice.

Comprehensive Pedestrian Strategy

The pedestrian analysis was conducted using population density data by five population density ranges representing average population densities in rural/exurban, low density suburban, high density suburban, urban, and activity center or regional center. The deployment assumptions for adding pedestrian amenities in these different density ranges through 2020 are:

1. All new developments have buffered sidewalks on both sides of the street, marked/signalized pedestrian crossings at intersections on collector and arterial streets, and street lighting.
2. New or fully-reconstructed streets in denser suburban neighborhoods and urban areas (>4,000 persons/sq mi and business districts) incorporate traffic calming measures.
3. "Complete Streets" policies are adopted by Maryland state and local transportation agencies, requiring appropriate pedestrian accommodations on all roadways.

4. By 2020, 50 percent of existing streets within ¼ mile of transit stations, schools, and business districts are audited for pedestrian accessibility and retrofitted with curb ramps, sidewalks, and crosswalks.

The approach is to apply an elasticity of VMT with respect to a pedestrian environment factor (PEF). PEFs represent an index reflecting qualities and deficiencies of pedestrian infrastructure. Elasticities from a 2001 study by Reid Ewing and Robert Cervero are applied to example changes in the PEF resulting from pedestrian improvements.[11] Two PEF change levels were tested that include different assumptions about the geographic scope of deployment (within ¼ mile of all transit stations/activity centers to within ½ mile). As Table D.11 shows, VMT decreases range from -1.5 percent in suburban areas (where it is assumed that a greater relative level of pedestrian improvement could be implemented) and -0.5 percent in urban areas.

Table D.11 Application of Pedestrian Environment Factor (PEF) Elasticities to VMT

	Suburban		Urban	
Portland PEF factors	**Base**	**Alt**	**Base**	**Alt**
Sidewalk availability	1	3	2	3
Ease of street crossing	1	2	2	2.5
Connectivity of street/ sidewalk system	1	1	3	3
Terrain	3	3	3	3
% change in PEF		50%		15%
% change in VMT:		**-1.5%**		**-0.5%**

The "suburban" percentage VMT reduction is applied to areas with population density less than 4,000 ppsm, the urban reduction to areas greater than 10,000 ppsm, and a mid-point reduction (1.0 percent) applied to areas between 4,000 and 10,000 ppsm.

The VMT change was not applied to all population; instead, it was applied to an estimate of the population affected by the relevant pedestrian improvements. This estimate varies by census tract density range, based on the estimated land area accessed by the improvements (Table D.6). The pedestrian strategy assumes pedestrian improvements only in certain areas, such as transit stations, school zones, and business districts, as it would probably be cost-prohibitive and not very effective to make such improvements to all neighborhoods, everywhere. The following assumptions are made about the number of each type of area:

- Schools – 1,446 total K-12 schools in Maryland (National Center for Educational Statistics, 2005-06) * 5/6 of population (schools) in metro areas = 1,200 schools. These were distributed across all density ranges, based on population.
- Transit stations: 104 transit stations in Maryland. These were distributed across the three highest density ranges, based on population.

[11] Ewing, R. and R. Cervero (2001) Travel and the Built Environment. *Transportation Research Record 1780*, 87-114.

- Business districts: Total population of 5,841,356 in 2010. Total business districts estimated at 413. Multiple estimation methods used:
  - 1 for each of the 368 cities, towns, and villages in the Maryland as defined in the 2000 Census. 1 per 15,000 people (approximately the market area for a grocery store) yields 390 districts. 1 per 5,000 people (market area for a convenience store), considering only urban population in areas w/>4,000 ppsm, yields 482 districts.

The percentage of total land area in Maryland affected is calculated based on improvements within a ¼ mile radius to a ½ mile radius. All numbers are increased from 2010 to 2020 based on an average annual population growth rate from 2000 to 2020 of 0.94 percent. The VMT reduction results in 2020 are presented in Table D.12. The VMT reduction is multiplied by a composite 2020 CO_2e emissions factor using the equation detailed on page D-3 of this Appendix to obtain GHG emissions reductions.

Table D.12 Comprehensive Urban Area Pedestrian Improvement GHG Reductions

	% of Total Area		VMT Reduction for Impacted Population (million)		1/4 mi GHG (mmt)	1/2 mi GHG (mmt)
2020 PPSM	**1/4 mi**	**1/2 mi**	**1/4 mi**	**1/2 mi**		
0 - 499	0.7%	3.0%	1.52	6.09	0.00	0.00
500 -1,999	7.9%	31.7%	14.54	58.18	0.01	0.04
2,000 - 3,999	24.2%	96.8%	49.70	198.78	0.04	0.14
4,000 - 9,999	52.4%	100%	99.92	190.51	0.07	0.14
10,000+	100%	100%	18.57	18.57	0.01	0.01
Total	**4.3%**	**17.3%**	**184.25**	**472.13**	**0.13**	**0.34**

Cost Estimation Assumptions

Buildout of the Maryland Trails Strategic Implementation Plan

Planning level estimates put the cost of building all priority *missing links* at approximately $378 million (2009 dollars).[12] It should be noted that under current planning processes, trail construction is primarily county-led, although significant funding is available from the state through the Transportation Enhancements Program and the Recreational Trails Program.

Comprehensive Pedestrian Strategy

The total capital cost estimate is $219.9 - $439 million over 10 years of implementation, or an average annual cost of $22 to $43.9 million (see Table D.13).

[12] The $378 million estimate for building all the missing links is a planning level estimate developed by MDOT and Cambridge Systematics that is not documented in the final Maryland Trail Strategic Implementation Plan.

Table D.13 Comprehensive Pedestrian Strategy Costs

		Cost per Area		Total Cost ($millions)	
Area Type	**Total #**	**1/4 mi**	**1/2 mi**	**1/4 mi**	**1/2 mi**
Schools	1,588	$191,000	$382,000	$151.6	$303.3
Transit Stations	104	$191,000	$382,000	$9.9	$19.0
Business Districts	454	$257,000	$514,000	$58.4	$116.7
Total 10-year capital ($millions)				**$219.9**	**$439.0**
Cost per Year, 2010-2020				**$22.0**	**$43.9**

Results

Based on the assumptions outlined above, the unfunded TLU-3 strategies will yield a 0.16 – 0.36 mmt reduction in GHG emissions in 2020 at a cost of approximately $597 - $817 million. Table D.14 illustrates the GHG emission benefits and total cost of the TLU-8 unfunded strategies.

Table D.14 Estimated GHG Emission Reductions and Costs for Unfunded Strategies

TLU-8 Bike and Pedestrian	GHG Reduction (mmt CO_2e)	Total Cost 2010 - 2020 (million $)
Buildout of the Maryland Strategic Trails Plan	0.02	$378
Comprehensive Pedestrian Strategy	0.13 – 0.34	$220 - $439

Transportation Pricing and Demand Management

The GHG reduction benefits of the funded pricing and demand management strategies identified in the CTP and MPO plans through 2020 are estimated as part of the emissions analysis of the funded plans and programs project bundle. The unfunded strategy approach is detailed in this section.

The draft MDOT policy design developed by the working group in Phase I considered four potential strategy areas combined with an education component for state and local officials:

- **Maryland motor fuel taxes or VMT fees** – There are two primary options for consideration: (1) an increase in the per gallon motor fuel tax consistent with alternatives under consideration by the Blue Ribbon Commission, and (2) establish a GHG emission-based road user fee (or VMT fee) statewide by 2020 in addition to existing motor fuel taxes. Both options would create additional revenue that could be used to fund transportation improvements and systems operations to help meet Maryland GHG reduction goals.
- **Congestion Pricing and Managed Lanes** – Establish as a local pricing option in urban areas that charges motorists more to use a roadway, bridge or tunnel during peak periods, with revenues used to fund transportation improvements and systems operations to help meet Maryland GHG reduction goals.

- **Parking Impact Fees** – Establish parking pricing policies that ensure effective use of urban street space. Provision of off-street parking should be regulated and managed with appropriate impact fees, taxes, incentives, and regulations.
- **Employer Commute Incentives** – Strengthen employer commute incentive programs by increasing marketing and financial and/or tax based incentives for employers, schools, and universities to encourage walking, biking, public transportation usage, carpooling, and teleworking.

In Phase III, motor fuel taxes were added as a pricing strategy in order to test alternative transportation revenue strategies consistent with concepts under discussion through the Blue Ribbon Commission.

GHG Emission Reduction Estimates - Data and Assumptions

Motor Fuel Taxes

Alternatives for new primary transportation revenue sources in Maryland under consideration by the Blue Ribbon Commission include potential increases to current per gallon taxes on motor fuels. These range from a nominal increase of $0.01 per gallon to $0.10 per gallon increase. The same assumptions used to calculate the benefit of VMT fees are applied here.

VMT Fees

VMT fees are a different form of a usage fee compared to current per mile gas taxes. Table D.15 presents the current motor fuel taxes in Maryland and adjacent states. This helps set a context for the magnitude of the VMT fees tested.

Table D.15 State and Federal Motor Fuel Taxes

State	State Tax ($/gallon)	Federal Tax ($/gallon)	Total ($/gallon)
Maryland	$0.235	$0.185	$0.420
Delaware	$0.230	$0.185	$0.415
Pennsylvania	$0.323	$0.185	$0.508
Virginia	$0.191	$0.185	$0.376
Washington DC	$0.200	$0.185	$0.385
Average	***$0.236***	***$0.185***	***$0.421***

Alternative VMT fees ranging from $0.01 per mile to a high of $0.05 per mile are evaluated in Maryland for the year 2020. Assuming 24 mpg light-duty vehicle average on-road fuel economy in 2020, these equate to an equivalent gas tax increase of $0.24 to $1.21 per gallon.

To estimate the related GHG reduction of VMT fees, travel cost elasticity's are applied to all private vehicle travel in Maryland. Automobile travel is generally inelastic, meaning that a price change causes a proportionally smaller change in vehicle mileage. For example, a 10 percent fuel price increase only reduces automobile use by about 1 percent in the short run, and

3 percent over the medium run. A 50 percent fuel price increase, which is significant to consumers, will generally reduce vehicle mileage by about 5 percent in the short run. The effect over time though will increase as consumers take the higher price into account in longer-term decisions, such as vehicle purchases and where to live or work.

A combined long and short run elasticity estimate was applied for both the VMT fee and congestion pricing analysis of a -0.45 percent change in volume for each 1.0 percent change in trip cost. This elasticity is consistent with the range of estimates made by FHWA in the 2006 Conditions and Performance Report.[13] .

The VMT reduction resulting from a statewide VMT fee in 2020 is illustrated in Table D.16. Depending on the level of per mile fee (from $0.01 to $0.05), statewide VMT reductions range from 0.6 percent to greater than 3 percent, with revenue ranging from $678 million to over $3.4 billion. The VMT reduction is multiplied by a composite 2020 CO_2e emissions factor (average for light, medium, and heavy-duty vehicles) using the equation detailed on page D-3 of this Appendix to obtain GHG emissions reductions.

Table D.16 Alternative VMT Reductions (2020)

VMT Fee ($/Mile)	Equivalent ($/gallon)	% VMT Reduction	Absolute VMT Reduction (Millions)	Revenue Collected ($ Millions)
$0.01	$0.24	0.65%	439	$678
$0.02	$0.48	1.30%	879	$1,365
$0.03	$0.72	1.96%	1,318	$2,060
$0.04	$0.96	2.61%	1,757	$2,765
$0.05	$1.20	3.26%	2,196	$3,478

Congestion Pricing and Managed Lanes

There are a total of 3,140 interstate and expressway lane miles in Maryland. Based on the 2008 Annual Attainment Report, 30.4 percent of freeway lane miles are congested daily in 2006. BMC and MWCOG travel demand models forecast 40 percent of freeway miles will be congested in 2020.

Table D.17 presents proposed ranges of deployment of congestion pricing in 2020.

[13] Cambridge Systematics and Harry Cohen, "Congestion Pricing and Investment Requirements", National Cooperative Highway Research Program Project 8-36, Task 85. Transportation Research Board, 2009. http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/NCHRP08-36(85)_FR.pdf

Table D.17 Maryland Congestion Pricing Deployment Levels

Percentage of Lane Miles to Apply Congestion Pricing	2020 Target
1. Half of congested areas, 1 lane each direction	7.5%
2. All congested areas, 1 lane each direction	15.0%
3. Half of congested areas, all lanes in both directions	20.0%
4. All congested areas, all lanes in both directions	40.0%

1. (Lowest Level) – Half of congested areas, 1 lane in each direction. The percentage for this scenario will be 7.5 percent in 2020, which is about 1/5 of 40 percent - the maximum percentage in Scenario 4.

2. (Mid-Level) – All congested areas, 1 lane in each direction. The maximum percentage will be 15.0 percent in 2020, which is about 2/5 of the maximum from Scenario 4. Two-fifths is used because the average number of lanes is slightly above 5 and congestion pricing will be applied on 2 of those lanes.

3. (Mid-Level) - Half of congested areas, all lanes in both directions. The maximum percentage will be 20.0 percent in 2020, which is exactly half of the maximum for Scenario 4.

4. (Maximum) – All congested areas, all lanes in both directions. The maximum percentage for this scenario will be 40 percent in 2020, which is calculated above.

To maintain level-of-service (LOS) D conditions on the priced facilities, an estimated congestion fee (cost per mile) ranging from $0.25 to $0.30 is required.

Two ranges of VMT reduction are estimated based on a moderate and high projection of growth in congested lane miles by 2020. In 2020, the annual VMT reduction from congestion pricing ranges from 279 million to a high of 1,499 million. The VMT reduction is multiplied by a composite 2020 CO_2e emissions factor (average for light, medium, and heavy-duty vehicles) using the equation detailed on page D-3 of this Appendix to obtain GHG emissions reductions.

The ultimate calculation of the GHG emissions reduction also accounts for fuel savings from reduced delay. The GHG benefit from reduced delay represents 25 percent of the total GHG reduction.

Parking Impact Fees and Parking Management

Most parking management strategies are under the domain of local government. In most U.S. cities, parking supply is constrained or priced only in the central business district (CBD) and possibly a few other major activity centers, primarily as a result of market forces that establish a strong premium on land costs. Outside of these areas, parking supply is generally plentiful, due to long-established planning and zoning regulations that require developers to provide ample parking, and free.[14]

[14] Shoup, D. (2005). *The High Cost of Free Parking.* APA Planners Press, Chicago, Illinois.

A recommendation of the TLU-9 working group is that Maryland should encourage testing of parking impact fees in transit-served metropolitan communities. These fees would be waived for employers who offer cash-in-lieu-of-parking and transit benefits. Parking impact fees serve as a disincentive for employers who choose not to offer parking and/or transit benefits to employees. The benefits of cash-in-lieu of parking and transit benefits provided by employers are estimated as part of the employer commute incentives strategy.

Employer Commute Incentives

A range of estimates is made for future participation in all employer based commute strategies. Data from national studies suggest that approximately 50 percent of the workforce could participate (based on job requirements) and 50 percent of workers offered the option would take advantage of it. Based on these assumptions, approximately 25 percent of the workforce could participate in some type of a commute program.

The 2008 State of the Commute survey in the Metropolitan Washington, D.C. region estimated that 19 percent of regional employed workers telework at least occasionally, of which 56 percent telework at least once a week.

As shown in Table D.18, EPAs COMMUTER Model was applied with baseline work-trip mode shares and trip distances specific to Maryland along with medium and high scenario assumptions for the extent of implementation and the employee participation rates in employer based commute programs in 2020.[15]

Table D.18 Employer Based Commute Strategy Participation Assumptions

		Employer Participation Rate		
Scenario	**Description**	**Baseline**	**Scenario 1**	**Scenario 2**
Parking & Transit Benefits	Parking fees/transit passes	10%	**15%**	**20%**
Employer Support Programs, Percentage of Employers Participating	Level 1	5%	**8%**	**10%**
	Level 2	2%	**2%**	**4%**
	Level 3	1%	**2%**	**3%**
	Level 4	1%	**2%**	**3%**
Alternative Work Schedules	Flex Time	5%	**8%**	**10%**
	Compressed 4/40	5%	**8%**	**10%**
	Compressed 9/80	5%	**8%**	**10%**
	Staggered Hours	5%	**8%**	**10%**
	Telecommute	5%	**8%**	**10%**

[15] The COMMUTER Model analyzes time and cost strategies using a "pivot-point" logit mode choice model, which uses the mode choice coefficients from regional travel models and applies a change in time and/or cost to "pivot" off of a baseline starting mode share to achieve a final mode share. http://www.epa.gov/OTAQ/stateresources/policy/pag_transp.htm#cp

Notes: The values in the table are all inputs into the USEPA Commuter Model. Level 1 includes a transit information center plus a transportation coordinator. Level 2 includes a transit information center and a policy of work hour's flexibility to accommodate transit schedules/delays, plus a transportation coordinator. Level 3 includes a transit information center and a policy of work hours flexibility, on-site transit pass sales, plus a transportation coordinator. Level 4 includes a transit information center and a policy of work hours flexibility, on-site transit pass sales, guaranteed ride home, and a full-time transportation coordinator.

The results of the two Commuter Model runs are listed in Table D-19. The change in VMT represents an additional reduction over the benefits of the TERM strategy benefits analysis in 2020. The VMT reduction is multiplied by a composite 2020 CO_2e emissions factor (average for light-duty vehicles) using the equation detailed on page D-3 of this Appendix to obtain GHG emissions reductions.

Table D.19 Employer Commute Incentives GHG Reductions (2020)

Employer Commute Incentives	Scenario 1	Scenario 2
Daily VMT Reductions	1,094,381	2,793,817
Annual VMT Reduction (millions)	273.60	698.45
2020 Emission Reductions (mmt CO2e)	**0.10**	**0.25**

Cost Estimation Assumptions

VMT Fees

In order to estimate the implementation cost, two different alternatives are evaluated for instituting a distance-based pricing framework.

Administrative Reporting – Motor vehicle owners self-report mileage through the motor vehicle registration and inspection process, or on-board odometer readings are recorded by inspectors. Under this scenario, the total cost is similar to costs for collecting state gas tax revenues. The cost assumptions for these strategies come from a 2008 Cambridge Systematics white paper completed for FHWA on *Estimating the Cost of Systemwide Road Pricing*.

Using these assumptions, Table D.20 presents annual revenue in 2020 and implementation costs. Implementation costs include annual administrative costs required for the program.

Table D.20 VMT Fee Annual Costs and Revenues (Administrative Scenario)

VMT Tax ($/Mile)	Equivalent ($/gallon)[1]	Revenue Collected ($ Millions)	Admin. Costs ($ Millions)	Net Revenue ($ Millions)
$0.01	$0.27	$678	$34	$644
$0.02	$0.55	$1,365	$68	$1,297
$0.03	$0.82	$2,060	$103	$1,957
$0.04	$1.09	$2,765	$138	$2,627
$0.05	$1.37	$3,478	$174	$3,304

Wireless Reporting – Under this scenario, motor vehicles will link to a receiver located at gas stations, where a RF (radio frequency) receiver picks up a transmission from an on-board unit (OBU) that provides the odometer reading since the last visit at a gas station.

The wireless reporting VMT fee system approach uses an on-board radio frequency (RF) transmitter connected to the vehicle odometer or to an electronic hub odometer. A recent paper on *Toll Collection Technology Considerations* estimated the price of GPS OBUs at $200 to $400.[16] Transceivers are located at gas stations and record mileage information between fill-ups. The estimate for these units, based on a recent paper on Vehicle Infrastructure Integration Benefit Cost Analysis, is $1,000, with an additional $4,800 for installation. Potential costs for electronic hub odometers, on-board units, and gas station RF receivers are presented in Table D.21. [17]

Table D.21 VMT Fee Capital Implementation Costs (Wireless Scenario)

Item	Units	Cost per Unit	Cost Extended
Hub Odometers (Electronic) & Start Up	4.72 million	$400	1,888 million
OBU RF Transmitters	4.72 million	$100	472 million
RF Receivers at Gas Stations	2,082	$5,800	$12.1 million
Total Deployment Cost			**2,372.1 million**

Total VMT fee estimated capital costs for the wireless reporting scenario are $2,372.1 million. The costs associated with the technology required to deploy a wireless system are highly variable, as the technologies required are continuing to advance, and increasingly the vehicle fleet is enabled with GPS units. Therefore, the costs in Table D.21 represent a high end estimate. Table D.22 illustrates total revenue collected in 2020 and the annual operations and maintenance costs in 2020.

Table D.22 VMT Fee Annual Costs & Revenues (Wireless Scenario)

VMT Fee ($/Mile)	Equivalent ($/gallon)[1]	2020 Revenue Collected ($ Millions)	2020 Annual O&M Cost ($ Millions)	2020 Net Revenue ($ Millions)
$0.01	$0.27	$678	$33.9	$644
$0.02	$0.55	$1,365	$68.3	$1,297
$0.03	$0.82	$2,060	$103.0	$1,957
$0.04	$1.09	$2,765	$138.3	$2,627
$0.05	$1.37	$3,478	$173.9	$3,304

[16] *Toll Collection Technology Considerations, Opportunities, and Risks*, Background Paper No. 8, Washington State Comprehensive Tolling Study, September 20, 2006 (IBI Group with Maryland Department of Transportation).

[17] *VII Initiative Benefit-Cost Analysis: Pre-Testing Estimates*, Draft Report, Sean Peirce and Ronald Mauri, John A. Volpe National Transportation Systems Center, Cambridge, Massachusetts, March 30, 2007.

Congestion Pricing and Managed Lanes

Initial capital costs include the on-board units (OBU) and installation, enforcement requirements and central system development. According to a 2008 study by the Puget Sound Regional Council (PSRC), the total capital startup cost for regional congestion pricing is $748.5 million. The same PSRC study estimated annual system costs, which include OBU repair, enforcement, and data communications needs at $287.7 million annually in 2008 dollars. These costs are expanded on a per capita basis (based on 2006 census population of the Seattle region, 3.3 million) to cover deployment to the Baltimore and Washington DC regions (total 2020 population in Maryland of 5.6 million). The maximum (if all urban freeways had congestion pricing) capital costs are $1.278 billion and annual operating costs of $0.491 billion. These values are scaled down based on the percentages of miles of deployment by scenario.

The capital cost estimates assume a major policy change allowing existing lanes to be priced. Therefore, no additional road facilities or capital expansion implementation costs are assumed in this estimate.

Employer Commute Incentives

The FY 2008 budget for the Metropolitan Washington Council of Governments' (MWCOG) regional Commuter Connections program was approximately $5 million, of which the largest expenses were $2.2 million for marketing and $1.0 million for employer outreach; other expenses included ridematching coordination and technical assistance ($0.6 million), a guaranteed ride home program ($0.5 million), a telework program, information kiosks, and evaluation.

The total statewide commute alternatives and incentives implementation cost through 2020 as evaluated through the TERM analysis is $136 million. The scope of the medium and high scenario tested here roughly increase participation in these programs by 50 and 100 percent respectively. While specific costs associated with this level in 2020 are not estimated here in detail, it is expected that through 2020, they would be in the order of $60 to $140 million.

Transportation Pricing and Demand Management Results

Based on the assumptions outlined above, the unfunded pricing and demand management strategies will yield a 0.24 – 2.01 mmt reduction in GHG emissions in 2020 at a cost of approximately $300 - $3,790 million. Table D.23 illustrates the GHG emission benefits and total cost of the unfunded strategies.

The VMT fees tested represent a significant increase in the current Maryland motor fuel tax. An evaluation of the total social cost of implementing a fee-based program is necessary in order to understand potential negative social and economic impacts.

Table D.23 Transportation Pricing and Demand Management Estimated GHG Emission Reductions and Costs for Unfunded Strategies

Transportation Pricing and TDM	GHG Reduction (mmt CO_2e)	Total Cost 2010 - 2020 (million $)
Blue Ribbon Commission – Motor Fuel Tax Alternatives	0.01 – 0.09	$0
VMT Fees	0.20 – 0.98	$0 – $2,372
Congestion Pricing	0.13 – 0.72	$240 - $1,278
Employer Commute Incentives	0.10 – 0.25	$60 -$140

Transportation Technology

The GHG reduction benefits of the funded Transportation Technology strategies identified in the CTP and MPO plans through 2020 are estimated as part of the emissions analysis of the funded plans and programs project bundle. The unfunded Transportation Technology strategy approach is detailed below.

The following strategies, identified by the Transportation Technology working group, were analyzed to determine the GHG emission reduction benefits and the estimated costs associated with Transportation Technology Strategies:

- Active Traffic Management and Traffic Management Centers
- Traffic Signal Synchronization / Optimization
- Initiate Marketing and Education Campaigns to Operators of On- and Off-Road Vehicles
- Timing of Highway Construction Schedules
- Green Port Strategy
- Reduce Idling Time in Light Duty Vehicles, Commercial Vehicles, Buses, Locomotives, and Construction Equipment
- Promote and Incentivize Fuel Efficiency Technologies for Medium and Heavy Duty Trucks
- Incentivize Fuel Efficient and Low GHG Vehicle Purchase (On-Highway Vehicles)
- Incentivize Technology Advances for Non-Highway Vehicles
- Provide Incentives for Low-Carbon Fuels and Infrastructure

The methodologies for analyzing each of the strategies varies and more information on the approach for each strategy can be found in the assumptions section, below.

GHG Emission Reduction Estimates - Data and Assumptions

Due to a lack of data, emissions resulting from the implementation of marketing and education campaigns, timing of highway construction schedules, green port strategy, incentives for low-GHG vehicles and incentives for low-carbon fuels and infrastructure were not analyzed.

The Maryland Port Administration will continue to provide leadership, seeking out innovative funding mechanisms that can be used by the Port and Port tenants to continue their voluntary environmental stewardship efforts.

The GHG reduction benefits associated with the Maryland Clean Car Program were included in the baseline 2020 GHG emissions analysis along with federal fuel economy, renewable fuel and low carbon fuel standards.

The assumptions used to arrive at the GHG emission reduction benefits and the estimated costs associated with implementation of the remaining Transportation Technology strategies are outlined below. All emission factors described in the assumptions below are subject to change following completion of updated MOVES modeling.

- **Active Traffic Management (ATM) / Traffic Management Centers –**The GHG emission benefits associated with this strategy were calculated based on 2009 data obtained from the CHART program, which were projected to 2020 utilizing the following assumptions:
  - An average annual statewide VMT growth rate of 1.4 percent
  - A 2020 fleet mix of 90 percent LDV, 3 percent HDGV, and 7 percent HDDV.
  - A 2009 average fuel economy (mpg) of 21.4 for LDVs, 8.0 for HDGVs, 8.3 for HDDVs, and 20.1 fleet-wide. A fuel economy adjustment factor of 0.74 (2009-2020).
  - A 2020 average fuel economy (mpg) of 29.4 for LDVs, 8.0 for HDGVs, 8.3 for HDDVs, and 27.3 fleet-wide. A fuel economy adjustment factor of 0.74.
  - A 2009 annual fuel savings of 6.4 mgal based on a delay reduction of 3.25 M veh-hr for trucks and 29.18 M veh-hr for cars.
- **Traffic Signal Synchronization / Optimization –** The GHG emission benefits resulting from the implementation of this strategy were calculated using the statewide average annual VMT growth rate, fleet mix, and fuel economy adjustment factor, and 2009 and 2020 fuel economy, assumptions as those used to calculate the benefits of the above traffic management strategies. In addition an annual 2009 fuel savings of 1,165,066.5 gallons, based on 2009 data from SHA, was used to project 2020 emissions benefits.
- **Reducing Idling Times –** The GHG emission benefits calculated from this strategy represent the sum of a reduction in 1) long term truck idling (overnight and loading), 2) transit bus idling, and 3) school bus operations.
  - Long Term Truck Idling – 3.4 percent of all class 8 truck (gross vehicle weight of 33,000 pounds or above – includes all tractor trailers) CO_2 emissions were assumed attributed to long term idling based on *Quantification of Pennsylvania Heavy-Duty Diesel Vehicle Idling Emissions,* Final Report March 2007. A 40 percent reduction in long-term truck idling was assumed, based on the assumption that this measure will be moderately enforceable, by 2020, resulting in a 1.36 percent reduction in class 8 truck GHG emissions.
  - Transit Bus Idling – Based on a California Air Resource Board (CARB) study (*On-Road Motor Vehicle Activity Data, Volume 1 – Bus Population and Activity Pattern, Final Report*), it was assumed that 7 percent of transit operating time is attributable to idling in excess of

1 minute. The average emission rate at the average operating speed of 15 mph is equivalent to 1,544 g/mi, while the CO_2 idling emission rate equals 12,271 g/hr. Assuming an 80 percent reduction, due to the high enforceability of this strategy, by 2020 results in a 0.21 percent reduction in transit bus emissions.

- School Bus Idling – Based on a CARB study (*On-Road Motor Vehicle Activity Data, Volume 1 – Bus Population and Activity Pattern, Final Report*), 14 percent of school bus operating time is attributable to idling in excess of 1 minute. The average emission rate at the average speed of 15 mph equals 1,254 g/hr. The average idling emission rate is equal to 5,042 g/hr. Using an assumption of a reduction in idling of 80 percent, due to the high enforceability of this strategy, by 2020 results in a 3.34 percent reduction in all school bus emissions statewide.

- **Technology Improvements for On-highway Vehicles –** EPA's SmartWay calculator was utilized to calculate the emission benefits from this strategy utilizing the following options: aluminum wheel sets for singlewide tires and automatic tire inflation. Bunker heaters and APUs were not included as they are included in the reduced idling times strategy. Based on these assumptions, the SmartWay calculator estimates a reduction in fuel burn of 4.6 percent. A 25 percent participation rate was anticipated, resulting in a 1.125 percent reduction in class 8 truck GHG emissions.

- **Technology Advances for Non-highway Vehicles –** In order to calculate the benefits from this strategy, a 5 percent reduction in fuel use was assumed. Since retrofitting, or utilizing after treatment technologies, does not increase fuel efficiency and engine replacements are reflected in the inventory, it is assumed that the impact of this strategy will be relatively small. An average annual off-road diesel fuel usage of 40,780,000 gal was assumed based on 2002-2006 EIA data. The projected annual growth in fuel use across all sectors, which is assumed to be conservative for off-highway diesel, is assumed to be 1.05, resulting in a total fuel use reduction of 2,133,866 gallons per year.

Cost Estimation Assumptions

- **Active Traffic Management (ATM) / Traffic Management Centers –** The costs associated with the implementation of this strategy were calculated assuming an annual funding rate of $12,960,000, which was published in the FY2011-2016 CTP.

- **Traffic Signal Synchronization / Optimization –** In order to estimate the costs associated with implementing this strategy, cost estimates for updating signal timing per intersection and retiming traffic signals in the Washington, DC area were obtained from the National Traffic Signal Report Card, and ITS costs estimated by DOT, respectively.

- **Reducing Idling Times –**

  - Long Term Truck Idling – The costs associated with a decrease in Class 8 truck emissions was estimated based an assumed anti-idling equipment cost of $5,000 per truck and a fuel savings of $3/gal.

  - Transit Bus Idling – The costs associated with this reduction were estimated based on an assumed anti-idling equipment cost of $5,000 per transit bus and a fuel savings of $3/gal.

- School Bus Idling – The costs associated with the reduction of school bus idling was based on a fuel cost of $3/gal.

- **Technology Improvements for On-highway Vehicles –** The costs for this strategy were calculated assuming a $1,500 / truck incentive and the participation of 6,705 trucks in 2020. The participation rate is based on 2006 HDDV trucks registered in Maryland (43.18 percent are class 8 trucks) and a growth factor of 1.1897 based on regional travel demand models and 1990-2008 HPMS.
- **Technology Advances for Non-highway Vehicles –** The costs for this strategy were estimated assuming that this program would be completely voluntary and reductions would be based only on a marketing campaign estimated to cost $500,000.

Transportation Technology Results

Based on the assumptions outlined above, the unfunded Transportation Technology strategies will yield a 0.24 mmt reduction in GHG emissions in 2020 at a cost of approximately $51.0 million, without accounting for any estimated fuel savings. Table D.24 illustrates the GHG emission reductions and costs by unfunded strategy.

Table D.24 Transportation Technology Estimated GHG Emission Reductions and Costs for Unfunded Strategies

Transportation Technology	GHG Reduction (mmt CO_2e)	Total Cost 2010 - 2020 (million $)
Active Traffic Management and Traffic Management Centers	0.03	$12.96
Traffic Signal Synchronization/ Optimization	0.01	$2.36
Reduce idling time in light duty vehicles, commercial vehicles, buses, locomotive, and construction equipment.	0.10	$24.97
Promote and incentivize fuel efficiency technologies for medium and heavy-duty trucks.	0.08	$10.06
Encourage Retrofit and /or Replacement of Non-highway Diesel Engines	0.02	$0.50

Evaluate the Greenhouse Gas Emission Impacts of Major Projects and Plans

GHG Emission Reduction Estimates - Data and Assumptions

The draft MDOT policy design considers the potential following strategies:

Actively Participate in Framing National GHG Emissions Evaluation Policy – Given the recent EPA proposed ruling that carbon emissions endanger Americans' health and well-being, Maryland should actively participate in framing national policy rather than implementing specific, state guidance requiring GHG emissions evaluation of all major projects on both the NEPA and statewide/regional planning level.

Evaluation of GHG Emissions through the NEPA Process – The impact of GHGs on major capital projects through the current NEPA decision-making process should be encouraged. GHGs should be considered during the impact assessment phase when conducting alternatives analyses for all major capital projects. Where appropriate, the alternatives analysis should be accompanied by analysis of potential alternatives, such as transit-oriented land use and investment; adding toll lanes and express bus; express toll lanes; a hybrid transit-oriented express toll lane; or a rail and express bus scenario. Where the proposed projects may lead to increased GHG emissions, mitigation measures should be considered. The GHG analysis should be included as part of the Air Quality Technical Report and should allow for the demonstration of GHG benefits as well as impacts through both quantitative and qualitative components with the understanding that appropriate and/or approved emissions models and methodologies may not be available. The GHG analysis would be required:

- If there is an Environmental Impact Statement (EIS) or an Environmental Assessment (EA). Categorical Exclusions (CE's) will be screened out.
- For any roadway capacity enhancement project which is identified for analysis through interagency consultation.
- For active projects that have yet to receive federal sign-off on draft NEPA documents. It is recommended that any project with approved NEPA draft documents would be "grandfathered" through the process.

Evaluation of GHG Emissions through Statewide/Regional Planning – The impact of GHGs should be addressed in the statewide and/or regional planning processes. The process would be similar to the current conformity process for ozone and PM; however, instead of setting a budget, a mechanism for tracking GHG emissions reductions would be established. Regional level analyses (determining the GHG impacts on a larger scale than just the project level) account for control strategies that are in place such as fleet make up, analysis years, VMT increases, etc.

While the strategies outlined above were determined by the Working Group and the Coordinating Committee to be either critical or important strategies in assisting MDOT in meeting its goals, these strategies were not quantified. The strategies under this policy option are assumed to contribute to the overall goal of reducing GHG emissions from the transportation sector, however, it is unclear what the GHG emissions impact of implementing these strategies will be at this time.

Implementation Tracking

MDOT currently tracks the performance of Maryland's transportation system and ongoing transportation investments through the MDOT Annual Attainment Report on Transportation System Performance. The report tracks Maryland's transportation system and investment against five primary goals: quality of service, safety and security, environmental stewardship, system preservation and performance, and connectivity for daily life. The report also tracks

MDOTs and MDTAs capital and operating budgets and project completion Examples of specific performance measures the Attainment Report currently tracks that are directly attributable to GHG emission reductions include:

1. Annual VMT reductions from transportation emission reduction measures including ridesharing, guaranteed ride home, MTA College Pass and Commuter Choice Pass, and teleworking,
2. MTA percent of service provided on time and average weekday transit ridership,
3. User cost savings for the traveling public due to incident management,
4. Number of park-and-ride spaces and reduction in VMT through park-and-ride usage,
5. Percent of state owned facilities with sidewalks and high bicycle level of comfort, and
6. Percent of freeway and arterial lane-miles with volumes at or above congested levels

Co-Benefits

Job Creation Resulting from Policy Implementation

The FHWA estimates that every one billion dollars of federal highway investment, plus the state match, supports 30,000 jobs.[18] The FHWA analysis measures the impact of three types of employment associated with highway investment:

4. Construction oriented employment including all jobs created by construction firms that work directly on the project or those firms that provide materials such as asphalt, steel and concrete directly on site;
5. Supporting industries' employment which includes those jobs not on site but that benefit directly from the project such as factory jobs. An example would be a job that provides the sheet steel to make the guard rails used on the project; and
6. Induced employment which includes all of the jobs supported by consumer expenditures resulting from wages to "construction oriented" and "supporting industries" employment

This FHWA estimate does not incorporate the job creation benefits for the highway construction expenditures as estimated under the American Recovery and Reinvestment Act of 2009 (ARRA). As part of ARRA, Maryland is receiving $638 million directed toward formula funding for transportation. Maryland also received numerous discretionary grants through ARRA including $60.0 million in design funds to replace the Baltimore and Potomac Tunnel, $9.4 million for a new platform and fourth track at BWI Rail Station, $12.3 million to construct the Takoma/Langley Transit Center, and $2.5 million for priority bus corridor enhancements in Prince George's and Montgomery counties. Smaller grants were awarded to MTA for

[18] http://www.fhwa.dot.gov/policy/otps/pubs/impacts/index.htm

greenhouse gas and energy reduction improvements, and to MPA for port security work totaling $3.4 million.

MDOT infrastructure based transportation GHG reduction strategies presented in this plan through 2020 will result in job creation associated with:

1. Construction of new transportation facilities and rehabilitation of existing facilities,
2. Maintenance of new transportation infrastructure and vehicles,
3. Operation of new transit routes,
4. New jobs associated with expanded capacity of intermodal freight facilities,
5. Management of new intelligent transportation and traffic management facilities and technologies, and
6. Administration of new tolling, pricing, and travel demand management programs.

Net Economic Benefits of Policy Implementation in 2020

MDOT infrastructure based transportation GHG reduction strategies presented in this plan through 2020 will result in net economic benefits associated with:

1. Congestion reduction which could lead to economic benefits realized in the form of fuel savings and time savings for Maryland citizens and visitors,
2. Improved access to employment opportunities and services for low income households through expansion of public transit,
3. Enhanced intercity passenger rail level-of-service, providing time savings for business travelers, and high speed rail access to developing economic centers (such as development associated with BRAC at Fort Meade and Aberdeen Proving Ground),
4. Logistics cost savings for shippers in Maryland (the CSX National Gateway initiative forecasts $350 to $700 million in logistic cost savings in Maryland between 2010 and 2021),
5. Highway safety cost savings resulting from improved highway facilities, and
6. Enhanced residential and commercial development opportunities adjacent to existing and future transit stations, including the increased tax revenues from these development locations.

E. MDOT Program Summary Forms

Program Summary Forms (April 2011)
PART 1 – Overview

Agency Name: MDOT

1. *Total GHG reduction target for your agency per the 2008 Climate Action Plan:*

   MDOT = 6.2 $MMtCO_2e$

2. *List all of the new names of the policies you are developing or implementing. This is your chance to rename your suite of strategies – and separate your new "smarter" suite of strategies from the old Climate Action Plan terminology.*

   MDOT's 2020 transportation sector assessment will identify the GHG emissions reduction impact of:

   - ***New Vehicle Technologies, Fuels, and State and Federal Regulations including:***
     - The CAFE standard for Model Years 2008-2011.
     - The final Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2012-2016.
     - The Maryland Clean Car Program that incorporates the California emission standards for model years (MY) through 2020.
     - The proposed Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2017-2025.
     - The proposed Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles for Model Years 2014-2018.
     - The EPA's Renewable Fuel Standard Program (RSF2).
     - Low Carbon Fuel Standard, under development through MDE, a regional effort to reduce the carbon intensity of transportation fuels across an 11 state Northeast – Mid-Atlantic Region.
   - ***Transportation Plans and Programs – Funded and Committed Efforts that will Reduce GHGs***
     - Transportation projects, land use and travel forecasts data from approved transportation programs, including the Maryland CTP and MPO long range plans and transportation improvement programs, will be assessed to quantify the GHG emissions associated with the State's proposed transportation investments through 2020. The estimated total cost of the subset of projects within these planning documents through 2020 that contribute to a reduction in GHG emission is $13.0 billion. Table 1, below presents the total capital cost summary of Maryland plans and programs for 2011-2020 by TLU.

Table 1: Draft Cost Summary of Funded Maryland Plans, Programs and TERMs Funded Through 2020

Transportation Example Efforts	***Total Cost (2011-2020) (billions $)***
Public Transportation *Examples: Red line (Baltimore), Purple line (Washington DC suburbs), Corridor Cities Transitway (I 270 Corridor), LOTS capital procurement projects, capital funding support for WMATA*	$6.963
Intercity Passenger and Freight Transportation *Examples: MARC infrastructure and operations improvements, rail freight capacity improvements, highway capacity projects on interstate highway system routes and intermodal connectors.*	$3.085
Bike and Pedestrian *Examples: Projects supporting completion of the statewide transportation trails network, as well as improved bicycle and pedestrian access to transit facilities. Includes lighting, tree planting, and bicycle parking facility enhancements.*	$1.385
Pricing and Demand Management *Examples: Includes MdTA projects, primarily the ICC and I-95 Express Toll Lanes. Also includes state funded commute alternative incentive programs in Maryland.*	$1.397
Transportation Technologies *Examples: CHART, signal synchronization, MTA diesel-hybrid electric bus purchases, transit CAD/AVL system upgrades, and high speed tolling at 1-95 Fort McHenry toll plaza.*	$0.390
Total	**$13.219**

- ***Policy Options – Unfunded Implementation Strategies:***
  - Public Transportation
  - Intercity Passenger and Freight Transportation
  - Bike and Pedestrian
  - Pricing and Demand Management
  - Transportation Technologies (in consultation with MDE)
  - Evaluate the GHG Emission Impacts of Major Projects and Plans

3. *What are the total 2020 emission reductions expected from this suite of policies?*

- **5.30 mmt CO_2e**. This includes the GHG reduction of the 2008-2011 CAFE standard, EPA's Renewable Fuels Standard Program, and funded and committed transportation plans and program in Maryland through 2020. MDOT consulted with MDE on the modeling methodologies and assumptions required for the MOVES modeling process supporting development of the 2020 emissions reduction estimate.

4. *What percentage of your agency's original total emission reduction target do your policies represent?*

   - **85 percent**

5. *What are your plans for making up any shortfall?*

   - MDOT has identified a comprehensive set of unfunded transportation sector GHG emission reduction strategies that could achieve a **1.14 to 3.14 mmt CO_2e** reduction by 2020. These additional reductions are estimated to require an additional capital investment of **$2.911 to $7.071 billion** through 2020.
   - Should additional funding become available, the combined reduction of the 2008-2011 CAFE Standard, RFS Program, and funded and committed Maryland plans and programs would total **6.44 – 8.44 mmt CO_2e**.

6. *What new legislation or funding is needed to meet the original targets?*

   - Unknown. The Maryland Blue Ribbon Commission on Maryland Transportation Funding is currently evaluating transportation funding shortfalls, identifying potential new revenue sources and any legislation required to jumpstart them, and potential uses for additional funds. The following potential primary transportation revenue sources are identified in the Commission's Report to the Governor and General Assembly:
     - Vehicle Titling Tax / Vehicle Sales and Use Tax
     - Motor Fuel (Gas) Tax
     - Vehicle Registration Fees
     - Driver's Licenses and Other MVA Fees
     - Sales and Use Tax
     - Corporate Income Tax

     In addition, the Commission identified environmental (climate change, water, and air quality), MTA expansion, and TOD/sustainable communities among the potential uses for any additional funds.

7. *What are your plans for proposing or implementing the new legislation or funding initiatives needed to achieve the original targets?*

   - Unknown. See number 6, above.

1. *Please describe any other complications you face in achieving the original reduction targets.*

   - Unknown.

PART 2 – Program-by-Program Summaries

Agency Name: MDOT
New Policy Name: New Vehicle Technologies, Fuels, and State and Federal Regulations

Linkage to old Climate Action Plan terminology:

- The CAP did not include all of the technology improvements outlined in this summary. The Maryland Clean Car Program was included under TLU-10, Transportation Technologies. Renewable fuels were included under TLU-4, Low Greenhouse Gas Fuel Standard, which was removed from the CAP pending further analysis and technological innovation.

1. Describe the policy, including all programs/initiatives/etc involved

- Vehicle fuel economy standards are a key consideration in estimating future GHG emissions. The 2020 GHG inventory projection considers current CAFE standards as well as potential legislation that will further improve vehicle fuel economy and/or average vehicle GHG emissions per mile. The technology improvements include:
    - The final Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2012-2016 finalized in the May 7, 2010 joint rulemaking by USDOT and EPA, and
    - The Maryland Clean Car Program that incorporates the California emission standards for model years through 2020.

  Assuming federal approval, there are two federal proposals on additional vehicle standards that would affect fuel economy and potential greenhouse gas emissions prior to 2020. These include:
    - The proposed Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2017-2025.
    - The proposed Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles for Model Years 2014-2018.
- Low Carbon Fuel Standard, under development through MDE, a regional effort to reduce the carbon intensity of transportation fuels across an 11 state Northeast – Mid-Atlantic Region.
- For fuels, The EPA issued the renewable fuel standard program (RFS2) final rule in March 2010, which mandates the use of 36 billion gallons of renewable fuel annually by 2022. The revised statutory requirements include allowable GHG performance reduction thresholds for the renewable fuel categories.

2. *For your agency's 2020 GHG reduction commitment, summarize total reductions from the above program*

   - **2.51 mmt CO_2e** for the 2008-2011 CAFE standard and EPA RFS Program.
   - **6.41 mmt CO_2e** for the 2012-2016 National fuel economy program, Maryland Clean Car and/or the proposed National fuel economy standard for MY 2017-2025, proposed MY 2014-2018 medium/heavy duty standard, and low carbon fuel standard.

3. *Identify how your agency will measure and track the success of this policy. How can that be used to calculate or estimate GHG reductions related to this policy?*

   - Assumptions have been made on each vehicle program based on the best available information at the time of the analysis. Legislative action or further program refinement could change or modify assumptions used to complete the GHG emission estimates.

4. *Identify estimated 2020 job creation information for this policy*

   - Unknown.

5. *Identify 2020 net economic benefit information for this policy.*

   - It is difficult to estimate the net economic benefits of all of the vehicle technology improvements and the RFS2; however, residents of the state can expect some savings in fuel consumption resulting from increased fuel economy.

PART 2 – Program-by-Program Summaries

Agency Name: MDOT
New Policy Name: Transportation Plans & Programs – Funded and Committed Strategies

Linkage to old Climate Action Plan terminology:

- The CAP did not include the benefits of funded and committed TLU strategies.

1. *Describe the policy, including all programs/initiatives/etc involved*

- Transportation projects, land use and travel forecasts data from the following list of approved transportation programs were used to assess and quantify the GHG emissions of the State's proposed transportation investments through 2020.
    - MDOT 2011-2016 CTP
    - MWCOG 2011-16 TIP and 2010 CLRP adopted 11/17/10
    - BRTB 2011-14 TIP adopted 7/27/10 and Transportation Outlook 2035 (adopted 11/07, amended 2/24/09)
    - Hagerstown/Eastern Panhandle MPO 2010-2013 TIP adopted 6/16/10 and 2035 LRMTP adopted 4/28/10
    - Salisbury-Wicomico MPO 2010-2013 TIP adopted 9/28/09 and Draft 2010 LRTP scheduled for adoption in October 2010
    - Cumberland Area MPO 2010-2013 TIP adopted 10/15/09 and Draft 2010 LRTP schedule for adoption in October 2010
    - WILMAPCO DRAFT 2012-2015 TIP and 2040 RTP (adopted 10/10)
    - Modal Plans including – Maryland Area Regional Commuter (MARC) Growth and Investment Plan, Port of Baltimore Regional Landside Access Study, Maryland Statewide Freight Plan, Washington Metropolitan Area Transit Authority (WMATA) Capital Plan, Maryland Aviation Administration (MAA) Capital Plan.

Based on the macro-level analysis of the overall fiscally constrained transportation infrastructure investment through 2020 and the associated local land use policies, statewide growth in VMT is forecast to be 1.4 percent annually. This represents a slower rate of growth than was included in the Maryland Climate Action Plan, developed in 2007.

The reduced forecasted rate of growth in VMT will contribute to a reduction in GHG emissions by 2020 compared to the 2020 base forecast. The infrastructure investment that affects travel and congestion documented in the Maryland 2011-2016 CTP and MPO TIPs and LRPs represent an estimated **$13.219 billion** in investment through 2020.

A complete list of the Funded Maryland Plans, Programs and TERMs, grouped by representative transportation improvements, can be made available upon request and will be included in the December 31, 2011 draft plan.

2. *For your agency's 2020 GHG reduction commitment, summarize total reductions from the above program*

   - **2.79 mmt CO_2e**. MDOT consulted with MDE on the modeling methodologies and assumptions required for the MOVES modeling process supporting development of the 2020 emissions reduction estimate.

3. *Identify how your agency will measure and track the success of this policy. How can that be used to calculate or estimate GHG reductions related to this policy?*

   - MDOT will continue to track the fiscally constrained transportation infrastructure investment through 2020 and the associated local land use policies and travel forecasts in the state's transportation plans and programs.

4. *Identify estimated 2020 job creation information for this policy*

   - It is difficult to estimate the impacts that transportation plans and programs will have on job creation. However, it is likely that any new investment will result in some increase in direct (construction) and indirect (supporting services) labor.

5. *Identify 2020 net economic benefit information for this policy.*

   - Similar to job creation, net economic benefits resulting from the implementation of the state's plans and programs are complex to estimate. Any new investment in transportation infrastructure can be assumed to result in increased consumer expenditures as a product of job creation. In addition, transportation system improvements resulting in reduced congestion could realize benefits in the form of fuel savings and time savings, such as more efficient consumer and business operations through reduced operating costs and travel times. Table 1, below presents the total capital cost summary of Maryland plans and programs for 2011-2020 by TLU.

Table 1: Draft Cost Summary of Funded Maryland Plans, Programs and TERMs Funded Through 2020

Transportation Example Efforts	***Total Cost (2011-2020) (billions $)***
Public Transportation *Examples: Red line (Baltimore), Purple line (Washington DC suburbs), Corridor Cities Transitway (I 270 Corridor), LOTS capital procurement projects, capital funding support for WMATA*	$6.963
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Bike and Pedestrian *Examples: Projects supporting completion of the statewide transportation trails network, as well as improved bicycle and pedestrian access to transit facilities. Includes lighting, tree planting, and bicycle parking facility enhancements.*	$1.385
Pricing and Demand Management *Examples: Includes MdTA projects, primarily the ICC and I-95 Express Toll Lanes. Also includes state funded commute alternative incentive programs in Maryland.*	$1.397
Transportation Technologies *Examples: CHART, signal synchronization, MTA diesel-hybrid electric bus purchases, transit CAD/AVL system upgrades, and high speed tolling at 1-95 Fort McHenry toll plaza.*	$0.390
Total	**$13.219**

PART 2 – Program-by-Program Summaries

Agency Name: MDOT
New Policy Name (Unfunded): Public Transportation

Linkage to old Climate Action Plan terminology:

- Public Transportation was included under TLU-3, Transit.

1. *Describe the policy, including all programs/initiatives/etc involved*

- This policy option identifies public transportation strategies to reduce on-road mobile source transportation GHG emissions. The strategies are designed to help Maryland meet a goal of doubling transit ridership by 2020, and continuing that same growth rate beyond 2020. In order to achieve this growth, actions to increase the attractiveness and convenience of public transportation, improve the operational efficiency of the system, and increase system capacity are required. Policies also involve supportive actions with regard to land use planning and policy, pricing (disincentives to auto use), and bike and pedestrian access improvements. Policies to reduce GHG produced by public transportation services are also included.

  The following strategies defined by the public transportation working group were identified to address the expected gap in meeting the transit ridership goal defined in the Climate Action Plan (e.g. a doubling of 2000 transit ridership by 2020). The intent is for these strategies to complement and support funded MTA and WMATA plans and programs identified for implementation by 2020 in the 2011-2016 CTP and MPO TIPs and long-range plans.

  - Additional Capacity on Existing Transit Routes
  - Increase Frequencies of Transit Services Statewide
  - Expanded Park and Ride Capacity
  - Increase Coverage of Transit Services – New Commuter / Intercity Bus Routes
  - Increase Coverage of Transit Services – New Local Bus Routes
  - Implement Bicycle and Pedestrian Improvements to Support Transit
  - Reduce GHG Emissions from Transit Vehicles
  - Bus Priority Improvements
  - Plan Transit in Conjunction with Land Use

2. *For your agency's 2020 GHG reduction commitment, summarize total reductions from the above program*

- **0.39 – 0.62 mmt CO_2e**. MDOT consulted with MDE on the modeling methodologies and assumptions required for the MOVES modeling process supporting development of the 2020 emissions reduction estimate.

3. *Identify how your agency will measure and track the success of this policy. How can that be used to calculate or estimate GHG reductions related to this policy?*

- MDOT will continue to track transit ridership and average vehicle occupancy trends, which will assist in tracking GHG reductions related to this policy.

4. *Identify estimated 2020 job creation information for this policy*

- This policy could result in the creation of new jobs due to an increase in routes, frequency of service, and construction of new / expanded facilities.

5. *Identify 2020 net economic benefit information for this policy.*

- This policy could result in reduced congestion. Economic benefits could be realized in the form of fuel savings, time savings, and improved access to employment.
- The unfunded portion of this policy has an estimated cost of implementation of **$1,214-$1,765 million** through 2020.

PART 2 – Program-by-Program Summaries

Agency Name: MDOT
New Policy Name (Unfunded): Intercity Passenger and Freight Transportation

Linkage to old Climate Action Plan terminology:

- Intercity Transportation was included under TLU-5, Intercity Travel: Aviation, Rail, Bus, and Freight.

1. *Describe the policy, including all programs/initiatives/etc involved*

- This policy option enhances connectivity and reliability of non-automobile intercity passenger modes and multimodal freight through infrastructure and technology investments. For intercity passenger modes, this includes expansion of intercity passenger rail and bus services as well as improved connections between air, rail, intercity bus and regional or local transit systems. For freight movement, this includes expansion and bottleneck relief on priority truck and rail corridors and enhanced intermodal freight connections at Maryland's intermodal terminals and ports.

  The intercity transportation working group identified improving passenger convenience for intermodal connections at airports, rail stations, and major bus terminals as the primary pre-2020 unfunded intercity transportation strategies. Two primary strategies are assessed for intercity passenger transportation in Maryland by 2020: (1) improve passenger access, convenience, and information across all modes at BWI Airport, and (2) improve travel times, reliability and overall level of service on the MARC Penn Line and Amtrak NE Corridor consistent with the MARC Growth and Investment Plan, and Northeast Corridor Infrastructure Master Plan.

  The intercity transportation working group did not recommend specific freight strategies in addition to projects identified in implemented and adopted transportation plans and programs for consideration before 2020. Recent developments and Maryland strategic involvement in the CSX Transportation National Gateway initiative will result in implementation of freight rail projects in Maryland and the mid-Atlantic region that will help reduce truck VMT in Maryland by 2020. Funding for the National Gateway is a public-private partnership between the federal government, six states and the District of Columbia, and CSX. The benefit of the National Gateway is assessed in this report.

  The benefits of Norfolk Southern's Crescent Corridor initiative is not assessed in this report as direct GHG emission reduction benefits to Maryland are unknown and a level of support and funding commitment from Maryland has not been recommended to date.

2. *For your agency's 2020 GHG reduction commitment, summarize total reductions from the above program*

- **0.11 mmt CO_2e**. MDOT consulted with MDE on the modeling methodologies and assumptions required for the MOVES modeling process supporting development of the 2020 emissions reduction estimate.

3. *Identify how your agency will measure and track the success of this policy. How can that be used to calculate or estimate GHG reductions related to this policy?*

- MDOT will continue to track passenger-miles for trips to and from BWI Marshall Airport, Amtrak boardings at intercity rail stations and changes to freight-rail activity, which will assist in tracking GHG reductions related to this policy.

4. *Identify estimated 2020 job creation information for this policy*

- Unknown. New jobs will be generated associated with the expanded capacity of intermodal freight facilities.

5. *Identify 2020 net economic benefit information for this policy.*

- This policy could result in reduced congestion. Economic benefits could be realized in the form of fuel savings and time savings for intercity passengers, and logistics cost savings for shippers.
- The unfunded portion of this policy has an estimated cost of implementation of **$748 million** through 2020.

PART 2 – Program-by-Program Summaries

Agency Name: MDOT
New Policy Name (Unfunded): Bike and Pedestrian

Linkage to old Climate Action Plan terminology:

- Bike and Pedestrian was included under TLU-8, Bike and Pedestrian Infrastructure.

1. *Describe the policy, including all programs/initiatives/etc involved:*

- The policy option includes infrastructure design and construction policies and funding, regulatory, and land use strategies improving bike and pedestrian amenities, and education and marketing measures. Increasing the number of trips made on foot or bicycle will reduce the number of vehicle trips, resulting in a reduction in GHG emissions. This policy also recognizes that local governments are responsible for the design and maintenance of approximately 80 percent of roads in Maryland.

  The following unfunded strategies were recommended for possible implementation prior to 2020 by MDOT's Bike and Pedestrian working group:

  - Promote use and regular review/updates to existing manuals and design standards
  - Complete Streets – improve bike/pedestrian access through corridor retrofits and new roadway construction projects
  - Update existing land use policy guidance and zoning/development standards to include provisions for bike and pedestrian supportive infrastructure
  - Bike facility and supportive infrastructure placement at strategic locations, including transit stations and government facilities
  - Provide funds for low-cost safety solutions
  - Education, safety programs, and marketing programs to encourage bicycle travel

  The focus of the analysis of the unfunded Bike and Pedestrian strategies is to determine the mode shift and resulting GHG emission reductions of building out the Maryland Trails plan. A secondary analysis considers the mode shift and resulting GHG emission reductions from a comprehensive improvement in pedestrian infrastructure on urban roadways in areas adjacent to activity centers, transit stations and schools.

  Maryland Trails: A Greener Way to Go is Maryland's coordinated approach to developing a comprehensive and connected statewide, shared-use trail network. This plan focuses on creating a state-wide transportation trails network. The Maryland Trails plan identifies approximately 820 miles of existing transportation trails and 770 miles of priority missing links (160 trail segments) that, when completed will result in a statewide trails network providing travelers a non-motorized option for making trips to and from work, transit, shopping, schools and other destinations.

2. *For your agency's 2020 GHG reduction commitment, summarize total reductions from the above program*

    - **0.16 mmt CO_2e**. MDOT consulted with MDE on the modeling methodologies and assumptions required for the MOVES modeling process supporting development of the 2020 emissions reduction estimate.

3. *Identify how your agency will measure and track the success of this policy. How can that be used to calculate or estimate GHG reductions related to this policy?*

    - Under development. MDOT will continue to track mode share, population densities, and the increased availability of bicycle and pedestrian infrastructure, which will assist in tracking GHG reductions related to this policy.

4. *Identify estimated 2020 job creation information for this policy*

    - This policy could result in the creation of new jobs due to construction of new / expanded facilities.

5. *Identify 2020 net economic benefit information for this policy.*

    - This policy could result in reduced congestion. Economic benefits could be realized in the form of fuel savings and time savings.
    - The unfunded portion of this policy has an estimated cost of implementation of **$598-$817 million** through 2020.

PART 2 – Program-by-Program Summaries

Agency Name: MDOT
New Policy Name (Unfunded): Pricing and Demand Management

Linkage to old Climate Action Plan terminology:

- Pricing was included under TLU-9, Incentives, Pricing and Resource Measures.

1. *Describe the policy, including all programs/initiatives/etc involved:*

- This policy option addresses transportation pricing and travel demand management incentive programs. It also tests the associated potential GHG reduction benefits of alternate funding sources for GHG beneficial programs. These strategies amplify GHG emission reductions from other strategies by supporting Smart Growth, transit, and bike and pedestrian investments. The draft MDOT policy design, developed by the pricing working group in Phase I, considers four strategy areas combined with an education component for state and local officials.

  The detailed definitions of the four strategy areas are listed below:

  - **Maryland motor fuel taxes or VMT fees** – There are two primary options for consideration: (1) an increase in the per gallon motor fuel tax consistent with alternatives under consideration by the Blue Ribbon Commission, and (2) establish a GHG emission-based road user fee (or VMT fee) statewide by 2020 in addition to existing motor fuel taxes. Both options would create additional revenue that could be used to fund transportation improvements and systems operations to help meet Maryland GHG reduction goals.
  - **Congestion Pricing and Managed Lanes** – Establish as a local pricing option in urban areas that charges motorists more to use a roadway, bridge or tunnel during peak periods, with revenues used to fund transportation improvements and systems operations to help meet Maryland GHG reduction goals.
  - **Parking Impact Fees and Parking Management** – Establish parking pricing policies that ensure effective use of urban street space. Provision of off-street parking should be regulated and managed with appropriate impact fees, taxes, incentives, and regulations.
  - **Employer Commute Incentives** – Strengthen employer commute incentive programs by increasing marketing and financial and/or tax based incentives for employers, schools, and universities to encourage walking, biking, public transportation usage, carpooling, and teleworking.

2. *For your agency's 2020 GHG reduction commitment, summarize total reductions from the above program*

- **0.24 – 2.01 mmt CO_2e**. MDOT consulted with MDE on the modeling methodologies and assumptions required for the MOVES modeling process supporting development of the 2020 emissions reduction estimate.

3. *Identify how your agency will measure and track the success of this policy. How can that be used to calculate or estimate GHG reductions related to this policy?*

- Under development. MDOT will track the deployment of the pricing mechanisms outlined under this strategy, which will assist in tracking GHG reductions related to this policy.

4. *Identify estimated 2020 job creation information for this policy*

- This policy could result in the creation of new jobs necessary to manage and administer the strategies.

5. *Identify 2020 net economic benefit information for this policy.*

- This policy could result in reduced congestion. Economic benefits could be realized in the form of fuel savings and time savings.
- The unfunded portion of this policy has an estimated cost of implementation of **\$300-\$3,690 million** through 2020.

PART 2 – Program-by-Program Summaries

Agency Name: MDOT
New Policy Name (Unfunded): Transportation Technologies

Linkage to old Climate Action Plan terminology:

- Transportation Technologies was included under TLU-10, Transportation Technologies.

1. *Describe the policy, including all programs/initiatives/etc involved:*

- This policy option aims to reduce GHG emissions from on and off-road vehicles/engines through the deployment of technologies designed to cut GHG emission rates per unit of activity through such measures as idling reduction, engine/vehicle replacements, and the promotion of fuel efficient technologies. This policy option also encompasses improvements to transportation system efficiencies through measure such as traffic signal synchronization/optimization and active traffic management.

  The following strategies were identified for further analysis and possible implementation under this policy option:

  - **Active Traffic Management (ATM) / Traffic Management Centers** – Provide real-time, variable-control of speed, lane movement, and traveler information (for drivers and transit users) within a corridor and conduct centralized data collection and analysis of the transportation system. System management decisions are based on inroad detectors, video monitoring, trend analysis, and incident detection (currently performed by CHART).
  - **Traffic Signal Synchronization / Optimization** – Traffic signal operations are synchronized to provide an efficient flow or prioritization of traffic, increasing the efficient operations of the corridor and reducing unwarranted idling at intersections. The system can also provide priority for transit and emergency vehicles. Specific performance measure is "reliability." Traffic Signal Synchronization is currently performed by SHA and local jurisdictions.
  - **Marketing and Education Campaigns –** Initiate marketing and education campaigns to operators of on-and off-road vehicles.
  - **Timing of Highway Construction Schedules –** Consider requiring non-emergency, highway and airport construction be scheduled for off-peak hours that minimize the delay in traffic flow. Include incentives for completing projects ahead of schedule.
  - **Green Port Strategy –** Develop and implement a "Green Port Strategy" consistent with industry trends and initiatives including EPA's Strategy for Sustainable seaports.

- **Reduce Idling Times –** Reduce idling time in light duty vehicles, commercial vehicles (including the use of truck stop electrification), buses, locomotive, and construction equipment.
- **Technology Improvements for On-highway Vehicles –** Promote and incentivize fuel efficiency technologies for medium and heavy-duty trucks (on-highway vehicles).
- **Incentives for Low-GHG Vehicles –** Provide incentives to increase purchases of fuel-efficient or low-GHG vehicles / fleets.
- **Technology Advances for Non-highway Vehicles –** Encourage or incentivize retrofits and/or replacement of old, diesel-powered non-highway engines, such as switchyard locomotives, with new hybrid locomotives.
- **Incentives for Low-Carbon Fuels and Infrastructure –** Incentivize the demand for clean low-carbon fuels and the development of infrastructure to provide for increased availability/accessibility of alternative fuels and plug-in locations for electric vehicles.

2. *For your agency's 2020 GHG reduction commitment, summarize total reductions from the above program*

   - **0.24 mmt CO_2e**. MDOT consulted with MDE on the modeling methodologies and assumptions required for the MOVES modeling process supporting development of the 2020 emissions reduction estimate.

3. *Identify how your agency will measure and track the success of this policy. How can that be used to calculate or estimate GHG reductions related to this policy?*

   - Under development. MDOT will continue to track the success of active traffic management programs in the state and the deployment / availability of new, aftermarket emission reduction technologies and electric vehicle charging stations, which will assist in tracking GHG reductions related to this policy.

4. *Identify estimated 2020 job creation information for this policy*

   - The implementation of these strategies is anticipated to result in minimal to no job creation in the state.

5. *Identify 2020 net economic benefit information for this policy.*

   - This policy could result in reduced congestion. Economic benefits could be realized in the form of fuel savings and time savings.
   - The unfunded portion of this policy has an estimated cost of implementation of **$51 million** through 2020.

PART 2 – Program-by-Program Summaries

Agency Name: MDOT
New Policy Name (Unfunded): Evaluate the Greenhouse Gas Emission Impacts of Major Projects and Plans

Linkage to old Climate Action Plan terminology:

- This policy option was included under TLU-11, Evaluate the GHG Emissions from Major Projects.

1. *Describe the policy, including all programs/initiatives/etc involved:*
   - This policy option focuses on the process of evaluating GHG emissions of all state and local major projects. The goals of this policy are to understand the impacts of new, major projects on the Governor's GHG reduction commitment; and to develop guidance for the state and other major project sponsors to use. MDOT's working group identified three potential unfunded implementation strategies for this policy option:
     - Participate in Framing National Policy
     - Evaluation of GHG Emissions through the NEPA Process
     - Evaluation of GHG Emissions through Statewide/Regional Planning

2. *For your agency's 2020 GHG reduction commitment, summarize total reductions from the above program*
   - The strategies under this policy option are assumed to contribute to the overall goal of reducing GHG emissions from the transportation sector; however, it is unclear what the GHG emissions impact of implementing these strategies will be at this time.

3. *Identify how your agency will measure and track the success of this policy. How can that be used to calculate or estimate GHG reductions related to this policy?*
   - MDOT will continue to participate in the national discussion on evaluating the impact of major projects on climate change and investigate the potential for including the impact of GHGs on major capital projects through the current NEPA decision-making process. However, as stated in question 2, it is unclear what the GHG emissions impact of implementing these strategies will be at this time.

4. *Identify estimated 2020 job creation information for this policy*
   - Unknown.

5. *Identify 2020 net economic benefit information for this policy.*
   - Unknown.

Refined Economic Impact Analysis for the Greenhouse Gas Emissions Reduction Act 2012 Plan – Appendices A through B

Prepared for
Maryland Department of the Environment

June 15, 2013

Regional Economic Studies Institute

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Appendix A—Detailed Impacts

A.1 Energy

Figure 1: Regional Greenhouse Gas Initiative—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	6.1	1.9	8.0
2011	6.3	2.2	8.6
2012	6.4	2.3	8.7
2013	6.1	2.2	8.3
2014	6.4	2.0	8.4
2015	5.9	1.9	7.8
2016	6.1	1.7	7.8
2017	6.4	2.2	8.6
2018	6.6	2.3	8.9
2019	5.9	1.8	7.7
2020	6.2	1.9	8.0
Average	***6.2***	***2.0***	***8.3***

Source: RESI

Figure 2: Regional Greenhouse Gas Initiative—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$483,305	$157,564	$640,869
2011	$506,319	$165,067	$671,387
2012	$506,319	$165,067	$671,387
2013	$483,305	$157,564	$640,869
2014	$529,334	$172,570	$701,904
2015	$460,290	$150,061	$610,352
2016	$506,319	$165,067	$671,387
2017	$506,319	$165,067	$671,387
2018	$552,348	$180,073	$732,422
2019	$552,348	$180,073	$732,422
2020	$552,348	$180,073	$732,422
Average	***$512,596***	***$167,114***	***$679,710***

Source: RESI

Figure 3: Regional Greenhouse Gas Initiative—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$241,652	$78,782	$320,435
2011	$241,652	$78,782	$320,435
2012	$264,667	$86,285	$350,952
2013	$276,174	$90,037	$366,211
2014	$276,174	$90,037	$366,211
2015	$299,189	$97,540	$396,729
2016	$310,696	$101,291	$411,987
2017	$345,218	$112,546	$457,764
2018	$379,740	$123,801	$503,540
2019	$333,710	$108,794	$442,505
2020	$356,725	$116,297	$473,022
Average	***$302,327***	***$98,563***	***$400,890***

Source: RESI

Figure 4: Regional Greenhouse Initiative—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	228.6	69.8	298.4
2011	211.5	54.7	266.1
2012	192.7	37.7	230.4
2013	174.8	21.8	196.7
2014	158.9	8.9	167.8
2015	145.1	-2.0	143.0
2016	133.6	-10.5	123.1
2017	125.2	-16.9	108.3
2018	118.2	-21.5	96.7
2019	114.4	-24.3	90.1
2020	113.1	-25.4	87.7
Average	***156.0***	***8.4***	***164.4***

Source: RESI

Figure 5: Regional Greenhouse Initiative—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$19,808,280	$1,065,743	$20,874,023
2011	$16,333,143	$878,771	$17,211,914
2012	$12,973,844	$698,031	$13,671,875
2013	$9,904,140	$532,872	$10,437,012
2014	$7,558,423	$406,665	$7,965,088
2015	$5,502,300	$296,040	$5,798,340
2016	$3,938,488	$211,902	$4,150,391
2017	$2,780,109	$149,578	$2,929,688
2018	$1,853,406	$99,719	$1,953,125
2019	$1,332,136	$71,673	$1,403,809
2020	$1,042,541	$56,092	$1,098,633
Average	***$7,547,892***	***$406,099***	***$7,953,991***

Source: RESI

Figure 6: Regional Greenhouse Initiative—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$10,686,046	$574,941	$11,260,986
2011	$10,671,566	$574,161	$11,245,728
2012	$10,454,370	$562,476	$11,016,846
2013	$10,063,417	$541,441	$10,604,858
2014	$9,802,782	$527,418	$10,330,200
2015	$9,585,586	$515,733	$10,101,318
2016	$9,310,471	$500,931	$9,811,401
2017	$9,223,592	$496,256	$9,719,849
2018	$9,165,673	$493,140	$9,658,813
2019	$9,194,633	$494,698	$9,689,331
2020	$9,368,390	$504,047	$9,872,437
Average	***$9,775,139***	***$525,931***	***$10,301,070***

Source: RESI

Figure 7: GHG Reductions from Imported Power—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.1	0.0	0.1
2013	-0.2	-0.3	-0.5
2014	0.1	0.1	0.1
2015	-0.2	-0.1	-0.3
2016	0.0	0.0	0.0
2017	0.0	-0.1	0.0
2018	0.0	-0.1	-0.1
2019	-0.2	-0.3	-0.5
2020	-0.5	-0.5	-1.0
Average	***-0.1***	***-0.1***	***-0.2***

Source: RESI

Figure 8: GHG Reductions from Imported Power—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	-$11,813	-$18,704	-$30,518
2014	$23,627	$37,409	$61,035
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	-$23,627	-$37,409	-$61,035
2019	$0	$0	$0
2020	-$23,627	-$37,409	-$61,035
Average	***-$3,222***	***-$5,101***	***-$8,323***

Source: RESI

Figure 9: GHG Reductions from Imported Power—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	-$5,907	-$9,352	-$15,259
2012	$0	$0	$0
2013	$0	$0	$0
2014	$5,907	$9,352	$15,259
2015	$5,907	$9,352	$15,259
2016	$0	$0	$0
2017	$11,813	$18,704	$30,518
2018	$0	$0	$0
2019	$0	$0	$0
2020	-$5,907	-$9,352	-$15,259
Average	***$1,074***	***$1,700***	***$2,774***

Source: RESI

Figure 10: GHG Reductions from Imported Power—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	2.1	1.7	3.8
2011	3.7	3.2	6.9
2012	4.9	4.3	9.1
2013	5.9	5.4	11.3
2014	6.7	5.6	12.3
2015	6.5	5.7	12.2
2016	7.2	6.3	13.5
2017	8.1	6.9	15.0
2018	8.3	7.3	15.6
2019	8.2	7.1	15.3
2020	7.4	6.3	13.7
Average	***6.3***	***5.4***	***11.7***

Source: RESI

Figure 11: GHG Reductions from Imported Power—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$245,803	$211,961	$457,764
2011	$393,285	$339,137	$732,422
2012	$507,993	$438,052	$946,045
2013	$622,701	$536,967	$1,159,668
2014	$737,409	$635,882	$1,373,291
2015	$721,023	$621,751	$1,342,773
2016	$786,570	$678,274	$1,464,844
2017	$884,891	$763,058	$1,647,949
2018	$884,891	$763,058	$1,647,949
2019	$950,439	$819,581	$1,770,020
2020	$884,891	$763,058	$1,647,949
Average	***$692,718***	***$597,343***	***$1,290,061***

Source: RESI

Figure 12: GHG Reductions from Imported Power—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$57,354	$49,457	$106,812
2011	$98,321	$84,784	$183,105
2012	$147,482	$127,176	$274,658
2013	$188,449	$162,503	$350,952
2014	$213,029	$183,699	$396,729
2015	$229,416	$197,830	$427,246
2016	$262,190	$226,091	$488,281
2017	$294,964	$254,353	$549,316
2018	$327,738	$282,614	$610,352
2019	$335,931	$289,679	$625,610
2020	$319,544	$275,549	$595,093
Average	***$224,947***	***$193,976***	***$418,923***

Source: RESI

Figure 13: Federal New Source Performance Standard—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	12.9	5.2	18.2
2014	13.1	4.8	17.9
2015	12.5	4.7	17.2
2016	12.3	4.5	16.8
2017	12.1	4.3	16.4
2018	11.8	4.1	15.9
2019	11.5	4.1	15.6
2020	11.0	3.4	14.4
Average	***8.8***	***3.2***	***12.0***

Source: RESI

Figure 14: Federal New Source Performance Standard—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$1,031,574	$372,234	$1,403,809
2014	$1,054,000	$380,326	$1,434,326
2015	$1,031,574	$372,234	$1,403,809
2016	$986,723	$356,050	$1,342,773
2017	$986,723	$356,050	$1,342,773
2018	$986,723	$356,050	$1,342,773
2019	$986,723	$356,050	$1,342,773
2020	$941,872	$339,866	$1,281,738
Average	***$727,810***	***$262,624***	***$990,434***

Source: RESI

Figure 15: Federal New Source Performance Standard—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$515,787	$186,117	$701,904
2014	$538,213	$194,209	$732,422
2015	$594,277	$214,439	$808,716
2016	$627,915	$226,577	$854,492
2017	$650,340	$234,669	$885,010
2018	$683,979	$246,807	$930,786
2019	$706,404	$254,900	$961,304
2020	$661,553	$238,715	$900,269
Average	***$452,588***	***$163,312***	***$615,900***

Source: RESI

Figure 16: Federal New Source Performance Standard—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	4.0	3.4	7.4
2012	6.3	5.5	11.9
2013	8.5	7.7	16.2
2014	10.1	8.6	18.8
2015	11.0	9.6	20.6
2016	12.5	10.9	23.4
2017	13.3	11.4	24.7
2018	14.1	12.2	26.3
2019	14.1	12.2	26.3
2020	13.9	12.0	25.9
Average	***9.8***	***8.5***	***18.3***

Source: RESI

Figure 17: Federal New Source Performance Standard—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$441,510	$382,465	$823,975
2012	$703,145	$609,111	$1,312,256
2013	$932,076	$807,426	$1,739,502
2014	$1,111,950	$963,245	$2,075,195
2015	$1,210,064	$1,048,237	$2,258,301
2016	$1,373,586	$1,189,891	$2,563,477
2017	$1,471,699	$1,274,883	$2,746,582
2018	$1,537,108	$1,331,544	$2,868,652
2019	$1,569,812	$1,359,875	$2,929,688
2020	$1,569,812	$1,359,875	$2,929,688
Average	***$1,083,706***	***$938,777***	***$2,022,483***

Source: RESI

Figure 18: Federal New Source Performance Standard—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$98,113	$84,992	$183,105
2012	$188,050	$162,902	$350,952
2013	$261,635	$226,646	$488,281
2014	$310,692	$269,142	$579,834
2015	$367,925	$318,721	$686,646
2016	$425,158	$368,299	$793,457
2017	$490,566	$424,961	$915,527
2018	$539,623	$467,457	$1,007,080
2019	$547,799	$474,540	$1,022,339
2020	$555,975	$481,622	$1,037,598
Average	***$344,140***	***$298,117***	***$642,256***

Source: RESI

Figure 19: MACT—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	1.0	0.4	1.5
2013	0.8	0.4	1.3
2014	0.8	0.2	1.0
2015	0.8	0.3	1.0
2016	1.0	0.5	1.5
2017	0.8	0.2	1.0
2018	1.0	0.5	1.5
2019	0.5	0.1	0.6
2020	0.5	0.0	0.5
Average	***0.7***	***0.2***	***0.9***

Source: RESI

Figure 20: MACT—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$88,984	$33,086	$122,070
2013	$66,738	$24,815	$91,553
2014	$88,984	$33,086	$122,070
2015	$44,492	$16,543	$61,035
2016	$88,984	$33,086	$122,070
2017	$88,984	$33,086	$122,070
2018	$44,492	$16,543	$61,035
2019	$88,984	$33,086	$122,070
2020	$44,492	$16,543	$61,035
Average	***$58,649***	***$21,807***	***$80,455***

Source: RESI

Figure 21: MACT—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$44,492	$16,543	$61,035
2013	$33,369	$12,407	$45,776
2014	$33,369	$12,407	$45,776
2015	$33,369	$12,407	$45,776
2016	$55,615	$20,679	$76,294
2017	$44,492	$16,543	$61,035
2018	$44,492	$16,543	$61,035
2019	$44,492	$16,543	$61,035
2020	$33,369	$12,407	$45,776
Average	***$33,369***	***$12,407***	***$45,776***

Source: RESI

Figure 22: MACT—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	196.4	60.4	256.7
2013	180.3	46.7	227.0
2014	163.8	32.9	196.7
2015	148.0	20.1	168.1
2016	134.2	9.1	143.3
2017	123.2	0.2	123.4
2018	113.4	-7.1	106.3
2019	107.1	-12.5	94.6
2020	103.9	-15.4	88.6
Average	***115.5***	***12.2***	***127.7***

Source: RESI

Figure 23: MACT—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$16,420,106	$1,737,853	$18,157,959
2013	$13,384,456	$1,416,570	$14,801,025
2014	$10,817,952	$1,144,939	$11,962,891
2015	$8,444,626	$893,753	$9,338,379
2016	$6,402,461	$677,617	$7,080,078
2017	$4,912,233	$519,896	$5,432,129
2018	$3,532,392	$373,858	$3,906,250
2019	$2,649,294	$280,393	$2,929,688
2020	$2,042,164	$216,136	$2,258,301
Average	***$6,236,880***	***$660,092***	***$6,896,973***

Source: RESI

Figure 24: MACT—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$9,231,135	$976,995	$10,208,130
2013	$9,203,538	$974,074	$10,177,612
2014	$9,079,353	$960,931	$10,040,283
2015	$8,886,175	$940,485	$9,826,660
2016	$8,624,005	$912,738	$9,536,743
2017	$8,417,029	$890,832	$9,307,861
2018	$8,223,851	$870,387	$9,094,238
2019	$8,085,867	$855,783	$8,941,650
2020	$8,085,867	$855,783	$8,941,650
Average	***$7,076,075***	***$748,910***	***$7,824,984***

Source: RESI

Figure 25: Energy Efficiency in the Residential Sector—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	3,483.3	3,035.6	6,518.9
2011	1,854.8	1,657.3	3,512.2
2012	2,071.4	1,916.0	3,987.3
2013	1,889.8	1,752.0	3,641.8
2014	1,799.8	1,667.1	3,466.9
2015	1,561.6	1,445.4	3,007.0
2016	190.3	173.2	363.5
2017	32.2	27.8	60.0
2018	-38.7	-36.5	-75.2
2019	-52.4	-48.3	-100.7
2020	-37.6	-34.1	-71.7
Average	***1,159.5***	***1,050.5***	***2,210.0***

Source: RESI

Figure 26: Energy Efficiency in the Residential Sector—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$220,251,963	$199,547,842	$419,799,805
2011	$116,098,210	$105,184,749	$221,282,959
2012	$129,515,711	$117,340,978	$246,856,689
2013	$115,810,006	$104,923,636	$220,733,643
2014	$108,829,063	$98,598,915	$207,427,979
2015	$92,161,260	$83,497,919	$175,659,180
2016	$2,177,542	$1,972,849	$4,150,391
2017	-$8,421,964	-$7,630,282	-$16,052,246
2018	-$13,033,229	-$11,808,080	-$24,841,309
2019	-$13,609,637	-$12,330,304	-$25,939,941
2020	-$12,232,662	-$11,082,768	-$23,315,430
Average	***$67,049,660***	***$60,746,859***	***$127,796,520***

Source: RESI

Figure 27: Energy Efficiency in the Residential Sector—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$79,624,383	$72,139,533	$151,763,916
2011	$47,265,469	$42,822,421	$90,087,891
2012	$54,182,367	$49,089,117	$103,271,484
2013	$51,892,746	$47,014,725	$98,907,471
2014	$52,084,882	$47,188,800	$99,273,682
2015	$47,889,911	$43,388,165	$91,278,076
2016	$10,879,704	$9,856,990	$20,736,694
2017	$3,882,749	$3,517,763	$7,400,513
2018	-$424,300	-$384,415	-$808,716
2019	-$2,569,820	-$2,328,252	-$4,898,071
2020	-$3,258,307	-$2,952,020	-$6,210,327
Average	***$31,040,889***	***$28,122,984***	***$59,163,874***

Source: RESI

Figure 28: Energy Efficiency in the Residential Sector—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	66.3	67.9	134.2
2011	55.8	57.9	113.7
2012	48.3	50.6	98.9
2013	42.7	45.4	88.1
2014	40.3	42.8	83.1
2015	38.6	41.2	79.8
2016	37.4	40.1	77.5
2017	37.5	39.7	77.2
2018	36.7	39.0	75.7
2019	35.8	38.2	74.1
2020	37.3	39.3	76.6
Average	***43.3***	***45.6***	***89.0***

Source: RESI

Figure 29: Energy Efficiency in the Residential Sector—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$1,203,874	-$1,268,050	-$2,471,924
2011	-$1,768,654	-$1,862,938	-$3,631,592
2012	-$2,169,945	-$2,285,621	-$4,455,566
2013	-$2,452,335	-$2,583,065	-$5,035,400
2014	-$2,556,374	-$2,692,650	-$5,249,023
2015	-$2,615,824	-$2,755,270	-$5,371,094
2016	-$2,645,549	-$2,786,580	-$5,432,129
2017	-$2,645,549	-$2,786,580	-$5,432,129
2018	-$2,675,275	-$2,817,889	-$5,493,164
2019	-$2,645,549	-$2,786,580	-$5,432,129
2020	-$2,586,099	-$2,723,960	-$5,310,059
Average	***-$2,360,457***	***-$2,486,289***	***-$4,846,746***

Source: RESI

Figure 30: Energy Efficiency in the Residential Sector—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$601,937	$634,025	$1,235,962
2011	$468,173	$493,131	$961,304
2012	$364,135	$383,546	$747,681
2013	$274,959	$289,616	$564,575
2014	$222,940	$234,824	$457,764
2015	$215,508	$226,997	$442,505
2016	$185,783	$195,687	$381,470
2017	$215,508	$226,997	$442,505
2018	$193,214	$203,514	$396,729
2019	$200,646	$211,342	$411,987
2020	$260,096	$273,961	$534,058
Average	***$291,173***	***$306,695***	***$597,867***

Source: RESI

Figure 31: Energy Efficiency in the Commercial and Industrial Sectors—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	2,362.8	892.4	3,255.3
2011	1,666.3	652.0	2,318.3
2012	2,099.2	817.0	2,916.2
2013	2,107.1	822.5	2,929.6
2014	2,248.7	879.1	3,127.8
2015	2,277.2	896.2	3,173.4
2016	4,058.1	1,608.0	5,666.1
2017	4,097.4	1,658.4	5,755.8
2018	4,107.6	1,681.7	5,789.3
2019	4,106.2	1,682.4	5,788.6
2020	4,117.3	1,690.3	5,807.6
Average	***3,022.5***	***1,207.3***	***4,229.8***

Source: RESI

Figure 32: Energy Efficiency in the Commercial and Industrial Sectors—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$178,819,309	$71,424,832	$250,244,141
2011	$125,675,082	$50,197,720	$175,872,803
2012	$158,255,088	$63,210,976	$221,466,064
2013	$157,557,257	$62,932,245	$220,489,502
2014	$169,267,741	$67,609,701	$236,877,441
2015	$172,102,681	$68,742,045	$240,844,727
2016	$316,161,261	$126,282,587	$442,443,848
2017	$320,784,394	$128,129,180	$448,913,574
2018	$324,229,937	$129,505,415	$453,735,352
2019	$324,229,937	$129,505,415	$453,735,352
2020	$325,494,756	$130,010,615	$455,505,371
Average	***$233,870,677***	***$93,413,703***	***$327,284,379***

Source: RESI

Figure 33: Energy Efficiency in the Commercial and Industrial Sectors—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$82,256,882	$32,855,423	$115,112,305
2011	$61,921,637	$24,733,026	$86,654,663
2012	$79,901,701	$31,914,705	$111,816,406
2013	$82,344,111	$32,890,264	$115,234,375
2014	$91,110,619	$36,391,823	$127,502,441
2015	$95,515,680	$38,151,313	$133,666,992
2016	$175,013,947	$69,904,877	$244,918,823
2017	$185,176,117	$73,963,898	$259,140,015
2018	$193,833,589	$77,421,905	$271,255,493
2019	$198,663,891	$79,351,246	$278,015,137
2020	$203,156,181	$81,145,577	$284,301,758
Average	***$131,717,668***	***$52,611,278***	***$184,328,946***

Source: RESI

Figure 34: Energy Efficiency in the Commercial and Industrial Sectors—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	164.4	146.7	311.1
2011	399.4	356.4	755.8
2012	703.3	627.4	1,330.7
2013	1,080.7	963.3	2,043.9
2014	1,547.3	1,371.6	2,918.9
2015	2,069.8	1,825.0	3,894.8
2016	2,346.7	2,052.1	4,398.8
2017	2,533.1	2,197.0	4,730.0
2018	2,639.2	2,268.3	4,907.5
2019	2,663.4	2,270.1	4,933.5
2020	2,645.3	2,234.7	4,880.0
Average	***1,708.4***	***1,483.0***	***3,191.4***

Source: RESI

Figure 35: Energy Efficiency in the Commercial and Industrial Sectors—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$12,856,996	$11,160,338	$24,017,334
2011	$32,575,413	$28,276,638	$60,852,051
2012	$59,514,658	$51,660,879	$111,175,537
2013	$94,965,333	$82,433,349	$177,398,682
2014	$141,328,934	$122,678,634	$264,007,568
2015	$195,811,883	$169,971,808	$365,783,691
2016	$233,680,392	$202,843,046	$436,523,438
2017	$264,524,113	$229,616,512	$494,140,625
2018	$290,172,757	$251,880,465	$542,053,223
2019	$308,143,145	$267,479,413	$575,622,559
2020	$322,094,701	$279,589,869	$601,684,570
Average	***$177,788,030***	***$154,326,450***	***$332,114,480***

Source: RESI

Figure 36: Energy Efficiency in the Commercial and Industrial Sectors—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$3,201,996	$2,779,449	$5,981,445
2011	$8,168,358	$7,090,431	$15,258,789
2012	$15,054,284	$13,067,664	$28,121,948
2013	$23,908,785	$20,753,691	$44,662,476
2014	$35,989,786	$31,240,438	$67,230,225
2015	$50,529,464	$43,861,405	$94,390,869
2016	$60,388,672	$52,419,555	$112,808,228
2017	$68,181,286	$59,183,826	$127,365,112
2018	$74,234,039	$64,437,836	$138,671,875
2019	$76,913,261	$66,763,497	$143,676,758
2020	$77,958,811	$67,671,072	$145,629,883
Average	***$44,957,158***	***$39,024,442***	***$83,981,601***

Source: RESI

Figure 37: Energy Efficiency – Appliances and Other Products—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	-13.2	-12.2	-25.4
2012	-31.6	-29.3	-60.9
2013	-49.1	-45.4	-94.6
2014	-64.7	-60.2	-124.9
2015	-82.1	-76.2	-158.3
2016	-96.3	-89.2	-185.5
2017	-95.2	-88.3	-183.4
2018	-86.0	-79.7	-165.7
2019	-72.9	-67.4	-140.2
2020	-59.4	-55.0	-114.3
Average	***-59.1***	***-54.8***	***-113.9***

Source: RESI

Figure 38: Energy Efficiency – Appliances and Other Products—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	-$855,257	-$792,692	-$1,647,949
2012	-$2,011,438	-$1,864,294	-$3,875,732
2013	-$3,088,429	-$2,862,499	-$5,950,928
2014	-$4,054,553	-$3,757,947	-$7,812,500
2015	-$5,131,543	-$4,756,152	-$9,887,695
2016	-$5,986,801	-$5,548,844	-$11,535,645
2017	-$5,828,420	-$5,402,049	-$11,230,469
2018	-$5,226,572	-$4,844,229	-$10,070,801
2019	-$4,339,639	-$4,022,178	-$8,361,816
2020	-$3,484,381	-$3,229,486	-$6,713,867
Average	***-$3,637,003***	***-$3,370,943***	***-$7,007,946***

Source: RESI

Figure 39: Energy Efficiency – Appliances and Other Products—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	-$308,843	-$286,250	-$595,093
2012	-$760,229	-$704,615	-$1,464,844
2013	-$1,235,372	-$1,145,000	-$2,380,371
2014	-$1,750,110	-$1,622,083	-$3,372,192
2015	-$2,328,200	-$2,157,884	-$4,486,084
2016	-$2,898,372	-$2,686,345	-$5,584,717
2017	-$3,048,834	-$2,825,800	-$5,874,634
2018	-$2,961,724	-$2,745,063	-$5,706,787
2019	-$2,644,962	-$2,451,473	-$5,096,436
2020	-$2,256,929	-$2,091,826	-$4,348,755
Average	***-$1,835,779***	***-$1,701,485***	***-$3,537,265***

Source: RESI

Figure 40: Energy Efficiency – Appliances and Other Products—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	25.8	26.4	52.1
2011	22.2	22.8	45.0
2012	19.0	19.8	38.7
2013	17.0	18.0	35.0
2014	15.6	16.5	32.1
2015	14.5	15.4	29.8
2016	14.4	15.3	29.7
2017	14.3	15.2	29.5
2018	14.2	15.1	29.3
2019	14.3	15.3	29.5
2020	14.3	15.0	29.4
Average	***16.9***	***17.7***	***34.6***

Source: RESI

Figure 41: Energy Efficiency – Appliances and Other Products—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$461,593	-$484,452	-$946,045
2011	-$670,054	-$703,237	-$1,373,291
2012	-$848,735	-$890,767	-$1,739,502
2013	-$938,076	-$984,532	-$1,922,607
2014	-$1,012,526	-$1,062,669	-$2,075,195
2015	-$1,072,086	-$1,125,179	-$2,197,266
2016	-$1,042,306	-$1,093,924	-$2,136,230
2017	-$1,042,306	-$1,093,924	-$2,136,230
2018	-$1,042,306	-$1,093,924	-$2,136,230
2019	-$982,746	-$1,031,414	-$2,014,160
2020	-$1,012,526	-$1,062,669	-$2,075,195
Average	***-$920,478***	***-$966,063***	***-$1,886,541***

Source: RESI

Figure 42: Energy Efficiency – Appliances and Other Products—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$238,241	$250,040	$488,281
2011	$193,571	$203,157	$396,729
2012	$148,901	$156,275	$305,176
2013	$119,121	$125,020	$244,141
2014	$81,895	$85,951	$167,847
2015	$67,005	$70,324	$137,329
2016	$81,895	$85,951	$167,847
2017	$96,786	$101,579	$198,364
2018	$96,786	$101,579	$198,364
2019	$104,231	$109,392	$213,623
2020	$119,121	$125,020	$244,141
Average	***$122,505***	***$128,572***	***$251,076***

Source: RESI

Figure 43: Energy Efficiency in the Power Sector – General—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-606.5	-512.9	-1,119.4
2011	-780.2	-668.3	-1,448.5
2012	-1,090.6	-941.9	-2,032.4
2013	-1,340.2	-1,164.3	-2,504.6
2014	-1,668.9	-1,447.7	-3,116.7
2015	-1,813.4	-1,572.1	-3,385.5
2016	-1,909.2	-1,652.8	-3,562.0
2017	-1,979.0	-1,711.0	-3,690.0
2018	-2,020.8	-1,742.9	-3,763.7
2019	-2,023.2	-1,742.1	-3,765.3
2020	-2,014.9	-1,732.2	-3,747.1
Average	***-1,567.9***	***-1,353.5***	***-2,921.4***

Source: RESI

Figure 44: Energy Efficiency in the Power Sector – General—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$69,315,368	-$59,835,023	-$129,150,391
2011	-$85,858,024	-$74,115,120	-$159,973,145
2012	-$118,845,064	-$102,590,483	-$221,435,547
2013	-$144,658,159	-$124,873,091	-$269,531,250
2014	-$181,789,052	-$156,925,547	-$338,714,600
2015	-$196,841,232	-$169,919,022	-$366,760,254
2016	-$207,520,253	-$179,137,461	-$386,657,715
2017	-$216,004,507	-$186,461,313	-$402,465,820
2018	-$222,687,085	-$192,229,907	-$414,916,992
2019	-$225,831,828	-$194,944,540	-$420,776,367
2020	-$228,026,596	-$196,839,127	-$424,865,723
Average	***-$172,488,833***	***-$148,897,330***	***-$321,386,164***

Source: RESI

Figure 45: Energy Efficiency in the Power Sector – General—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$16,559,035	-$14,294,236	-$30,853,271
2011	-$21,898,546	-$18,903,456	-$40,802,002
2012	-$31,496,563	-$27,188,740	-$58,685,303
2013	-$39,776,080	-$34,335,858	-$74,111,938
2014	-$51,904,632	-$44,805,573	-$96,710,205
2015	-$59,013,060	-$50,941,774	-$109,954,834
2016	-$64,974,968	-$56,088,264	-$121,063,232
2017	-$70,191,637	-$60,591,444	-$130,783,081
2018	-$74,818,668	-$64,585,629	-$139,404,297
2019	-$77,046,194	-$66,508,494	-$143,554,688
2020	-$78,512,102	-$67,773,909	-$146,286,011
Average	***-$53,290,135***	***-$46,001,580***	***-$99,291,715***

Source: RESI

Figure 46: Energy Efficiency in the Power Sector – General—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	43.5	36.8	80.3
2011	76.8	65.6	142.3
2012	117.4	101.4	218.8
2013	182.0	158.2	340.2
2014	273.7	237.2	510.8
2015	387.5	335.7	723.2
2016	381.1	330.7	711.8
2017	387.6	335.7	723.4
2018	386.8	334.1	720.9
2019	378.9	326.8	705.7
2020	371.3	319.2	690.5
Average	***271.5***	***234.7***	***506.2***

Source: RESI

Figure 47: Energy Efficiency in the Power Sector – General—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$4,959,962	$4,286,864	$9,246,826
2011	$8,528,515	$7,371,143	$15,899,658
2012	$12,833,697	$11,092,085	$23,925,781
2013	$19,954,434	$17,246,494	$37,200,928
2014	$30,234,487	$26,131,480	$56,365,967
2015	$42,986,336	$37,152,824	$80,139,160
2016	$41,316,646	$35,709,721	$77,026,367
2017	$42,135,121	$36,417,125	$78,552,246
2018	$42,495,251	$36,728,382	$79,223,633
2019	$42,364,294	$36,615,198	$78,979,492
2020	$42,102,382	$36,388,829	$78,491,211
Average	***$29,991,920***	***$25,921,831***	***$55,913,752***

Source: RESI

Figure 48: Energy Efficiency in the Power Sector – General—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$1,178,605	$1,018,661	$2,197,266
2011	$2,128,036	$1,839,249	$3,967,285
2012	$3,380,304	$2,921,576	$6,301,880
2013	$5,385,569	$4,654,714	$10,040,283
2014	$8,454,852	$7,307,477	$15,762,329
2015	$12,539,045	$10,837,419	$23,376,465
2016	$12,940,098	$11,184,047	$24,124,146
2017	$13,807,683	$11,933,895	$25,741,577
2018	$14,454,278	$12,492,743	$26,947,021
2019	$14,601,604	$12,620,076	$27,221,680
2020	$14,658,897	$12,669,594	$27,328,491
Average	***$9,411,725***	***$8,134,496***	***$17,546,220***

Source: RESI

Figure 49: Maryland Renewable Energy Portfolio Standard Program—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	239.4	247.6	487.1
2011	3,563.5	3,685.7	7,249.2
2012	1,329.9	1,368.5	2,698.3
2013	3,160.6	3,280.4	6,441.0
2014	1,848.7	1,920.4	3,769.0
2015	5,333.8	5,553.6	10,887.4
2016	3,565.3	3,717.6	7,282.8
2017	19,821.4	20,641.3	40,462.6
2018	18,972.4	20,952.2	39,924.7
2019	8,713.6	9,055.9	17,769.5
2020	3,108.6	3,318.6	6,427.2
Average	***6,332.5***	***6,703.8***	***13,036.3***

Source: RESI

Figure 50: Maryland Renewable Energy Portfolio Standard Program—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$13,623,408	$14,422,246	$28,045,654
2011	$203,031,768	$214,936,982	$417,968,750
2012	$74,876,859	$79,267,428	$154,144,287
2013	$177,652,797	$188,069,859	$365,722,656
2014	$102,449,806	$108,457,176	$210,906,982
2015	$299,299,898	$316,850,005	$616,149,902
2016	$197,368,937	$208,942,098	$406,311,035
2017	$1,117,178,746	$1,182,686,977	$2,299,865,723
2018	$1,070,304,735	$1,133,064,405	$2,203,369,141
2019	$484,957,744	$513,394,307	$998,352,051
2020	$157,610,526	$166,852,365	$324,462,891
Average	***$354,395,929***	***$375,176,714***	***$729,572,643***

Source: RESI

Figure 51: Maryland Renewable Energy Portfolio Standard Program—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$5,292,227	$5,602,548	$10,894,775
2011	$81,191,953	$85,952,822	$167,144,775
2012	$35,837,420	$37,938,825	$73,776,245
2013	$81,006,651	$85,756,654	$166,763,306
2014	$54,360,214	$57,547,745	$111,907,959
2015	$148,345,422	$157,043,982	$305,389,404
2016	$111,485,135	$118,022,311	$229,507,446
2017	$584,583,547	$618,861,888	$1,203,445,435
2018	$626,313,572	$663,038,845	$1,289,352,417
2019	$331,527,633	$350,967,484	$682,495,117
2020	$153,304,106	$162,293,429	$315,597,534
Average	***$201,204,353***	***$213,002,412***	***$414,206,765***

Source: RESI

Figure 52: Maryland Renewable Energy Portfolio Standard Program—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-186.6	-159.9	-346.5
2011	-334.9	-290.7	-625.6
2012	-451.3	-394.6	-845.9
2013	-546.3	-479.4	-1,025.7
2014	-604.9	-529.6	-1,134.5
2015	-638.0	-555.0	-1,193.0
2016	-683.3	-592.5	-1,275.8
2017	-972.7	-847.3	-1,819.9
2018	-1,309.0	-1,142.1	-2,451.1
2019	-1,536.6	-1,341.2	-2,877.8
2020	-1,685.3	-1,469.3	-3,154.6
Average	***-813.5***	***-709.2***	***-1,522.8***

Source: RESI

Figure 53: Maryland Renewable Energy Portfolio Standard Program—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$20,037,125	-$17,468,978	-$37,506,104
2011	-$34,433,205	-$30,019,920	-$64,453,125
2012	-$45,796,815	-$39,927,062	-$85,723,877
2013	-$55,285,510	-$48,199,597	-$103,485,107
2014	-$62,149,326	-$54,183,682	-$116,333,008
2015	-$67,757,765	-$59,073,290	-$126,831,055
2016	-$73,333,596	-$63,934,470	-$137,268,066
2017	-$102,973,542	-$89,775,481	-$192,749,023
2018	-$137,471,962	-$119,852,257	-$257,324,219
2019	-$162,253,435	-$141,457,503	-$303,710,938
2020	-$180,317,824	-$157,206,590	-$337,524,414
Average	***-$85,619,100***	***-$74,645,348***	***-$160,264,449***

Source: RESI

Figure 54: Maryland Renewable Energy Portfolio Standard Program—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$2,527,058	-$2,203,166	-$4,730,225
2011	-$6,611,110	-$5,763,768	-$12,374,878
2012	-$10,010,411	-$8,727,382	-$18,737,793
2013	-$13,091,791	-$11,413,824	-$24,505,615
2014	-$15,651,457	-$13,645,418	-$29,296,875
2015	-$14,518,356	-$12,657,547	-$27,175,903
2016	-$16,727,494	-$14,583,541	-$31,311,035
2017	-$26,982,459	-$23,524,133	-$50,506,592
2018	-$39,740,027	-$34,646,570	-$74,386,597
2019	-$49,481,428	-$43,139,421	-$92,620,850
2020	-$56,744,682	-$49,471,748	-$106,216,431
Average	***-$22,916,934***	***-$19,979,683***	***-$42,896,618***

Source: RESI

Figure 55: Incentives and Grant Programs to Support Renewable Energy—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	176.1	65.3	241.4
2011	262.4	61.4	323.8
2012	68.5	-63.3	5.1
2013	-77.6	-176.6	-254.2
2014	-112.2	-207.7	-320.0
2015	-107.7	-202.1	-309.8
2016	-135.5	-198.0	-333.5
2017	-101.5	-165.9	-267.3
2018	-88.8	-140.8	-229.6
2019	-52.9	-107.2	-160.2
2020	-21.9	-78.5	-100.4
Average	***-17.4***	***-110.3***	***-127.7***

Source: RESI

Figure 56: Incentives and Grant Programs to Support Renewable Energy—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$2,532,324	$16,083,399	$18,615,723
2011	$3,632,431	$23,070,450	$26,702,881
2012	$631,005	$4,007,667	$4,638,672
2013	-$1,693,751	-$10,757,421	-$12,451,172
2014	-$2,208,518	-$14,026,833	-$16,235,352
2015	-$2,059,070	-$13,077,649	-$15,136,719
2016	-$2,366,270	-$15,028,750	-$17,395,020
2017	-$1,735,264	-$11,021,083	-$12,756,348
2018	-$1,436,367	-$9,122,715	-$10,559,082
2019	-$797,059	-$5,062,316	-$5,859,375
2020	-$257,384	-$1,634,706	-$1,892,090
Average	***-$523,448***	***-$3,324,542***	***-$3,847,989***

Source: RESI

Figure 57: Incentives and Grant Programs to Support Renewable Energy—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$1,181,059	$7,501,192	$8,682,251
2011	$1,922,075	$12,207,564	$14,129,639
2012	$763,848	$4,851,386	$5,615,234
2013	-$199,265	-$1,265,579	-$1,464,844
2014	-$514,767	-$3,269,412	-$3,784,180
2015	-$568,735	-$3,612,173	-$4,180,908
2016	-$898,767	-$5,708,288	-$6,607,056
2017	-$716,108	-$4,548,174	-$5,264,282
2018	-$689,124	-$4,376,794	-$5,065,918
2019	-$406,832	-$2,583,890	-$2,990,723
2020	-$136,995	-$870,086	-$1,007,080
Average	***-$23,965***	***-$152,205***	***-$176,170***

Source: RESI

Figure 58: Incentives and Grant Programs to Support Renewable Energy—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-54.2	30.5	-23.7
2011	-28.5	53.5	25.0
2012	-7.9	72.0	64.0
2013	7.6	85.7	93.3
2014	19.9	94.9	114.8
2015	27.5	100.1	127.6
2016	33.6	103.8	137.3
2017	37.2	105.3	142.4
2018	37.2	104.1	141.3
2019	34.0	100.4	134.4
2020	30.2	95.7	125.9
Average	***12.4***	***86.0***	***98.4***

Source: RESI

Figure 59: Incentives and Grant Programs to Support Renewable Energy—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$796,737	-$5,520,402	-$6,317,139
2011	-$254,032	-$1,760,128	-$2,014,160
2012	$215,542	$1,493,442	$1,708,984
2013	$615,835	$4,266,977	$4,882,813
2014	$954,544	$6,613,815	$7,568,359
2015	$1,216,274	$8,427,281	$9,643,555
2016	$1,447,212	$10,027,397	$11,474,609
2017	$1,639,661	$11,360,828	$13,000,488
2018	$1,778,224	$12,320,897	$14,099,121
2019	$1,862,901	$12,907,607	$14,770,508
2020	$1,916,787	$13,280,967	$15,197,754
Average	***$963,292***	***$6,674,426***	***$7,637,718***

Source: RESI

Figure 60: Incentives and Grant Programs to Support Renewable Energy—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$531,158	-$3,680,268	-$4,211,426
2011	-$444,556	-$3,080,224	-$3,524,780
2012	-$361,803	-$2,506,849	-$2,868,652
2013	-$292,522	-$2,026,814	-$2,319,336
2014	-$240,561	-$1,666,788	-$1,907,349
2015	-$196,297	-$1,360,099	-$1,556,396
2016	-$161,657	-$1,120,082	-$1,281,738
2017	-$138,563	-$960,070	-$1,098,633
2018	-$134,714	-$933,401	-$1,068,115
2019	-$153,959	-$1,066,744	-$1,220,703
2020	-$186,675	-$1,293,428	-$1,480,103
Average	***-$258,406***	***-$1,790,433***	***-$2,048,839***

Source: RESI

Figure 61: Offshore Wind Initiatives to Support Renewable Energy—Investment Phase, Employment Impacts[1]

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	751.8	1,416.1	2,167.9
2018	14.0	11.9	25.9
2019	-3.6	-4.1	-7.7
2020	-12.6	-12.6	-25.1
Average	***187.4***	***352.8***	***540.2***

Source: RESI

Figure 62: Offshore Wind Initiatives to Support Renewable Energy—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$30,574,595	$57,560,171	$88,134,766
2018	$402,297	$757,371	$1,159,668
2019	-$359,950	-$677,647	-$1,037,598
2020	-$783,421	-$1,474,880	-$2,258,301
Average	***$7,458,380***	***$14,041,254***	***$21,499,634***

Source: RESI

[1] Offshore Wind according to MEA data is scheduled for the first investment in 2017. This program is therefore defined as having a lifespan from 2017-2020. Averages are done over this period of time.

Figure 63: Offshore Wind Initiatives to Support Renewable Energy—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$19,490,246	$36,692,616	$56,182,861
2018	$1,042,797	$1,963,184	$3,005,981
2019	$381,124	$717,509	$1,098,633
2020	-$47,640	-$89,689	-$137,329
Average	***$5,216,631***	***$9,820,905***	***$15,037,537***

Source: RESI

Figure 64: Offshore Wind Initiatives to Support Renewable Energy—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	146.1	135.7	281.8
2019	150.8	140.3	291.2
2020	150.6	139.6	290.2
Average	***149.2***	***138.5***	***287.7***

Source: RESI

Figure 65: Offshore Wind Initiatives to Support Renewable Energy—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$8,639,369	$8,023,229	$16,662,598
2019	$8,987,476	$8,346,509	$17,333,984
2020	$8,987,476	$8,346,509	$17,333,984
Average	***$8,871,440***	***$8,238,749***	***$17,110,189***

Source: RESI

Figure 66: Offshore Wind Initiatives to Support Renewable Energy—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$19,652,191	$18,250,641	$37,902,832
2019	$20,546,192	$19,080,883	$39,627,075
2020	$21,210,759	$19,698,055	$40,908,813
Average	***$20,469,714***	***$19,009,860***	***$39,479,574***

Source: RESI

A.2 Transportation

Figure 67: Maryland Clean Cars Program—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	985.6	913.1	1,898.7
2013	915.4	839.9	1,755.3
2014	1,214.1	1,115.1	2,329.2
2015	1,206.7	1,105.5	2,312.2
2016	1,192.5	1,089.7	2,282.2
2017	1,174.9	1,070.8	2,245.8
2018	1,150.6	1,045.9	2,196.5
2019	1,109.0	1,006.0	2,115.0
2020	1,077.2	975.4	2,052.6
Average	***911.5***	***832.9***	***1,744.3***

Source: RESI

Figure 68: Maryland Clean Cars Program—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$55,222,000	$50,460,373	$105,682,373
2013	$51,857,333	$47,385,831	$99,243,164
2014	$69,749,070	$63,734,817	$133,483,887
2015	$70,131,781	$64,084,528	$134,216,309
2016	$69,972,318	$63,938,815	$133,911,133
2017	$69,621,499	$63,618,247	$133,239,746
2018	$69,238,788	$63,268,536	$132,507,324
2019	$67,739,837	$61,898,835	$129,638,672
2020	$66,591,704	$60,849,702	$127,441,406
Average	***$53,647,666***	***$49,021,789***	***$102,669,456***

Source: RESI

Figure 69: Maryland Clean Cars Program—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$19,558,124	$17,871,686	$37,429,810
2013	$20,036,513	$18,308,824	$38,345,337
2014	$27,969,792	$25,558,040	$53,527,832
2015	$29,915,239	$27,335,738	$57,250,977
2016	$31,342,432	$28,639,868	$59,982,300
2017	$32,402,860	$29,608,859	$62,011,719
2018	$33,255,987	$30,388,423	$63,644,409
2019	$33,064,631	$30,213,567	$63,278,198
2020	$32,889,222	$30,053,283	$62,942,505
Average	***$23,675,891***	***$21,634,390***	***$45,310,281***

Source: RESI

Figure 70: Maryland Clean Cars Program—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	-521.4	-485.7	-1,007.1
2013	-514.0	-478.6	-992.6
2014	-496.7	-461.5	-958.3
2015	-476.4	-441.2	-917.6
2016	-454.3	-419.6	-873.9
2017	-432.7	-398.5	-831.1
2018	-411.3	-377.5	-788.8
2019	-396.5	-363.4	-759.9
2020	-386.7	-354.1	-740.8
Average	***-371.8***	***-343.6***	***-715.5***

Source: RESI

Figure 71: Maryland Clean Cars Program—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	-$27,945,502	-$25,826,471	-$53,771,973
2013	-$28,008,942	-$25,885,101	-$53,894,043
2014	-$27,596,580	-$25,504,006	-$53,100,586
2015	-$26,962,176	-$24,917,707	-$51,879,883
2016	-$26,105,730	-$24,126,204	-$50,231,934
2017	-$25,249,284	-$23,334,700	-$48,583,984
2018	-$24,551,440	-$22,689,771	-$47,241,211
2019	-$24,012,196	-$22,191,417	-$46,203,613
2020	-$23,694,994	-$21,898,267	-$45,593,262
Average	***-$21,284,259***	***-$19,670,331***	***-$40,954,590***

Source: RESI

Figure 72: Maryland Clean Cars Program—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	-$10,221,837	-$9,446,743	-$19,668,579
2013	-$10,991,052	-$10,157,630	-$21,148,682
2014	-$11,593,735	-$10,714,614	-$22,308,350
2015	-$11,855,427	-$10,956,462	-$22,811,890
2016	-$11,942,658	-$11,037,079	-$22,979,736
2017	-$11,895,077	-$10,993,106	-$22,888,184
2018	-$11,791,987	-$10,897,833	-$22,689,819
2019	-$11,649,246	-$10,765,915	-$22,415,161
2020	-$11,585,805	-$10,707,285	-$22,293,091
Average	***-$9,411,529***	***-$8,697,879***	***-$18,109,408***

Source: RESI

Figure 73: Federal Medium- and Heavy-Duty GHG Standards—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	-1,037.2	-941.5	-1,978.8
2013	-1,445.4	-1,303.9	-2,749.3
2014	-1,808.9	-1,622.1	-3,431.1
2015	-2,114.9	-1,887.4	-4,002.3
2016	-2,397.1	-2,130.2	-4,527.4
2017	-1,385.2	-1,199.2	-2,584.4
2018	-1,055.9	-899.5	-1,955.4
2019	-824.2	-690.9	-1,515.0
2020	-663.9	-547.9	-1,211.9
Average	***-1,157.5***	***-1,020.2***	***-2,177.8***

Source: RESI

Figure 74: Federal Medium- and Heavy-Duty GHG Standards—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	-$78,654,457	-$69,325,280	-$147,979,736
2013	-$122,434,283	-$107,912,397	-$230,346,680
2014	-$161,915,608	-$142,710,856	-$304,626,465
2015	-$196,141,408	-$172,877,146	-$369,018,555
2016	-$228,031,419	-$200,984,694	-$429,016,113
2017	-$157,081,822	-$138,450,404	-$295,532,227
2018	-$127,689,809	-$112,544,566	-$240,234,375
2019	-$106,732,589	-$94,073,075	-$200,805,664
2020	-$91,290,427	-$80,462,503	-$171,752,930
Average	***-$115,451,984***	***-$101,758,266***	***-$217,210,249***

Source: RESI

Figure 75: Federal Medium- and Heavy-Duty GHG Standards—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	-$23,779,632	-$20,959,138	-$44,738,770
2013	-$35,409,915	-$31,209,958	-$66,619,873
2014	-$47,161,854	-$41,568,004	-$88,729,858
2015	-$57,972,990	-$51,096,834	-$109,069,824
2016	-$68,735,463	-$60,582,774	-$129,318,237
2017	-$43,601,398	-$38,429,852	-$82,031,250
2018	-$33,722,956	-$29,723,089	-$63,446,045
2019	-$25,766,674	-$22,710,498	-$48,477,173
2020	-$19,789,325	-$17,442,120	-$37,231,445
Average	***-$32,358,201***	***-$28,520,206***	***-$60,878,407***

Source: RESI

Figure 76: Federal Medium- and Heavy-Duty GHG Standards—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	155.1	141.4	296.6
2021	151.4	166.1	317.4
2022	168.9	154.1	323.1
2023	167.8	152.7	320.4
2024	164.2	149.4	313.6
2025	160.8	146.1	306.9
Average	***60.5***	***56.9***	***117.4***

Source: RESI

Figure 77: Federal Medium- and Heavy-Duty GHG Standards—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$14,473,649	$13,602,523	$28,076,172
2021	$15,260,261	$14,341,790	$29,602,051
2022	$15,511,976	$14,578,356	$30,090,332
2023	$15,480,512	$14,548,785	$30,029,297
2024	$15,354,654	$14,430,502	$29,785,156
2025	$15,228,796	$14,312,219	$29,541,016
Average	***$5,706,866***	***$5,363,386***	***$11,070,251***

Source: RESI

Figure 78: Federal Medium- and Heavy-Duty GHG Standards—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$5,168,037	$4,856,988	$10,025,024
2021	$5,993,979	$5,633,219	$11,627,197
2022	$6,481,678	$6,091,564	$12,573,242
2023	$6,796,322	$6,387,271	$13,183,594
2024	$6,985,109	$6,564,696	$13,549,805
2025	$7,095,235	$6,668,193	$13,763,428
Average	***$2,407,522***	***$2,262,621***	***$4,670,143***

Source: RESI

Figure 79: Clean Fuel Standard—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	-204.7	-186.0	-390.8
2013	-283.9	-256.1	-540.1
2014	-356.5	-319.8	-676.4
2015	-420.4	-375.1	-795.6
2016	-481.5	-428.1	-909.6
2017	-241.9	-208.1	-450.0
2018	-165.1	-138.4	-303.5
2019	-111.4	-90.2	-201.5
2020	-74.6	-58.0	-132.6
Average	***-212.7***	***-187.3***	***-400.0***

Source: RESI

Figure 80: Clean Fuel Standard—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	-$15,451,308	-$13,601,426	-$29,052,734
2013	-$23,939,790	-$21,073,638	-$45,013,428
2014	-$31,843,978	-$28,031,510	-$59,875,488
2015	-$39,017,800	-$34,346,458	-$73,364,258
2016	-$45,899,475	-$40,404,236	-$86,303,711
2017	-$28,630,365	-$25,202,642	-$53,833,008
2018	-$21,651,308	-$19,059,141	-$40,710,449
2019	-$16,619,895	-$14,630,105	-$31,250,000
2020	-$13,016,753	-$11,458,344	-$24,475,098
Average	***-$21,460,970***	***-$18,891,591***	***-$40,352,561***

Source: RESI

Figure 81: Clean Fuel Standard—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	-$4,698,691	-$4,136,148	-$8,834,839
2013	-$6,954,712	-$6,122,070	-$13,076,782
2014	-$9,300,000	-$8,186,573	-$17,486,572
2015	-$11,515,445	-$10,136,777	-$21,652,222
2016	-$13,820,157	-$12,165,561	-$25,985,718
2017	-$7,750,000	-$6,822,144	-$14,572,144
2018	-$5,339,790	-$4,700,493	-$10,040,283
2019	-$3,432,722	-$3,021,745	-$6,454,468
2020	-$2,020,681	-$1,778,758	-$3,799,438
Average	***-$5,893,836***	***-$5,188,206***	***-$11,082,042***

Source: RESI

Figure 82: Clean Fuel Standard—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	18.3	17.5	35.8
2021	15.4	15.9	31.3
2022	14.2	13.9	28.2
2023	13.0	12.6	25.6
2024	12.0	11.8	23.7
2025	11.4	11.3	22.7
Average	***5.3***	***5.2***	***10.5***

Source: RESI

Figure 83: Clean Fuel Standard—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	-$461,260	-$454,267	-$915,527
2021	-$584,263	-$575,405	-$1,159,668
2022	-$707,266	-$696,543	-$1,403,809
2023	-$768,767	-$757,112	-$1,525,879
2024	-$830,269	-$817,681	-$1,647,949
2025	-$799,518	-$787,396	-$1,586,914
Average	***-$259,459***	***-$255,525***	***-$514,984***

Source: RESI

Figure 84: Clean Fuel Standard—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$299,819	$295,274	$595,093
2021	$307,507	$302,845	$610,352
2022	$261,381	$257,418	$518,799
2023	$230,630	$227,134	$457,764
2024	$199,879	$196,849	$396,729
2025	$215,255	$211,991	$427,246
Average	***$94,654***	***$93,219***	***$187,874***

Source: RESI

Figure 85: Transportation Climate Initiative—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	0.0	0.0	0.0

Source: RESI

Figure 86: Transportation Climate Initiative—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 87: Transportation Climate Initiative—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 88: Transportation Climate Initiative—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.2	0.2	0.5
2014	0.5	0.1	0.6
2015	0.2	0.1	0.3
2016	0.7	0.3	0.9
2017	0.5	0.2	0.6
2018	0.2	0.0	0.2
2019	0.2	0.0	0.3
2020	0.2	0.0	0.2
Average	***0.2***	***0.1***	***0.3***

Source: RESI

Figure 89: Transportation Climate Initiative—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$22,386	$8,131	$30,518
2014	$44,772	$16,263	$61,035
2015	$0	$0	$0
2016	$44,772	$16,263	$61,035
2017	$44,772	$16,263	$61,035
2018	$0	$0	$0
2019	$44,772	$16,263	$61,035
2020	$0	$0	$0
Average	***$18,316***	***$6,653***	***$24,969***

Source: RESI

Figure 90: Transportation Climate Initiative—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$22,386	$8,131	$30,518
2014	$11,193	$4,066	$15,259
2015	$11,193	$4,066	$15,259
2016	$33,579	$12,197	$45,776
2017	$44,772	$16,263	$61,035
2018	$11,193	$4,066	$15,259
2019	$22,386	$8,131	$30,518
2020	$22,386	$8,131	$30,518
Average	***$16,281***	***$5,914***	***$22,195***

Source: RESI

Figure 91: Public Transportation Initiatives—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	761.2	287.7	1,048.9
2011	1,414.1	544.0	1,958.1
2012	1,439.3	563.2	2,002.5
2013	1,446.2	568.9	2,015.1
2014	1,439.8	567.7	2,007.5
2015	1,433.1	567.0	2,000.1
2016	1,429.5	569.3	1,998.8
2017	799.9	323.0	1,122.9
2018	787.8	316.5	1,104.4
2019	792.6	322.7	1,115.3
2020	805.1	334.9	1,140.1
Average	***1,140.8***	***451.4***	***1,592.1***

Source: RESI

Figure 92: Public Transportation Initiatives—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$57,769,773	$22,857,669	$80,627,441
2011	$107,536,617	$42,548,832	$150,085,449
2012	$109,285,891	$43,240,964	$152,526,855
2013	$108,979,768	$43,119,841	$152,099,609
2014	$108,914,170	$43,093,886	$152,008,057
2015	$108,673,645	$42,998,718	$151,672,363
2016	$108,542,450	$42,946,808	$151,489,258
2017	$57,113,795	$22,598,119	$79,711,914
2018	$56,282,890	$22,269,356	$78,552,246
2019	$56,676,477	$22,425,086	$79,101,563
2020	$57,813,505	$22,874,972	$80,688,477
Average	***$85,235,362***	***$33,724,932***	***$118,960,294***

Source: RESI

Figure 93: Public Transportation Initiatives—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$26,545,232	$10,503,107	$37,048,340
2011	$51,319,325	$20,305,431	$71,624,756
2012	$54,697,610	$21,642,111	$76,339,722
2013	$56,599,946	$22,394,805	$78,994,751
2014	$58,633,477	$23,199,409	$81,832,886
2015	$60,295,287	$23,856,935	$84,152,222
2016	$61,804,036	$24,453,899	$86,257,935
2017	$34,974,546	$13,838,320	$48,812,866
2018	$33,881,250	$13,405,737	$47,286,987
2019	$33,651,658	$13,314,895	$46,966,553
2020	$34,187,373	$13,526,860	$47,714,233
Average	***$46,053,613***	***$18,221,955***	***$64,275,568***

Source: RESI

Figure 94: Public Transportation Initiatives—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	459.1	293.5	752.6
2011	485.1	309.5	794.6
2012	489.1	313.5	802.6
2013	485.5	311.2	796.7
2014	480.7	307.8	788.6
2015	474.7	304.1	778.8
2016	470.5	301.7	772.2
2017	452.6	294.5	747.2
2018	449.2	293.3	742.6
2019	441.6	286.7	728.3
2020	438.4	283.7	722.2
Average	***466.1***	***300.0***	***766.0***

Source: RESI

Figure 95: Public Transportation Initiatives—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$28,686,380	$18,463,278	$47,149,658
2011	$30,023,221	$19,323,703	$49,346,924
2012	$29,874,683	$19,228,100	$49,102,783
2013	$29,057,724	$18,702,285	$47,760,010
2014	$28,426,438	$18,295,974	$46,722,412
2015	$27,628,047	$17,782,109	$45,410,156
2016	$26,959,627	$17,351,897	$44,311,523
2017	$25,288,576	$16,276,366	$41,564,941
2018	$24,768,693	$15,941,756	$40,710,449
2019	$24,137,407	$15,535,445	$39,672,852
2020	$23,877,466	$15,368,140	$39,245,605
Average	***$27,157,115***	***$17,479,005***	***$44,636,119***

Source: RESI

Figure 96: Public Transportation Initiatives—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$11,938,733	$7,684,070	$19,622,803
2011	$13,637,635	$8,777,526	$22,415,161
2012	$14,621,698	$9,410,894	$24,032,593
2013	$15,225,134	$9,799,280	$25,024,414
2014	$15,967,823	$10,277,294	$26,245,117
2015	$16,645,527	$10,713,482	$27,359,009
2016	$17,248,962	$11,101,868	$28,350,830
2017	$17,351,082	$11,167,595	$28,518,677
2018	$17,991,652	$11,579,881	$29,571,533
2019	$18,270,160	$11,759,137	$30,029,297
2020	$18,622,938	$11,986,193	$30,609,131
Average	***$16,138,304***	***$10,387,020***	***$26,525,324***

Source: RESI

Figure 97: Initiatives to Double Transit Ridership by 2020—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	6,178.2	2,348.3	8,526.5
2012	8,073.0	3,126.2	11,199.2
2013	8,143.2	3,186.7	11,329.9
2014	8,109.0	3,182.8	11,291.8
2015	8,302.4	3,257.0	11,559.3
2016	8,244.1	3,236.5	11,480.6
2017	8,195.0	3,225.9	11,420.9
2018	8,158.6	3,226.4	11,385.1
2019	8,146.5	3,223.6	11,370.1
2020	8,172.9	3,250.8	11,423.6
Average	***7,247.5***	***2,842.2***	***10,089.7***

Source: RESI

Figure 98: Initiatives to Double Transit Ridership by 2020—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$472,727,370	$185,384,202	$658,111,572
2012	$618,546,172	$242,568,329	$861,114,502
2013	$620,606,751	$243,376,403	$863,983,154
2014	$621,395,909	$243,685,879	$865,081,787
2015	$639,173,877	$250,657,666	$889,831,543
2016	$636,455,668	$249,591,696	$886,047,363
2017	$634,175,879	$248,697,656	$882,873,535
2018	$636,236,457	$249,505,730	$885,742,188
2019	$635,622,668	$249,265,028	$884,887,695
2020	$639,349,246	$250,726,438	$890,075,684
Average	***$559,480,909***	***$219,405,366***	***$778,886,275***

Source: RESI

Figure 99: Initiatives to Double Transit Ridership by 2020—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$221,479,295	$86,855,056	$308,334,351
2012	$305,195,772	$119,685,210	$424,880,981
2013	$321,252,938	$125,982,169	$447,235,107
2014	$336,685,355	$132,034,127	$468,719,482
2015	$358,891,375	$140,742,414	$499,633,789
2016	$369,534,043	$144,916,030	$514,450,073
2017	$378,861,449	$148,573,854	$527,435,303
2018	$389,712,367	$152,829,137	$542,541,504
2019	$396,551,733	$155,511,255	$552,062,988
2020	$404,695,402	$158,704,866	$563,400,269
Average	***$316,623,612***	***$124,166,738***	***$440,790,350***

Source: RESI

Figure 100: Initiatives to Double Transit Ridership by 2020—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	895.1	844.1	1,739.2
2012	909.2	858.6	1,767.8
2013	896.3	847.9	1,744.2
2014	879.2	831.2	1,710.4
2015	855.4	808.8	1,664.2
2016	832.4	787.0	1,619.4
2017	809.6	765.5	1,575.1
2018	785.2	742.8	1,528.0
2019	763.8	722.7	1,486.5
2020	952.9	903.0	1,856.0
2021	84.0	92.2	176.2
2022	75.1	69.2	144.3
2023	76.5	71.0	147.5
2024	87.5	81.8	169.3
2025	104.5	98.1	202.5
Average	***562.9***	***532.7***	***1,095.7***

Source: RESI

Figure 101: Initiatives to Double Transit Ridership by 2020—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$37,162,099	$35,408,701	$72,570,801
2012	$37,646,551	$35,870,295	$73,516,846
2013	$36,365,099	$34,649,305	$71,014,404
2014	$35,177,412	$33,517,656	$68,695,068
2015	$33,474,019	$31,894,633	$65,368,652
2016	$31,754,998	$30,256,720	$62,011,719
2017	$30,035,978	$28,618,807	$58,654,785
2018	$28,504,487	$27,159,576	$55,664,063
2019	$27,285,545	$25,998,147	$53,283,691
2020	$34,692,961	$33,056,063	$67,749,023
2021	$562,589	$536,044	$1,098,633
2022	-$625,098	-$595,605	-$1,220,703
2023	-$562,589	-$536,044	-$1,098,633
2024	$125,020	$119,121	$244,141
2025	$1,281,452	$1,220,990	$2,502,441
Average	***$20,805,033***	***$19,823,401***	***$40,628,433***

Source: RESI

Figure 102: Initiatives to Double Transit Ridership by 2020—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$14,799,204	$14,100,942	$28,900,146
2012	$16,768,264	$15,977,097	$32,745,361
2013	$17,768,422	$16,930,065	$34,698,486
2014	$18,862,344	$17,972,373	$36,834,717
2015	$19,628,090	$18,701,989	$38,330,078
2016	$20,229,747	$19,275,258	$39,505,005
2017	$20,698,571	$19,721,962	$40,420,532
2018	$21,151,767	$20,153,775	$41,305,542
2019	$21,151,767	$20,153,775	$41,305,542
2020	$25,800,936	$24,583,585	$50,384,521
2021	$4,391,316	$4,184,123	$8,575,439
2022	$2,422,256	$2,307,968	$4,730,225
2023	$1,484,609	$1,414,561	$2,899,170
2024	$1,218,942	$1,161,429	$2,380,371
2025	$1,468,981	$1,399,671	$2,868,652
Average	***$12,990,326***	***$12,377,411***	***$25,367,737***

Source: RESI

Figure 103: Intercity Transportation Initiatives—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	372.0	141.2	513.3
2012	392.2	152.3	544.6
2013	395.4	155.1	550.5
2014	324.0	127.2	451.3
2015	306.7	119.1	425.8
2016	303.2	117.5	420.7
2017	0.9	-2.7	-1.9
2018	-5.6	-8.1	-13.7
2019	-5.2	-7.3	-12.5
2020	-2.2	-4.2	-6.4
Average	***189.2***	***71.8***	***261.0***

Source: RESI

Figure 104: Intercity Transportation Initiatives—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$28,689,610	$10,891,689	$39,581,299
2012	$30,326,488	$11,513,111	$41,839,600
2013	$30,392,848	$11,538,304	$41,931,152
2014	$24,907,094	$9,455,699	$34,362,793
2015	$23,535,655	$8,935,048	$32,470,703
2016	$23,270,216	$8,834,277	$32,104,492
2017	-$1,725,358	-$655,013	-$2,380,371
2018	-$2,388,957	-$906,941	-$3,295,898
2019	-$2,344,718	-$890,146	-$3,234,863
2020	-$2,079,278	-$789,375	-$2,868,652
Average	***$13,871,236***	***$5,266,059***	***$19,137,296***

Source: RESI

Figure 105: Intercity Transportation Initiatives—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$13,460,006	$5,109,940	$18,569,946
2012	$15,074,764	$5,722,965	$20,797,729
2013	$15,815,783	$6,004,285	$21,820,068
2014	$13,725,446	$5,210,712	$18,936,157
2015	$13,504,246	$5,126,736	$18,630,981
2016	$13,692,266	$5,198,115	$18,890,381
2017	$232,260	$88,175	$320,435
2018	-$873,739	-$331,705	-$1,205,444
2019	-$1,371,439	-$520,651	-$1,892,090
2020	-$1,559,458	-$592,031	-$2,151,489
Average	***$7,427,285***	***$2,819,685***	***$10,246,970***

Source: RESI

Figure 106: Intercity Transportation Initiatives—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	152.5	145.3	297.8
2012	154.3	147.1	301.4
2013	154.1	147.2	301.3
2014	152.4	145.1	297.5
2015	267.9	255.0	522.9
2016	267.6	254.6	522.2
2017	199.2	188.9	388.0
2018	193.9	184.1	378.0
2019	188.6	178.9	367.5
2020	185.1	175.4	360.4
Average	***174.1***	***165.6***	***339.7***

Source: RESI

Figure 107: Intercity Transportation Initiatives—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$5,960,009	$5,667,188	$11,627,197
2012	$6,022,581	$5,726,686	$11,749,268
2013	$5,928,723	$5,637,439	$11,566,162
2014	$5,803,578	$5,518,443	$11,322,021
2015	$10,449,570	$9,936,172	$20,385,742
2016	$10,355,711	$9,846,925	$20,202,637
2017	$7,571,245	$7,199,263	$14,770,508
2018	$7,258,384	$6,901,772	$14,160,156
2019	$6,976,809	$6,634,031	$13,610,840
2020	$6,789,092	$6,455,537	$13,244,629
Average	***$6,646,882***	***$6,320,314***	***$12,967,196***

Source: RESI

Figure 108: Intercity Transportation Initiatives—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$2,205,673	$2,097,306	$4,302,979
2012	$2,510,713	$2,387,359	$4,898,071
2013	$2,714,072	$2,580,727	$5,294,800
2014	$2,870,503	$2,729,472	$5,599,976
2015	$5,224,785	$4,968,086	$10,192,871
2016	$5,647,148	$5,369,698	$11,016,846
2017	$4,739,850	$4,506,976	$9,246,826
2018	$4,778,957	$4,544,163	$9,323,120
2019	$4,724,207	$4,492,102	$9,216,309
2020	$4,700,742	$4,469,790	$9,170,532
Average	***$3,646,968***	***$3,467,789***	***$7,114,757***

Source: RESI

Figure 109: Bike and Pedestrian Initiatives—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	2,050.8	761.0	2,811.8
2012	2,143.2	808.6	2,951.8
2013	2,136.8	803.5	2,940.3
2014	1,973.8	733.3	2,707.1
2015	1,835.4	667.9	2,503.3
2016	1,622.3	574.2	2,196.5
2017	1,066.2	343.4	1,409.6
2018	1,032.0	319.0	1,351.0
2019	1,017.8	308.4	1,326.2
2020	1,019.5	310.8	1,330.4
Average	***1,445.3***	***511.8***	***1,957.1***

Source: RESI

Figure 110: Bike and Pedestrian Initiatives—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$161,136,001	$57,064,683	$218,200,684
2012	$168,730,803	$59,754,305	$228,485,107
2013	$167,581,441	$59,347,270	$226,928,711
2014	$155,772,313	$55,165,187	$210,937,500
2015	$145,450,594	$51,509,855	$196,960,449
2016	$128,593,290	$45,540,011	$174,133,301
2017	$82,393,457	$29,178,808	$111,572,266
2018	$80,455,318	$28,492,436	$108,947,754
2019	$79,734,150	$28,237,042	$107,971,191
2020	$80,545,464	$28,524,360	$109,069,824
Average	***$113,672,075***	***$40,255,814***	***$153,927,890***

Source: RESI

Figure 111: Bike and Pedestrian Initiatives—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$76,725,527	$27,171,568	$103,897,095
2012	$85,999,298	$30,455,780	$116,455,078
2013	$90,371,379	$32,004,109	$122,375,488
2014	$89,300,896	$31,625,008	$120,925,903
2015	$87,869,828	$31,118,210	$118,988,037
2016	$81,908,922	$29,007,215	$110,916,138
2017	$58,628,714	$20,762,765	$79,391,479
2018	$57,828,668	$20,479,437	$78,308,105
2019	$57,490,621	$20,359,721	$77,850,342
2020	$58,223,057	$20,619,106	$78,842,163
Average	***$67,667,901***	***$23,963,902***	***$91,631,803***

Source: RESI

Figure 112: Bike and Pedestrian Initiatives—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	-0.1	-0.1
2012	0.2	0.3	0.5
2013	-0.2	-0.1	-0.3
2014	0.0	-0.1	-0.1
2015	0.0	-0.1	-0.1
2016	0.2	0.2	0.5
2017	0.0	0.0	0.0
2018	0.0	-0.1	-0.1
2019	0.0	0.1	0.1
2020	0.0	0.0	0.0
2021	0.0	0.0	0.0
2022	0.0	0.0	0.0
2023	0.0	0.0	0.0
2024	0.0	0.0	0.0
2025	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 113: Bike and Pedestrian Initiatives—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$20,158	$10,359	$30,518
2013	-$20,158	-$10,359	-$30,518
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	-$40,317	-$20,718	-$61,035
2019	$40,317	$20,718	$61,035
2020	$0	$0	$0
2021	$0	$0	$0
2022	$0	$0	$0
2023	$0	$0	$0
2024	$0	$0	$0
2025	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 114: Bike and Pedestrian Initiatives—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	-$10,079	-$5,180	-$15,259
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$20,158	$10,359	$30,518
2018	-$10,079	-$5,180	-$15,259
2019	$0	$0	$0
2020	$0	$0	$0
2021	$0	$0	$0
2022	$0	$0	$0
2023	$0	$0	$0
2024	$0	$0	$0
2025	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 115: Pricing Initiatives—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	1,912.3	727.0	2,639.2
2012	1,962.2	766.9	2,729.0
2013	1,979.5	781.2	2,760.7
2014	1,974.0	782.1	2,756.1
2015	54.2	32.1	86.3
2016	4.3	-11.0	-6.7
2017	-9.2	-21.7	-30.9
2018	-0.5	-11.6	-12.1
2019	20.1	9.3	29.4
2020	40.9	29.5	70.5
Average	***721.6***	***280.3***	***1,002.0***

Source: RESI

Figure 116: Pricing Initiatives—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$146,687,985	$56,986,332	$203,674,316
2012	$150,556,292	$58,489,118	$209,045,410
2013	$150,929,936	$58,634,273	$209,564,209
2014	$151,149,726	$58,719,659	$209,869,385
2015	-$2,153,944	-$836,779	-$2,990,723
2016	-$7,165,161	-$2,783,570	-$9,948,730
2017	-$8,747,650	-$3,398,346	-$12,145,996
2018	-$8,132,238	-$3,159,266	-$11,291,504
2019	-$6,242,042	-$2,424,950	-$8,666,992
2020	-$4,263,930	-$1,656,480	-$5,920,410
Average	***$51,147,179***	***$19,869,999***	***$71,017,179***

Source: RESI

Figure 117: Pricing Initiatives—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$68,706,419	$26,691,530	$95,397,949
2012	$74,574,817	$28,971,325	$103,546,143
2013	$77,904,639	$30,264,917	$108,169,556
2014	$81,179,513	$31,537,162	$112,716,675
2015	$4,472,731	$1,737,596	$6,210,327
2016	-$1,263,794	-$490,967	-$1,754,761
2017	-$4,593,615	-$1,784,558	-$6,378,174
2018	-$6,143,136	-$2,386,527	-$8,529,663
2019	-$6,286,000	-$2,442,027	-$8,728,027
2020	-$5,769,493	-$2,241,371	-$8,010,864
Average	***$25,707,462***	***$9,987,007***	***$35,694,469***

Source: RESI

Figure 118: Pricing Initiatives—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	130.8	121.9	252.6
2011	137.8	129.4	267.1
2012	143.3	135.6	278.9
2013	144.7	137.9	282.6
2014	148.1	141.6	289.7
2015	150.2	144.0	294.2
2016	153.5	147.9	301.4
2017	157.7	152.1	309.8
2018	160.6	155.7	316.2
2019	153.7	149.7	303.3
2020	149.4	145.8	295.1
Average	***148.2***	***141.9***	***290.1***

Source: RESI

Figure 119: Pricing Initiatives—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$8,228,911	$7,884,370	$16,113,281
2011	$8,104,230	$7,764,910	$15,869,141
2012	$7,870,455	$7,540,922	$15,411,377
2013	$7,356,148	$7,048,149	$14,404,297
2014	$6,982,106	$6,689,769	$13,671,875
2015	$6,483,384	$6,211,928	$12,695,313
2016	$6,047,003	$5,793,818	$11,840,820
2017	$5,672,961	$5,435,437	$11,108,398
2018	$5,236,580	$5,017,327	$10,253,906
2019	$4,519,667	$4,330,431	$8,850,098
2020	$4,145,626	$3,972,050	$8,117,676
Average	***$6,422,461***	***$6,153,556***	***$12,576,017***

Source: RESI

Figure 120: Pricing Initiatives—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$3,646,904	$3,494,210	$7,141,113
2011	$4,067,700	$3,897,388	$7,965,088
2012	$4,465,119	$4,278,167	$8,743,286
2013	$4,722,273	$4,524,553	$9,246,826
2014	$5,096,314	$4,882,934	$9,979,248
2015	$5,478,148	$5,248,781	$10,726,929
2016	$5,891,152	$5,644,492	$11,535,645
2017	$6,327,534	$6,062,603	$12,390,137
2018	$6,756,123	$6,473,247	$13,229,370
2019	$6,802,878	$6,518,045	$13,320,923
2020	$6,896,388	$6,607,640	$13,504,028
Average	***$5,468,230***	***$5,239,278***	***$10,707,508***

Source: RESI

Figure 121: Transportation Technology Initiatives—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	5.5	2.2	7.6
2012	84.1	31.8	115.9
2013	6.1	2.7	8.8
2014	4.7	1.3	6.0
2015	-1.8	-1.7	-3.5
2016	-2.3	-2.3	-4.7
2017	-2.0	-1.9	-4.0
2018	-2.2	-2.0	-4.2
2019	-1.8	-1.6	-3.4
2020	-1.6	-1.6	-3.3
Average	***8.1***	***2.4***	***10.5***

Source: RESI

Figure 122: Transportation Technology Initiatives—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$445,487	$134,347	$579,834
2012	$6,916,766	$2,085,919	$9,002,686
2013	$445,487	$134,347	$579,834
2014	$375,147	$113,135	$488,281
2015	-$234,467	-$70,709	-$305,176
2016	-$281,360	-$84,851	-$366,211
2017	-$234,467	-$70,709	-$305,176
2018	-$281,360	-$84,851	-$366,211
2019	-$140,680	-$42,425	-$183,105
2020	-$140,680	-$42,425	-$183,105
Average	***$624,534***	***$188,343***	***$812,877***

Source: RESI

Figure 123: Transportation Technology Initiatives—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$199,297	$60,103	$259,399
2012	$3,388,043	$1,021,747	$4,409,790
2013	$410,317	$123,741	$534,058
2014	$328,253	$98,993	$427,246
2015	$46,893	$14,142	$61,035
2016	-$23,447	-$7,071	-$30,518
2017	-$46,893	-$14,142	-$61,035
2018	-$82,063	-$24,748	-$106,812
2019	-$58,617	-$17,677	-$76,294
2020	-$70,340	-$21,213	-$91,553
Average	***$371,949***	***$112,170***	***$484,120***

Source: RESI

Figure 124: Transportation Technology Initiatives—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-500.8	-470.8	-971.6
2011	-462.0	-433.0	-895.1
2012	-420.8	-393.1	-813.9
2013	-386.4	-359.5	-745.8
2014	-344.1	-318.2	-662.3
2015	-306.7	-281.2	-587.9
2016	-271.2	-246.0	-517.3
2017	-239.3	-215.0	-454.3
2018	-209.0	-184.5	-393.4
2019	-202.1	-177.2	-379.3
2020	-192.7	-168.2	-360.9
Average	***-321.4***	***-295.2***	***-616.5***

Source: RESI

Figure 125: Transportation Technology Initiatives—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$20,727,686	-$19,036,718	-$39,764,404
2011	-$20,282,272	-$18,627,640	-$38,909,912
2012	-$19,693,688	-$18,087,074	-$37,780,762
2013	-$19,136,920	-$17,575,727	-$36,712,646
2014	-$18,261,998	-$16,772,181	-$35,034,180
2015	-$17,657,507	-$16,217,005	-$33,874,512
2016	-$17,053,016	-$15,661,828	-$32,714,844
2017	-$16,607,601	-$15,252,750	-$31,860,352
2018	-$16,257,633	-$14,931,332	-$31,188,965
2019	-$16,671,232	-$15,311,190	-$31,982,422
2020	-$16,703,047	-$15,340,410	-$32,043,457
Average	***-$18,095,691***	***-$16,619,441***	***-$34,715,132***

Source: RESI

Figure 126: Transportation Technology Initiatives—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$7,802,709	-$7,166,163	-$14,968,872
2011	-$7,834,525	-$7,195,383	-$15,029,907
2012	-$7,540,233	-$6,925,099	-$14,465,332
2013	-$7,110,726	-$6,530,632	-$13,641,357
2014	-$6,482,373	-$5,953,540	-$12,435,913
2015	-$5,702,898	-$5,237,654	-$10,940,552
2016	-$4,875,699	-$4,477,939	-$9,353,638
2017	-$3,976,916	-$3,652,479	-$7,629,395
2018	-$3,101,995	-$2,848,933	-$5,950,928
2019	-$2,799,749	-$2,571,345	-$5,371,094
2020	-$2,433,873	-$2,235,317	-$4,669,189
Average	***-$5,423,790***	***-$4,981,317***	***-$10,405,107***

Source: RESI

Figure 127: Electric Vehicle Initiatives—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	19.9	7.7	27.7
2011	20.4	8.0	28.3
2012	20.7	8.4	29.1
2013	20.6	8.6	29.3
2014	20.3	8.0	28.3
2015	20.2	8.2	28.4
2016	19.8	7.9	27.7
2017	20.6	8.4	29.0
2018	20.7	8.9	29.6
2019	20.4	8.6	29.0
2020	20.9	8.9	29.8
Average	***20.4***	***8.3***	***28.7***

Source: RESI

Figure 128: Electric Vehicle Initiatives—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$1,495,837	$609,876	$2,105,713
2011	$1,517,515	$618,715	$2,136,230
2012	$1,560,873	$636,393	$2,197,266
2013	$1,560,873	$636,393	$2,197,266
2014	$1,560,873	$636,393	$2,197,266
2015	$1,517,515	$618,715	$2,136,230
2016	$1,474,158	$601,037	$2,075,195
2017	$1,560,873	$636,393	$2,197,266
2018	$1,604,231	$654,070	$2,258,301
2019	$1,647,588	$671,748	$2,319,336
2020	$1,604,231	$654,070	$2,258,301
Average	***$1,554,961***	***$633,982***	***$2,188,943***

Source: RESI

Figure 129: Electric Vehicle Initiatives—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$682,882	$278,422	$961,304
2011	$726,240	$296,099	$1,022,339
2012	$791,276	$322,616	$1,113,892
2013	$812,955	$331,454	$1,144,409
2014	$812,955	$331,454	$1,144,409
2015	$856,312	$349,132	$1,205,444
2016	$856,312	$349,132	$1,205,444
2017	$910,509	$371,229	$1,281,738
2018	$943,027	$384,487	$1,327,515
2019	$975,546	$397,745	$1,373,291
2020	$997,224	$406,584	$1,403,809
Average	***$851,385***	***$347,123***	***$1,198,509***

Source: RESI

Figure 130: Electric Vehicle Initiatives—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-9.9	-9.7	-19.7
2011	-8.9	-8.5	-17.4
2012	-7.4	-7.2	-14.6
2013	-6.7	-6.4	-13.1
2014	-5.8	-5.7	-11.6
2015	-5.4	-5.4	-10.9
2016	-4.4	-4.3	-8.6
2017	-3.7	-3.7	-7.4
2018	-3.0	-2.9	-5.8
2019	-2.8	-2.6	-5.4
2020	-3.0	-2.9	-5.9
Average	***-5.5***	***-5.4***	***-10.9***

Source: RESI

Figure 131: Electric Vehicle Initiatives—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$386,134	-$376,805	-$762,939
2011	-$355,244	-$346,661	-$701,904
2012	-$308,908	-$301,444	-$610,352
2013	-$293,462	-$286,372	-$579,834
2014	-$262,571	-$256,227	-$518,799
2015	-$278,017	-$271,300	-$549,316
2016	-$278,017	-$271,300	-$549,316
2017	-$216,235	-$211,011	-$427,246
2018	-$216,235	-$211,011	-$427,246
2019	-$185,345	-$180,866	-$366,211
2020	-$247,126	-$241,155	-$488,281
Average	***-$275,209***	***-$268,559***	***-$543,768***

Source: RESI

Figure 132: Electric Vehicle Initiatives—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$146,731	-$143,186	-$289,917
2011	-$139,008	-$135,650	-$274,658
2012	-$115,840	-$113,041	-$228,882
2013	-$100,395	-$97,969	-$198,364
2014	-$100,395	-$97,969	-$198,364
2015	-$77,227	-$75,361	-$152,588
2016	-$61,782	-$60,289	-$122,070
2017	-$30,891	-$30,144	-$61,035
2018	-$7,723	-$7,536	-$15,259
2019	$15,445	$15,072	$30,518
2020	$7,723	$7,536	$15,259
Average	***-$68,802***	***-$67,140***	***-$135,942***

Source: RESI

Figure 133: Low-Emitting Vehicles Initiatives—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	33.1	12.3	45.4
2011	8.9	3.7	12.6
2012	8.5	3.2	11.7
2013	8.0	3.0	11.0
2014	7.9	2.6	10.5
2015	7.0	2.1	9.1
2016	6.9	1.9	8.8
2017	7.2	2.2	9.4
2018	7.1	2.2	9.3
2019	7.1	2.1	9.3
2020	6.9	1.9	8.7
Average	***9.9***	***3.4***	***13.3***

Source: RESI

Figure 134: Low-Emitting Vehicles Initiatives—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$2,615,204	$894,318	$3,509,521
2011	$682,227	$233,300	$915,527
2012	$636,745	$217,747	$854,492
2013	$614,004	$209,970	$823,975
2014	$636,745	$217,747	$854,492
2015	$545,782	$186,640	$732,422
2016	$500,300	$171,087	$671,387
2017	$591,264	$202,194	$793,457
2018	$591,264	$202,194	$793,457
2019	$636,745	$217,747	$854,492
2020	$545,782	$186,640	$732,422
Average	***$781,460***	***$267,235***	***$1,048,695***

Source: RESI

Figure 135: Low-Emitting Vehicles Initiatives—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$1,228,009	$419,940	$1,647,949
2011	$386,595	$132,203	$518,799
2012	$386,595	$132,203	$518,799
2013	$386,595	$132,203	$518,799
2014	$375,225	$128,315	$503,540
2015	$386,595	$132,203	$518,799
2016	$397,966	$136,092	$534,058
2017	$409,336	$139,980	$549,316
2018	$443,448	$151,645	$595,093
2019	$432,077	$147,757	$579,834
2020	$432,077	$147,757	$579,834
Average	***$478,593***	***$163,664***	***$642,256***

Source: RESI

Figure 136: Low-Emitting Vehicles Initiatives—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-5.7	-5.4	-11.1
2011	-4.9	-4.7	-9.6
2012	-4.2	-3.9	-8.0
2013	-3.9	-3.6	-7.5
2014	-3.7	-3.5	-7.1
2015	-3.4	-3.2	-6.6
2016	-2.8	-2.4	-5.2
2017	-1.9	-1.9	-3.7
2018	-2.0	-1.8	-3.9
2019	-2.2	-1.9	-4.1
2020	-2.2	-2.0	-4.3
Average	***-3.3***	***-3.1***	***-6.5***

Source: RESI

Figure 137: Low-Emitting Vehicles Initiatives—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$237,357	-$220,407	-$457,764
2011	-$221,533	-$205,713	-$427,246
2012	-$189,886	-$176,325	-$366,211
2013	-$189,886	-$176,325	-$366,211
2014	-$174,062	-$161,631	-$335,693
2015	-$189,886	-$176,325	-$366,211
2016	-$189,886	-$176,325	-$366,211
2017	-$158,238	-$146,938	-$305,176
2018	-$189,886	-$176,325	-$366,211
2019	-$158,238	-$146,938	-$305,176
2020	-$189,886	-$176,325	-$366,211
Average	***-$189,886***	***-$176,325***	***-$366,211***

Source: RESI

Figure 138: Low-Emitting Vehicles Initiatives—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$87,031	-$80,816	-$167,847
2011	-$87,031	-$80,816	-$167,847
2012	-$71,207	-$66,122	-$137,329
2013	-$63,295	-$58,775	-$122,070
2014	-$71,207	-$66,122	-$137,329
2015	-$55,383	-$51,428	-$106,812
2016	-$47,471	-$44,081	-$91,553
2017	-$15,824	-$14,694	-$30,518
2018	-$15,824	-$14,694	-$30,518
2019	-$15,824	-$14,694	-$30,518
2020	-$23,736	-$22,041	-$45,776
Average	***-$50,348***	***-$46,753***	***-$97,101***

Source: RESI

Figure 139: Airport Initiatives—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 140: Airport Initiatives—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 141: Airport Initiatives—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 142: Airport Initiatives—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 143: Airport Initiatives—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 144: Airport Initiatives—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 145: Port Initiatives—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.5	0.3	0.7
2011	0.0	0.0	0.0
2012	0.0	-0.1	-0.1
2013	-0.2	-0.1	-0.4
2014	0.0	0.1	0.1
2015	-0.2	-0.1	-0.3
2016	0.2	0.1	0.4
2017	0.0	-0.2	-0.2
2018	0.0	0.0	0.0
2019	-0.2	-0.1	-0.3
2020	-0.3	-0.3	-0.5
Average	***0.0***	***0.0***	***-0.1***

Source: RESI

Figure 146: Port Initiatives—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$13,488	$17,029	$30,518
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$13,488	$17,029	$30,518
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$2,452***	***$3,096***	***$5,549***

Source: RESI

Figure 147: Port Initiatives—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	-$6,744	-$8,515	-$15,259
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$6,744	$8,515	$15,259
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 148: Port Initiatives—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 149: Port Initiatives—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 150: Port Initiatives—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 151: Freight and Freight Rail Strategies—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.5	0.5	0.9
2011	0.0	0.0	0.0
2012	0.0	-0.1	-0.1
2013	-0.2	-0.1	-0.4
2014	0.0	0.1	0.1
2015	-0.2	-0.1	-0.3
2016	0.2	0.1	0.3
2017	0.0	-0.2	-0.2
2018	0.0	0.0	-0.1
2019	-0.2	-0.1	-0.3
2020	-0.3	-0.3	-0.6
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 152: Freight and Freight Rail Strategies—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$18,356	$12,161	$30,518
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$18,356	$12,161	$30,518
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$3,338***	***$2,211***	***$5,549***

Source: RESI

Figure 153: Freight and Freight Rail Strategies—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	-$9,178	-$6,081	-$15,259
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$9,178	$6,081	$15,259
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 154: Freight and Freight Rail Strategies—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	-1.2	-1.2	-2.4
2013	-2.6	-2.5	-5.1
2014	-3.4	-3.5	-6.9
2015	-4.0	-3.9	-7.9
2016	-4.4	-4.5	-8.9
2017	-4.5	-4.5	-9.0
2018	-4.5	-4.5	-9.0
2019	-5.0	-5.0	-10.0
2020	-5.2	-5.3	-10.4
Average	***-3.2***	***-3.2***	***-6.3***

Source: RESI

Figure 155: Freight and Freight Rail Strategies—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	-$45,804	-$45,749	-$91,553
2013	-$122,144	-$121,997	-$244,141
2014	-$167,948	-$167,745	-$335,693
2015	-$244,288	-$243,993	-$488,281
2016	-$274,824	-$274,492	-$549,316
2017	-$305,360	-$304,992	-$610,352
2018	-$335,896	-$335,491	-$671,387
2019	-$366,432	-$365,990	-$732,422
2020	-$427,504	-$426,988	-$854,492
Average	***-$208,200***	***-$207,949***	***-$416,149***

Source: RESI

Figure 156: Freight and Freight Rail Strategies—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	-$15,268	-$15,250	-$30,518
2013	-$30,536	-$30,499	-$61,035
2014	-$53,438	-$53,374	-$106,812
2015	-$53,438	-$53,374	-$106,812
2016	-$53,438	-$53,374	-$106,812
2017	-$53,438	-$53,374	-$106,812
2018	-$45,804	-$45,749	-$91,553
2019	-$45,804	-$45,749	-$91,553
2020	-$45,804	-$45,749	-$91,553
Average	***-$36,088***	***-$36,044***	***-$72,132***

Source: RESI

Figure 157: Renewable Fuels Standard—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 158: Renewable Fuels Standard—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 159: Renewable Fuels Standard—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 160: Renewable Fuels Standard—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	-16.1	-15.0	-31.1
2014	-14.7	-13.7	-28.4
2015	-13.4	-12.6	-26.1
2016	-11.9	-10.7	-22.7
2017	-9.9	-9.1	-19.0
2018	-8.7	-7.6	-16.3
2019	-8.0	-7.1	-15.0
2020	-7.5	-6.7	-14.2
Average	***-8.2***	***-7.5***	***-15.7***

Source: RESI

Figure 161: Renewable Fuels Standard—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	-$812,744	-$743,653	-$1,556,396
2014	-$780,872	-$714,490	-$1,495,361
2015	-$796,808	-$729,071	-$1,525,879
2016	-$764,936	-$699,908	-$1,464,844
2017	-$669,319	-$612,420	-$1,281,738
2018	-$669,319	-$612,420	-$1,281,738
2019	-$637,446	-$583,257	-$1,220,703
2020	-$637,446	-$583,257	-$1,220,703
Average	***-$524,444***	***-$479,861***	***-$1,004,306***

Source: RESI

Figure 162: Renewable Fuels Standard—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	-$211,154	-$193,204	-$404,358
2014	-$207,170	-$189,558	-$396,729
2015	-$199,202	-$182,268	-$381,470
2016	-$159,362	-$145,814	-$305,176
2017	-$127,489	-$116,651	-$244,141
2018	-$95,617	-$87,489	-$183,105
2019	-$71,713	-$65,616	-$137,329
2020	-$63,745	-$58,326	-$122,070
Average	***-$103,223***	***-$94,448***	***-$197,671***

Source: RESI

Figure 163: CAFÉ Standards: Model Years 2008-2011—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 164: CAFÉ Standards: Model Years 2008-2011—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 165: CAFÉ Standards: Model Years 2008-2011—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 166: CAFÉ Standards: Model Years 2008-2011—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-10.3	-9.9	-20.2
2011	-9.1	-8.6	-17.7
2012	-8.1	-7.5	-15.6
2013	-7.4	-6.8	-14.1
2014	-6.4	-6.0	-12.4
2015	-5.7	-5.3	-11.1
2016	-5.0	-4.6	-9.5
2017	-4.3	-4.0	-8.3
2018	-3.9	-3.4	-7.3
2019	-3.9	-3.3	-7.2
2020	-3.6	-3.2	-6.9
Average	***-6.2***	***-5.7***	***-11.9***

Source: RESI

Figure 167: CAFÉ Standards: Model Years 2008-2011—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$444,001	-$410,491	-$854,492
2011	-$396,430	-$366,510	-$762,939
2012	-$364,715	-$337,189	-$701,904
2013	-$364,715	-$337,189	-$701,904
2014	-$317,144	-$293,208	-$610,352
2015	-$348,858	-$322,529	-$671,387
2016	-$317,144	-$293,208	-$610,352
2017	-$317,144	-$293,208	-$610,352
2018	-$317,144	-$293,208	-$610,352
2019	-$285,429	-$263,887	-$549,316
2020	-$285,429	-$263,887	-$549,316
Average	***-$341,650***	***-$315,865***	***-$657,515***

Source: RESI

Figure 168: CAFÉ Standards: Model Years 2008-2011—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$142,715	-$131,944	-$274,658
2011	-$134,786	-$124,613	-$259,399
2012	-$118,929	-$109,953	-$228,882
2013	-$107,036	-$98,958	-$205,994
2014	-$95,143	-$87,962	-$183,105
2015	-$87,214	-$80,632	-$167,847
2016	-$55,500	-$51,311	-$106,812
2017	-$47,572	-$43,981	-$91,553
2018	-$31,714	-$29,321	-$61,035
2019	-$23,786	-$21,991	-$45,776
2020	-$23,786	-$21,991	-$45,776
Average	***-$78,926***	***-$72,969***	***-$151,894***

Source: RESI

Figure 169: Promoting Hybrid and Electric Vehicles—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	2.0	0.7	2.7
2014	2.7	0.9	3.6
2015	2.2	0.7	2.8
2016	2.1	0.6	2.7
2017	2.4	1.0	3.4
2018	2.3	1.0	3.3
2019	2.3	1.0	3.3
2020	2.1	0.6	2.7
Average	***1.6***	***0.6***	***2.2***

Source: RESI

Figure 170: Promoting Hybrid and Electric Vehicles—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$156,756	$56,867	$213,623
2014	$223,937	$81,239	$305,176
2015	$179,150	$64,991	$244,141
2016	$134,362	$48,743	$183,105
2017	$223,937	$81,239	$305,176
2018	$179,150	$64,991	$244,141
2019	$223,937	$81,239	$305,176
2020	$179,150	$64,991	$244,141
Average	***$136,398***	***$49,482***	***$185,880***

Source: RESI

Figure 171: Promoting Hybrid and Electric Vehicles—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$89,575	$32,495	$122,070
2014	$100,772	$36,557	$137,329
2015	$111,969	$40,619	$152,588
2016	$111,969	$40,619	$152,588
2017	$156,756	$56,867	$213,623
2018	$111,969	$40,619	$152,588
2019	$123,165	$44,681	$167,847
2020	$134,362	$48,743	$183,105
Average	***$85,503***	***$31,018***	***$116,522***

Source: RESI

Figure 172: Promoting Hybrid and Electric Vehicles—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	50.8	49.5	100.3
2014	45.1	43.9	89.0
2015	40.7	39.5	80.2
2016	36.9	36.2	73.1
2017	34.7	33.8	68.5
2018	31.8	31.3	63.1
2019	29.8	29.5	59.2
2020	28.9	28.3	57.2
Average	***27.2***	***26.5***	***53.7***

Source: RESI

Figure 173: Promoting Hybrid and Electric Vehicles—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	-$1,003,083	-$980,560	-$1,983,643
2014	-$1,280,859	-$1,252,100	-$2,532,959
2015	-$1,543,204	-$1,508,554	-$3,051,758
2016	-$1,728,388	-$1,689,580	-$3,417,969
2017	-$1,820,981	-$1,780,094	-$3,601,074
2018	-$1,944,437	-$1,900,778	-$3,845,215
2019	-$2,006,165	-$1,961,120	-$3,967,285
2020	-$2,037,029	-$1,991,291	-$4,028,320
Average	***-$1,214,922***	***-$1,187,643***	***-$2,402,566***

Source: RESI

Figure 174: Promoting Hybrid and Electric Vehicles—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$671,294	$656,221	$1,327,515
2014	$632,714	$618,507	$1,251,221
2015	$601,850	$588,336	$1,190,186
2016	$555,553	$543,079	$1,098,633
2017	$532,405	$520,451	$1,052,856
2018	$486,109	$475,194	$961,304
2019	$447,529	$437,481	$885,010
2020	$439,813	$429,938	$869,751
Average	***$397,024***	***$388,110***	***$785,134***

Source: RESI

Figure 175: PAYD Insurance in Maryland—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 176: PAYD Insurance in Maryland—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 177: PAYD Insurance in Maryland—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 178: PAYD Insurance in Maryland—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-0.2	-0.2	-0.5
2011	0.0	-0.1	-0.1
2012	-0.2	-0.3	-0.5
2013	-0.5	-0.3	-0.7
2014	0.2	0.1	0.3
2015	0.0	-0.1	-0.1
2016	0.2	0.3	0.6
2017	0.0	-0.2	-0.2
2018	0.0	0.0	0.0
2019	0.0	0.1	0.1
2020	0.3	0.3	0.6
2021	0.0	0.2	0.2
2022	0.0	0.2	0.2
2023	-0.1	-0.1	-0.2
2024	-0.4	-0.2	-0.6
2025	0.0	0.1	0.1
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 179: PAYD Insurance in Maryland—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$27,271	-$3,247	-$30,518
2011	-$27,271	-$3,247	-$30,518
2012	-$54,542	-$6,493	-$61,035
2013	-$54,542	-$6,493	-$61,035
2014	$0	$0	$0
2015	-$54,542	-$6,493	-$61,035
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$54,542	$6,493	$61,035
2020	$54,542	$6,493	$61,035
2021	$0	$0	$0
2022	$0	$0	$0
2023	$0	$0	$0
2024	-$54,542	-$6,493	-$61,035
2025	$0	$0	$0
Average	***-$10,227***	***-$1,217***	***-$11,444***

Source: RESI

Figure 180: PAYD Insurance in Maryland—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$13,636	-$1,623	-$15,259
2011	-$13,636	-$1,623	-$15,259
2012	-$13,636	-$1,623	-$15,259
2013	$0	$0	$0
2014	$13,636	$1,623	$15,259
2015	$0	$0	$0
2016	$13,636	$1,623	$15,259
2017	$13,636	$1,623	$15,259
2018	$0	$0	$0
2019	$13,636	$1,623	$15,259
2020	$13,636	$1,623	$15,259
2021	$27,271	$3,247	$30,518
2022	$54,542	$6,493	$61,035
2023	$27,271	$3,247	$30,518
2024	$27,271	$3,247	$30,518
2025	$0	$0	$0
Average	***$10,227***	***$1,217***	***$11,444***

Source: RESI

A.3 Agriculture and Forestry

Figure 181: Managing Forests to Capture Carbon—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	96.1	291.7	387.8
2011	95.3	288.0	383.4
2012	93.4	284.1	377.5
2013	91.1	280.3	371.4
2014	88.3	274.4	362.7
2015	84.7	268.7	353.4
2016	82.4	263.9	346.3
2017	80.0	259.4	339.5
2018	77.8	254.1	331.9
2019	76.0	252.1	328.1
2020	74.9	249.4	324.3
Average	***85.5***	***269.6***	***355.1***

Source: RESI

Figure 182: Managing Forests to Capture Carbon—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$536,144	$1,691,639	$2,227,783
2011	$543,488	$1,714,812	$2,258,301
2012	$514,111	$1,622,120	$2,136,230
2013	$470,044	$1,483,081	$1,953,125
2014	$418,633	$1,320,869	$1,739,502
2015	$352,533	$1,112,311	$1,464,844
2016	$293,778	$926,926	$1,220,703
2017	$264,400	$834,233	$1,098,633
2018	$235,022	$741,540	$976,563
2019	$220,333	$695,194	$915,527
2020	$176,267	$556,155	$732,422
Average	***$365,887***	***$1,154,444***	***$1,520,330***

Source: RESI

Figure 183: Managing Forests to Capture Carbon—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$389,255	$1,228,176	$1,617,432
2011	$455,355	$1,436,735	$1,892,090
2012	$495,750	$1,564,187	$2,059,937
2013	$525,127	$1,656,879	$2,182,007
2014	$536,144	$1,691,639	$2,227,783
2015	$543,488	$1,714,812	$2,258,301
2016	$554,505	$1,749,572	$2,304,077
2017	$547,161	$1,726,399	$2,273,560
2018	$558,177	$1,761,159	$2,319,336
2019	$543,488	$1,714,812	$2,258,301
2020	$532,472	$1,680,053	$2,212,524
Average	***$516,448***	***$1,629,493***	***$2,145,941***

Source: RESI

Figure 184: Managing Forests to Capture Carbon—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	24.2	23.6	47.8
2013	24.7	24.0	48.7
2014	24.6	23.9	48.5
2015	24.2	23.4	47.6
2016	23.8	23.2	47.0
2017	23.9	23.0	46.9
2018	23.3	22.8	46.1
2019	22.9	22.2	45.0
2020	22.3	21.6	43.9
Average	***19.4***	***18.9***	***38.3***

Source: RESI

Figure 185: Managing Forests to Capture Carbon—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$712,505	$691,304	$1,403,809
2013	$712,505	$691,304	$1,403,809
2014	$743,484	$721,360	$1,464,844
2015	$681,527	$661,247	$1,342,773
2016	$650,548	$631,190	$1,281,738
2017	$650,548	$631,190	$1,281,738
2018	$619,570	$601,134	$1,220,703
2019	$650,548	$631,190	$1,281,738
2020	$588,591	$571,077	$1,159,668
Average	***$546,348***	***$530,090***	***$1,076,438***

Source: RESI

Figure 186: Managing Forests to Capture Carbon—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$178,126	$172,826	$350,952
2013	$216,849	$210,397	$427,246
2014	$232,339	$225,425	$457,764
2015	$263,317	$255,482	$518,799
2016	$271,062	$262,996	$534,058
2017	$286,551	$278,024	$564,575
2018	$286,551	$278,024	$564,575
2019	$294,296	$285,538	$579,834
2020	$271,062	$262,996	$534,058
Average	***$209,105***	***$202,883***	***$411,987***

Source: RESI

Figure 187: Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	1.2	0.4	1.6
2011	1.5	0.6	2.1
2012	1.2	0.5	1.7
2013	1.2	0.6	1.8
2014	1.2	0.4	1.6
2015	1.2	0.4	1.6
2016	1.1	0.4	1.6
2017	1.2	0.3	1.5
2018	1.1	0.5	1.6
2019	0.9	0.4	1.3
2020	0.6	0.0	0.6
Average	***1.1***	***0.4***	***1.5***

Source: RESI

Figure 188: Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$88,819	$33,252	$122,070
2011	$88,819	$33,252	$122,070
2012	$88,819	$33,252	$122,070
2013	$88,819	$33,252	$122,070
2014	$133,228	$49,877	$183,105
2015	$88,819	$33,252	$122,070
2016	$88,819	$33,252	$122,070
2017	$88,819	$33,252	$122,070
2018	$88,819	$33,252	$122,070
2019	$88,819	$33,252	$122,070
2020	$44,409	$16,626	$61,035
Average	***$88,819***	***$33,252***	***$122,070***

Source: RESI

Figure 189: Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$44,409	$16,626	$61,035
2011	$33,307	$12,469	$45,776
2012	$55,512	$20,782	$76,294
2013	$66,614	$24,939	$91,553
2014	$55,512	$20,782	$76,294
2015	$55,512	$20,782	$76,294
2016	$55,512	$20,782	$76,294
2017	$88,819	$33,252	$122,070
2018	$66,614	$24,939	$91,553
2019	$55,512	$20,782	$76,294
2020	$55,512	$20,782	$76,294
Average	***$57,530***	***$21,538***	***$79,068***

Source: RESI

Figure 190: Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	534.1	-113.5	420.6
2014	175.1	-459.7	-284.6
2015	-99.4	-722.7	-822.1
2016	-312.5	-925.3	-1,237.8
2017	-442.5	-1,047.4	-1,489.9
2018	-491.2	-1,090.0	-1,581.2
2019	-547.8	-1,143.8	-1,691.6
2020	-581.1	-1,177.0	-1,758.1
Average	***-160.5***	***-607.2***	***-767.7***

Source: RESI

Figure 191: Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$17,899,855	$67,732,469	$85,632,324
2014	$14,359,434	$54,335,634	$68,695,068
2015	$11,673,818	$44,173,350	$55,847,168
2016	$9,683,528	$36,642,156	$46,325,684
2017	$8,726,658	$33,021,389	$41,748,047
2018	$8,803,207	$33,311,051	$42,114,258
2019	$8,548,042	$32,345,513	$40,893,555
2020	$8,535,284	$32,297,236	$40,832,520
Average	$8,020,893	$30,350,800	$38,371,693

Source: RESI

Figure 192: Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$10,436,266	$39,490,492	$49,926,758
2014	$10,251,271	$38,790,477	$49,041,748
2015	$9,833,438	$37,209,409	$47,042,847
2016	$9,300,780	$35,193,849	$44,494,629
2017	$8,905,273	$33,697,266	$42,602,539
2018	$8,790,449	$33,262,774	$42,053,223
2019	$8,611,833	$32,586,897	$41,198,730
2020	$8,557,611	$32,381,720	$40,939,331
Average	***$6,789,720***	***$25,692,080***	***$32,481,800***

Source: RESI

Figure 193: Increasing Urban Trees to Capture Carbon—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	1.8	3.7	5.5
2011	1.8	3.8	5.6
2012	1.5	3.7	5.3
2013	1.8	3.8	5.7
2014	1.8	3.6	5.4
2015	1.5	3.1	4.7
2016	1.5	3.4	4.9
2017	1.3	3.1	4.4
2018	1.7	3.4	5.1
2019	1.6	3.3	4.8
2020	1.0	2.8	3.8
Average	***1.6***	***3.4***	***5.0***

Source: RESI

Figure 194: Increasing Urban Trees to Capture Carbon—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$28,874	$62,679	$91,553
2011	$28,874	$62,679	$91,553
2012	$28,874	$62,679	$91,553
2013	$38,498	$83,572	$122,070
2014	$48,123	$104,465	$152,588
2015	$19,249	$41,786	$61,035
2016	$38,498	$83,572	$122,070
2017	$19,249	$41,786	$61,035
2018	$19,249	$41,786	$61,035
2019	$38,498	$83,572	$122,070
2020	$19,249	$41,786	$61,035
Average	***$29,749***	***$64,578***	***$94,327***

Source: RESI

Figure 195: Increasing Urban Trees to Capture Carbon—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$19,249	$41,786	$61,035
2011	$14,437	$31,340	$45,776
2012	$14,437	$31,340	$45,776
2013	$24,061	$52,233	$76,294
2014	$24,061	$52,233	$76,294
2015	$14,437	$31,340	$45,776
2016	$14,437	$31,340	$45,776
2017	$19,249	$41,786	$61,035
2018	$19,249	$41,786	$61,035
2019	$19,249	$41,786	$61,035
2020	$19,249	$41,786	$61,035
Average	***$18,374***	***$39,887***	***$58,261***

Source: RESI

Figure 196: Increasing Urban Trees to Capture Carbon—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	121.0	113.2	234.2
2011	151.8	140.4	292.2
2012	175.0	161.0	336.0
2013	189.8	173.9	363.7
2014	199.9	181.3	381.2
2015	205.2	185.3	390.5
2016	209.3	187.6	396.9
2017	210.0	186.9	396.9
2018	208.9	185.1	394.1
2019	203.9	179.3	383.2
2020	198.2	173.3	371.5
Average	***188.4***	***169.8***	***358.2***

Source: RESI

Figure 197: Increasing Urban Trees to Capture Carbon—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$5,474,632	$4,931,862	$10,406,494
2011	$8,203,921	$7,390,561	$15,594,482
2012	$10,451,571	$9,415,373	$19,866,943
2013	$12,169,417	$10,962,907	$23,132,324
2014	$13,694,608	$12,336,886	$26,031,494
2015	$14,866,597	$13,392,681	$28,259,277
2016	$15,926,203	$14,347,234	$30,273,438
2017	$16,728,935	$15,070,381	$31,799,316
2018	$17,467,449	$15,735,676	$33,203,125
2019	$17,884,869	$16,111,713	$33,996,582
2020	$18,173,853	$16,372,046	$34,545,898
Average	***$13,731,096***	***$12,369,756***	***$26,100,852***

Source: RESI

Figure 198: Increasing Urban Trees to Capture Carbon—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$2,006,830	$1,807,867	$3,814,697
2011	$2,785,480	$2,509,320	$5,294,800
2012	$3,451,748	$3,109,532	$6,561,279
2013	$3,933,387	$3,543,420	$7,476,807
2014	$4,390,944	$3,955,614	$8,346,558
2015	$4,800,337	$4,324,418	$9,124,756
2016	$5,105,376	$4,599,214	$9,704,590
2017	$5,370,277	$4,837,853	$10,208,130
2018	$5,587,015	$5,033,102	$10,620,117
2019	$5,595,042	$5,040,334	$10,635,376
2020	$5,570,960	$5,018,639	$10,589,600
Average	***$4,417,945***	***$3,979,938***	***$8,397,883***

Source: RESI

Figure 199: Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.5	1.6	2.1
2011	0.6	1.6	2.1
2012	0.5	1.6	2.2
2013	3.8	14.4	18.2
2014	4.0	14.3	18.3
2015	3.7	14.4	18.1
2016	3.9	14.8	18.7
2017	4.0	14.8	18.9
2018	3.9	15.0	18.9
2019	4.0	14.9	18.9
2020	3.5	14.3	17.7
Average	***3.0***	***11.1***	***14.0***

Source: RESI

Figure 200: Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$12,868	$48,167	$61,035
2011	$12,868	$48,167	$61,035
2012	$6,434	$24,084	$30,518
2013	$83,643	$313,086	$396,729
2014	$96,511	$361,253	$457,764
2015	$77,209	$289,002	$366,211
2016	$77,209	$289,002	$366,211
2017	$90,077	$337,169	$427,246
2018	$77,209	$289,002	$366,211
2019	$90,077	$337,169	$427,246
2020	$77,209	$289,002	$366,211
Average	***$63,756***	***$238,646***	***$302,401***

Source: RESI

Figure 201: Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$3,217	$12,042	$15,259
2011	$3,217	$12,042	$15,259
2012	$3,217	$12,042	$15,259
2013	$38,604	$144,501	$183,105
2014	$38,604	$144,501	$183,105
2015	$45,038	$168,585	$213,623
2016	$45,038	$168,585	$213,623
2017	$54,689	$204,710	$259,399
2018	$51,472	$192,668	$244,141
2019	$54,689	$204,710	$259,399
2020	$48,255	$180,626	$228,882
Average	***$35,095***	***$131,365***	***$166,460***

Source: RESI

Figure 202: Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	58.2	94.7	152.9
2011	57.9	93.9	151.8
2012	57.0	92.8	149.8
2013	76.1	124.7	200.9
2014	19.7	32.5	52.2
2015	17.3	30.3	47.6
2016	16.0	29.1	45.1
2017	16.0	28.9	44.9
2018	15.7	28.6	44.3
2019	16.0	28.7	44.7
2020	16.1	28.4	44.4
Average	***33.3***	***55.7***	***89.0***

Source: RESI

Figure 203: Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$1,540,927	$2,578,946	$4,119,873
2011	$1,552,341	$2,598,049	$4,150,391
2012	$1,540,927	$2,578,946	$4,119,873
2013	$2,043,155	$3,419,491	$5,462,646
2014	$513,642	$859,649	$1,373,291
2015	$410,914	$687,719	$1,098,633
2016	$342,428	$573,099	$915,527
2017	$365,257	$611,306	$976,563
2018	$365,257	$611,306	$976,563
2019	$410,914	$687,719	$1,098,633
2020	$410,914	$687,719	$1,098,633
Average	***$863,334***	***$1,444,904***	***$2,308,239***

Source: RESI

Figure 204: Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$610,664	$1,022,027	$1,632,690
2011	$662,028	$1,107,992	$1,770,020
2012	$719,099	$1,203,508	$1,922,607
2013	$970,213	$1,623,781	$2,593,994
2014	$365,257	$611,306	$976,563
2015	$308,185	$515,789	$823,975
2016	$262,528	$439,376	$701,904
2017	$268,235	$448,928	$717,163
2018	$256,821	$429,824	$686,646
2019	$262,528	$439,376	$701,904
2020	$256,821	$429,824	$686,646
Average	***$449,307***	***$751,976***	***$1,201,283***

Source: RESI

Figure 205: Geological Opportunities to Store Carbon—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.2	0.1	0.4
2011	0.3	0.1	0.4
2012	0.0	0.0	0.0
2013	0.0	0.1	0.1
2014	0.3	0.1	0.4
2015	0.0	0.0	0.0
2016	0.2	0.3	0.5
2017	0.1	0.0	0.0
2018	0.2	0.3	0.5
2019	0.3	0.2	0.5
2020	0.3	0.2	0.5
Average	***0.2***	***0.1***	***0.3***

Source: RESI

Figure 206: Geological Opportunities to Store Carbon—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$17,386	$13,131	$30,518
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$34,772	$26,263	$61,035
2015	$0	$0	$0
2016	$0	$0	$0
2017	$34,772	$26,263	$61,035
2018	$0	$0	$0
2019	$34,772	$26,263	$61,035
2020	$34,772	$26,263	$61,035
Average	***$14,225***	***$10,744***	***$24,969***

Source: RESI

Figure 207: Geological Opportunities to Store Carbon—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	-$8,693	-$6,566	-$15,259
2012	$0	$0	$0
2013	$8,693	$6,566	$15,259
2014	$0	$0	$0
2015	$0	$0	$0
2016	$8,693	$6,566	$15,259
2017	$8,693	$6,566	$15,259
2018	$0	$0	$0
2019	$17,386	$13,131	$30,518
2020	$8,693	$6,566	$15,259
Average	***$3,951***	***$2,984***	***$6,936***

Source: RESI

Figure 208: Geological Opportunities to Store Carbon—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	73.7	64.9	138.6
2011	103.2	90.3	193.4
2012	121.0	105.5	226.6
2013	130.1	113.0	243.0
2014	134.9	115.5	250.4
2015	135.8	115.1	251.0
2016	134.9	113.3	248.2
2017	133.7	110.9	244.6
2018	129.8	106.2	236.0
2019	124.8	101.0	225.7
2020	120.8	96.5	217.2
Average	***122.1***	***102.9***	***225.0***

Source: RESI

Figure 209: Geological Opportunities to Store Carbon—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$6,639,031	$5,598,518	$12,237,549
2011	$10,049,605	$8,474,565	$18,524,170
2012	$12,549,590	$10,582,735	$23,132,324
2013	$14,321,102	$12,076,603	$26,397,705
2014	$15,695,265	$13,235,399	$28,930,664
2015	$16,721,749	$14,101,005	$30,822,754
2016	$17,516,446	$14,771,152	$32,287,598
2017	$18,244,918	$15,385,453	$33,630,371
2018	$18,774,716	$15,832,218	$34,606,934
2019	$19,138,952	$16,139,368	$35,278,320
2020	$19,470,076	$16,418,596	$35,888,672
Average	***$15,374,677***	***$12,965,056***	***$28,339,733***

Source: RESI

Figure 210: Geological Opportunities to Store Carbon—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$1,498,335	$1,263,506	$2,761,841
2011	$2,218,529	$1,870,826	$4,089,355
2012	$2,756,605	$2,324,572	$5,081,177
2013	$3,071,173	$2,589,838	$5,661,011
2014	$3,294,681	$2,778,317	$6,072,998
2015	$3,460,243	$2,917,931	$6,378,174
2016	$3,518,190	$2,966,796	$6,484,985
2017	$3,584,414	$3,022,641	$6,607,056
2018	$3,551,302	$2,994,718	$6,546,021
2019	$3,443,687	$2,903,969	$6,347,656
2020	$3,302,959	$2,785,298	$6,088,257
Average	***$3,063,647***	***$2,583,492***	***$5,647,139***

Source: RESI

Figure 211: Planting Forests in Maryland—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	96.0	94.4	190.3
2012	95.9	94.4	190.3
2013	50.3	49.5	99.8
2014	54.4	53.4	107.8
2015	52.1	51.2	103.4
2016	50.8	49.9	100.7
2017	49.1	48.1	97.2
2018	48.0	47.3	95.4
2019	47.1	46.6	93.7
2020	46.4	45.5	91.9
Average	***53.6***	***52.8***	***106.4***

Source: RESI

Figure 212: Planting Forests in Maryland—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$1,138,546	$1,119,755	$2,258,301
2012	$1,200,089	$1,180,282	$2,380,371
2013	$600,044	$590,141	$1,190,186
2014	$600,044	$590,141	$1,190,186
2015	$461,573	$453,955	$915,527
2016	$400,030	$393,427	$793,457
2017	$338,487	$332,900	$671,387
2018	$307,715	$302,636	$610,352
2019	$307,715	$302,636	$610,352
2020	$246,172	$242,109	$488,281
Average	***$509,129***	***$500,726***	***$1,009,854***

Source: RESI

Figure 213: Planting Forests in Maryland—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$823,138	$809,553	$1,632,690
2012	$1,000,074	$983,569	$1,983,643
2013	$692,359	$680,932	$1,373,291
2014	$715,438	$703,630	$1,419,067
2015	$715,438	$703,630	$1,419,067
2016	$715,438	$703,630	$1,419,067
2017	$700,052	$688,498	$1,388,550
2018	$715,438	$703,630	$1,419,067
2019	$692,359	$680,932	$1,373,291
2020	$684,666	$673,366	$1,358,032
Average	***$677,673***	***$666,488***	***$1,344,161***

Source: RESI

Figure 214: Planting Forests in Maryland—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.5	0.3	0.8
2012	0.5	0.4	0.9
2013	0.0	0.2	0.3
2014	0.2	0.1	0.3
2015	0.0	0.0	0.0
2016	0.5	0.3	0.7
2017	0.2	0.2	0.5
2018	0.2	0.2	0.4
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.2***	***0.2***	***0.4***

Source: RESI

Figure 215: Planting Forests in Maryland—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	-$16,613	-$13,904	-$30,518
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***-$1,510***	***-$1,264***	***-$2,774***

Source: RESI

Figure 216: Planting Forests in Maryland—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$8,307	$6,952	$15,259
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$8,307	$6,952	$15,259
2017	$16,613	$13,904	$30,518
2018	$0	$0	$0
2019	$8,307	$6,952	$15,259
2020	$0	$0	$0
Average	***$3,776***	***$3,160***	***$6,936***

Source: RESI

Figure 217: Expanded Use of Forests and Feedstocks for Energy Production—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	13.4	24.7	38.1
2014	20.2	36.8	57.0
2015	19.7	36.6	56.3
2016	12.8	24.3	37.1
2017	12.5	23.7	36.1
2018	12.3	23.7	36.0
2019	12.4	23.8	36.2
2020	12.4	23.5	35.8
Average	***10.5***	***19.7***	***30.3***

Source: RESI

Figure 218: Expanded Use of Forests and Feedstocks for Energy Production—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$594,315	$1,114,669	$1,708,984
2014	$870,247	$1,632,194	$2,502,441
2015	$827,796	$1,552,575	$2,380,371
2016	$509,413	$955,431	$1,464,844
2017	$488,187	$915,621	$1,403,809
2018	$466,962	$875,812	$1,342,773
2019	$488,187	$915,621	$1,403,809
2020	$466,962	$875,812	$1,342,773
Average	***$428,370***	***$803,430***	***$1,231,800***

Source: RESI

Figure 219: Expanded Use of Forests and Feedstocks for Energy Production—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$302,464	$567,287	$869,751
2014	$472,268	$885,764	$1,358,032
2015	$504,107	$945,478	$1,449,585
2016	$355,528	$666,811	$1,022,339
2017	$360,834	$676,763	$1,037,598
2018	$366,141	$686,716	$1,052,856
2019	$382,060	$716,573	$1,098,633
2020	$382,060	$716,573	$1,098,633
Average	***$284,133***	***$532,906***	***$817,039***

Source: RESI

Figure 220: Expanded Use of Forests and Feedstocks for Energy Production—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	2.9	2.5	5.3
2014	4.8	4.1	8.9
2015	5.9	5.2	11.1
2016	6.9	6.1	13.0
2017	8.2	7.1	15.2
2018	8.6	7.6	16.2
2019	8.7	7.5	16.3
2020	8.4	7.1	15.6
Average	***4.9***	***4.3***	***9.2***

Source: RESI

Figure 221: Expanded Use of Forests and Feedstocks for Energy Production—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$310,231	$269,603	$579,834
2014	$522,494	$454,069	$976,563
2015	$620,462	$539,206	$1,159,668
2016	$751,085	$652,724	$1,403,809
2017	$881,708	$766,241	$1,647,949
2018	$947,020	$822,999	$1,770,020
2019	$1,012,332	$879,758	$1,892,090
2020	$1,012,332	$879,758	$1,892,090
Average	***$550,697***	***$478,578***	***$1,029,275***

Source: RESI

Figure 222: Expanded Use of Forests and Feedstocks for Energy Production—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$81,640	$70,948	$152,588
2014	$138,787	$120,612	$259,399
2015	$204,099	$177,371	$381,470
2016	$253,083	$219,939	$473,022
2017	$302,067	$262,508	$564,575
2018	$326,559	$283,793	$610,352
2019	$359,215	$312,172	$671,387
2020	$351,051	$305,077	$656,128
Average	***$183,318***	***$159,311***	***$342,629***

Source: RESI

Figure 223: Conservation of Agricultural Land for GHG Benefits—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	108.7	40.1	148.8
2011	110.2	41.3	151.6
2012	109.9	41.0	150.9
2013	81.9	29.7	111.6
2014	79.6	27.8	107.4
2015	76.5	25.6	102.1
2016	75.0	24.4	99.4
2017	74.1	23.8	97.9
2018	73.2	23.8	97.0
2019	72.8	23.3	96.1
2020	72.0	22.6	94.6
Average	***84.9***	***29.4***	***114.3***

Source: RESI

Figure 224: Conservation of Agricultural Land for GHG Benefits—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$8,523,880	$2,950,729	$11,474,609
2011	$8,637,230	$2,989,968	$11,627,197
2012	$8,614,560	$2,982,120	$11,596,680
2013	$6,347,570	$2,197,352	$8,544,922
2014	$6,234,221	$2,158,113	$8,392,334
2015	$5,984,852	$2,071,789	$8,056,641
2016	$5,939,512	$2,056,093	$7,995,605
2017	$5,939,512	$2,056,093	$7,995,605
2018	$5,939,512	$2,056,093	$7,995,605
2019	$5,984,852	$2,071,789	$8,056,641
2020	$5,939,512	$2,056,093	$7,995,605
Average	***$6,735,019***	***$2,331,476***	***$9,066,495***

Source: RESI

Figure 225: Conservation of Agricultural Land for GHG Benefits—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$3,989,901	$1,381,192	$5,371,094
2011	$4,329,950	$1,498,908	$5,828,857
2012	$4,590,654	$1,589,156	$6,179,810
2013	$3,706,528	$1,283,096	$4,989,624
2014	$3,774,537	$1,306,639	$5,081,177
2015	$3,831,212	$1,326,259	$5,157,471
2016	$3,921,892	$1,357,649	$5,279,541
2017	$4,001,236	$1,385,116	$5,386,353
2018	$4,137,256	$1,432,202	$5,569,458
2019	$4,216,600	$1,459,669	$5,676,270
2020	$4,273,275	$1,479,288	$5,752,563
Average	***$4,070,276***	***$1,409,016***	***$5,479,292***

Source: RESI

Figure 226: Conservation of Agricultural Land for GHG Benefits—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	316.4	255.1	571.5
2011	320.1	259.3	579.4
2012	311.5	252.4	563.9
2013	223.2	179.1	402.3
2014	204.5	160.9	365.4
2015	188.6	145.9	334.5
2016	177.7	135.8	313.5
2017	170.8	128.8	299.6
2018	164.8	123.2	288.0
2019	162.7	121.7	284.3
2020	162.1	121.2	283.3
Average	***218.4***	***171.2***	***389.6***

Source: RESI

Figure 227: Conservation of Agricultural Land for GHG Benefits—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$75,151,950	$58,911,771	$134,063,721
2011	$75,254,593	$58,992,233	$134,246,826
2012	$74,450,554	$58,361,946	$132,812,500
2013	$55,324,700	$43,369,148	$98,693,848
2014	$53,904,802	$42,256,087	$96,160,889
2015	$52,621,761	$41,250,309	$93,872,070
2016	$51,732,187	$40,552,970	$92,285,156
2017	$51,116,327	$40,070,196	$91,186,523
2018	$50,637,325	$39,694,706	$90,332,031
2019	$50,397,825	$39,506,961	$89,904,785
2020	$50,226,753	$39,372,857	$89,599,609
Average	***$58,256,252***	***$45,667,199***	***$103,923,451***

Source: RESI

Figure 228: Conservation of Agricultural Land for GHG Benefits—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$13,146,887	$10,305,872	$23,452,759
2011	$15,028,679	$11,781,013	$26,809,692
2012	$16,149,201	$12,659,393	$28,808,594
2013	$13,352,173	$10,466,797	$23,818,970
2014	$13,163,994	$10,319,282	$23,483,276
2015	$12,984,368	$10,178,474	$23,162,842
2016	$12,787,635	$10,024,254	$22,811,890
2017	$12,693,546	$9,950,497	$22,644,043
2018	$12,616,563	$9,890,151	$22,506,714
2019	$12,505,367	$9,802,983	$22,308,350
2020	$12,436,938	$9,749,342	$22,186,279
Average	***$13,351,396***	***$10,466,187***	***$23,817,583***

Source: RESI

Figure 229: Buy Local for GHG Benefits—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	44.9	16.5	61.4
2011	45.4	17.0	62.4
2012	45.3	16.9	62.3
2013	15.9	5.6	21.5
2014	15.0	4.5	19.5
2015	13.8	3.8	17.6
2016	13.4	3.2	16.6
2017	13.7	3.5	17.2
2018	13.2	3.4	16.6
2019	13.2	3.6	16.8
2020	13.2	3.2	16.4
Average	***22.5***	***7.4***	***29.9***

Source: RESI

Figure 230: Buy Local for GHG Benefits—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$3,558,850	$1,171,374	$4,730,225
2011	$3,604,771	$1,186,489	$4,791,260
2012	$3,627,731	$1,194,046	$4,821,777
2013	$1,216,897	$400,534	$1,617,432
2014	$1,148,016	$377,863	$1,525,879
2015	$1,056,175	$347,634	$1,403,809
2016	$1,010,254	$332,519	$1,342,773
2017	$1,056,175	$347,634	$1,403,809
2018	$1,010,254	$332,519	$1,342,773
2019	$1,102,096	$362,748	$1,464,844
2020	$1,056,175	$347,634	$1,403,809
Average	***$1,767,945***	***$581,909***	***$2,349,854***

Source: RESI

Figure 231: Buy Local for GHG Benefits—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$1,653,143	$544,122	$2,197,266
2011	$1,790,905	$589,466	$2,380,371
2012	$1,917,187	$631,031	$2,548,218
2013	$838,052	$275,840	$1,113,892
2014	$769,171	$253,168	$1,022,339
2015	$757,691	$249,389	$1,007,080
2016	$757,691	$249,389	$1,007,080
2017	$769,171	$253,168	$1,022,339
2018	$803,611	$264,504	$1,068,115
2019	$792,131	$260,725	$1,052,856
2020	$803,611	$264,504	$1,068,115
Average	***$1,059,306***	***$348,664***	***$1,407,970***

Source: RESI

Figure 232: Buy Local for GHG Benefits—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	17.0	13.6	30.5
2011	17.2	13.8	30.9
2012	17.0	13.8	30.8
2013	15.7	12.9	28.7
2014	15.2	12.0	27.2
2015	13.5	10.6	24.1
2016	13.4	10.3	23.7
2017	12.8	9.7	22.4
2018	12.2	9.3	21.5
2019	11.4	8.6	20.1
2020	11.1	8.3	19.4
Average	14.2	11.2	25.4

Source: RESI

Figure 233: Buy Local for GHG Benefits—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$3,999,562	$3,141,552	$7,141,113
2011	$3,999,562	$3,141,552	$7,141,113
2012	$3,999,562	$3,141,552	$7,141,113
2013	$3,914,101	$3,074,424	$6,988,525
2014	$3,845,732	$3,020,723	$6,866,455
2015	$3,726,087	$2,926,745	$6,652,832
2016	$3,691,903	$2,899,894	$6,591,797
2017	$3,691,903	$2,899,894	$6,591,797
2018	$3,589,350	$2,819,341	$6,408,691
2019	$3,589,350	$2,819,341	$6,408,691
2020	$3,555,166	$2,792,490	$6,347,656
Average	***$3,782,025***	***$2,970,682***	***$6,752,708***

Source: RESI

Figure 234: Buy Local for GHG Benefits—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$692,232	$543,730	$1,235,962
2011	$786,239	$617,570	$1,403,809
2012	$871,699	$684,697	$1,556,396
2013	$897,338	$704,835	$1,602,173
2014	$922,976	$724,973	$1,647,949
2015	$931,522	$731,686	$1,663,208
2016	$931,522	$731,686	$1,663,208
2017	$922,976	$724,973	$1,647,949
2018	$940,068	$738,399	$1,678,467
2019	$922,976	$724,973	$1,647,949
2020	$897,338	$704,835	$1,602,173
Average	***$883,353***	***$693,851***	***$1,577,204***

Source: RESI

Figure 235: Nutrient Trading for GHG Benefits—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	4.6	1.8	6.4
2011	4.8	1.9	6.7
2012	4.9	2.1	7.0
2013	8.7	3.6	12.3
2014	8.7	3.4	12.0
2015	8.1	3.0	11.1
2016	7.9	2.9	10.8
2017	8.0	2.9	10.9
2018	7.8	2.8	10.7
2019	7.6	2.6	10.2
2020	7.1	2.1	9.2
Average	***7.1***	***2.6***	***9.7***

Source: RESI

Figure 236: Nutrient Trading for GHG Benefits—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$356,213	$132,068	$488,281
2011	$356,213	$132,068	$488,281
2012	$378,476	$140,323	$518,799
2013	$667,899	$247,628	$915,527
2014	$712,426	$264,137	$976,563
2015	$623,373	$231,120	$854,492
2016	$623,373	$231,120	$854,492
2017	$623,373	$231,120	$854,492
2018	$623,373	$231,120	$854,492
2019	$623,373	$231,120	$854,492
2020	$578,846	$214,611	$793,457
Average	***$560,630***	***$207,858***	***$768,488***

Source: RESI

Figure 237: Nutrient Trading for GHG Benefits—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$178,106	$66,034	$244,141
2011	$166,975	$61,907	$228,882
2012	$200,370	$74,288	$274,658
2013	$367,345	$136,196	$503,540
2014	$367,345	$136,196	$503,540
2015	$378,476	$140,323	$518,799
2016	$411,871	$152,704	$564,575
2017	$423,003	$156,831	$579,834
2018	$434,134	$160,958	$595,093
2019	$423,003	$156,831	$579,834
2020	$400,739	$148,577	$549,316
Average	***$341,033***	***$126,440***	***$467,474***

Source: RESI

Figure 238: Nutrient Trading for GHG Benefits—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	62.0	33.4	95.5
2011	63.0	34.0	97.0
2012	62.3	33.4	95.7
2013	60.9	32.5	93.3
2014	59.6	31.2	90.7
2015	57.3	29.2	86.5
2016	55.8	28.3	84.1
2017	55.1	27.5	82.6
2018	53.5	26.7	80.2
2019	52.2	25.5	77.7
2020	51.3	24.5	75.8
Average	***57.5***	***29.6***	***87.2***

Source: RESI

Figure 239: Nutrient Trading for GHG Benefits—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$4,451,328	$2,293,056	$6,744,385
2011	$4,491,612	$2,313,808	$6,805,420
2012	$4,451,328	$2,293,056	$6,744,385
2013	$4,330,478	$2,230,802	$6,561,279
2014	$4,270,052	$2,199,674	$6,469,727
2015	$4,108,918	$2,116,668	$6,225,586
2016	$3,988,068	$2,054,413	$6,042,480
2017	$3,947,784	$2,033,661	$5,981,445
2018	$3,867,217	$1,992,158	$5,859,375
2019	$3,867,217	$1,992,158	$5,859,375
2020	$3,826,934	$1,971,406	$5,798,340
Average	***$4,145,540***	***$2,135,533***	***$6,281,072***

Source: RESI

Figure 240: Nutrient Trading for GHG Benefits—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$1,953,750	$1,006,455	$2,960,205
2011	$2,124,955	$1,094,649	$3,219,604
2012	$2,245,806	$1,156,904	$3,402,710
2013	$2,326,373	$1,198,407	$3,524,780
2014	$2,386,798	$1,229,535	$3,616,333
2015	$2,457,294	$1,265,850	$3,723,145
2016	$2,497,578	$1,286,602	$3,784,180
2017	$2,588,216	$1,333,293	$3,921,509
2018	$2,628,499	$1,354,045	$3,982,544
2019	$2,648,641	$1,364,420	$4,013,062
2020	$2,668,783	$1,374,796	$4,043,579
Average	***$2,411,518***	***$1,242,269***	***$3,653,786***

Source: RESI

A.4 Recycling

Figure 241: Recycling and Source Reduction—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 242: Recycling and Source Reduction—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 243: Recycling and Source Reduction—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 244: Recycling and Source Reduction—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-46.8	-11.8	-58.6
2011	-40.7	-6.3	-47.0
2012	-35.1	-0.9	-36.0
2013	-30.0	3.8	-26.2
2014	-24.6	8.2	-16.4
2015	-21.5	10.8	-10.7
2016	-17.9	13.7	-4.2
2017	-14.9	15.7	0.8
2018	-13.3	17.2	3.9
2019	-12.8	17.3	4.5
2020	-12.8	17.2	4.4
Average	***-24.6***	***7.7***	***-16.9***

Source: RESI

Figure 245: Recycling and Source Reduction—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$6,497,957	$2,042,391	-$4,455,566
2011	-$5,073,747	$1,594,743	-$3,479,004
2012	-$3,605,031	$1,133,107	-$2,471,924
2013	-$2,447,860	$769,394	-$1,678,467
2014	-$1,246,184	$391,691	-$854,492
2015	-$534,079	$167,868	-$366,211
2016	$178,026	-$55,956	$122,070
2017	$801,118	-$251,802	$549,316
2018	$1,157,170	-$363,713	$793,457
2019	$1,335,197	-$419,669	$915,527
2020	$1,335,197	-$419,669	$915,527
Average	***-$1,327,105***	***$417,126***	***-$909,979***

Source: RESI

Figure 246: Recycling and Source Reduction—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$3,560,524	$1,119,118	-$2,441,406
2011	-$3,382,498	$1,063,162	-$2,319,336
2012	-$3,182,219	$1,000,212	-$2,182,007
2013	-$2,937,433	$923,272	-$2,014,160
2014	-$2,759,406	$867,317	-$1,892,090
2015	-$2,559,127	$804,366	-$1,754,761
2016	-$2,403,354	$755,405	-$1,647,949
2017	-$2,180,821	$685,460	-$1,495,361
2018	-$2,091,808	$657,482	-$1,434,326
2019	-$2,091,808	$657,482	-$1,434,326
2020	-$2,136,315	$671,471	-$1,464,844
Average	-$2,662,301	$836,795	-$1,825,506

Source: RESI

A.5 Buildings

Figure 247: Building Codes—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	14.1	5.4	19.5
2011	16.5	6.6	23.1
2012	15.6	6.1	21.7
2013	15.3	6.1	21.4
2014	14.9	5.6	20.5
2015	14.0	4.9	18.9
2016	14.2	5.1	19.3
2017	14.0	4.9	18.8
2018	14.0	5.2	19.2
2019	13.7	4.6	18.3
2020	13.8	4.8	18.6
Average	***14.6***	***5.4***	***19.9***

Source: RESI

Figure 248: Building Codes—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$1,092,207	$403,154	$1,495,361
2011	$1,270,526	$468,976	$1,739,502
2012	$1,203,657	$444,293	$1,647,949
2013	$1,181,367	$436,065	$1,617,432
2014	$1,203,657	$444,293	$1,647,949
2015	$1,114,497	$411,382	$1,525,879
2016	$1,114,497	$411,382	$1,525,879
2017	$1,114,497	$411,382	$1,525,879
2018	$1,114,497	$411,382	$1,525,879
2019	$1,159,077	$427,837	$1,586,914
2020	$1,114,497	$411,382	$1,525,879
Average	***$1,152,998***	***$425,593***	***$1,578,591***

Source: RESI

Figure 249: Building Codes—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$490,379	$181,008	$671,387
2011	$612,973	$226,260	$839,233
2012	$635,263	$234,488	$869,751
2013	$668,698	$246,829	$915,527
2014	$668,698	$246,829	$915,527
2015	$679,843	$250,943	$930,786
2016	$713,278	$263,284	$976,563
2017	$713,278	$263,284	$976,563
2018	$769,003	$283,854	$1,052,856
2019	$780,148	$287,967	$1,068,115
2020	$780,148	$287,967	$1,068,115
Average	***$682,883***	***$252,065***	***$934,948***

Source: RESI

Figure 250: Building Codes—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	52.8	46.4	99.3
2012	54.5	48.1	102.7
2013	54.9	48.5	103.4
2014	54.8	48.3	103.1
2015	54.4	47.8	102.1
2016	53.8	47.1	100.9
2017	53.3	46.5	99.7
2018	52.9	45.9	98.8
2019	52.1	45.2	97.3
2020	51.8	44.8	96.6
Average	***48.7***	***42.6***	***91.3***

Source: RESI

Figure 251: Building Codes—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$5,677,864	$4,971,550	$10,649,414
2012	$5,879,947	$5,148,495	$11,028,442
2013	$5,978,548	$5,234,831	$11,213,379
2014	$6,090,817	$5,333,133	$11,423,950
2015	$6,176,727	$5,408,356	$11,585,083
2016	$6,253,851	$5,475,886	$11,729,736
2017	$6,332,927	$5,545,125	$11,878,052
2018	$6,460,815	$5,657,105	$12,117,920
2019	$6,514,509	$5,704,119	$12,218,628
2020	$6,591,633	$5,771,649	$12,363,281
Average	***$5,632,512***	***$4,931,841***	***$10,564,353***

Source: RESI

Figure 252: Building Codes—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$1,778,970	$1,557,670	$3,336,639
2012	$1,945,176	$1,703,201	$3,648,376
2013	$2,055,492	$1,799,794	$3,855,286
2014	$2,185,821	$1,913,910	$4,099,731
2015	$2,297,602	$2,011,785	$4,309,387
2016	$2,398,400	$2,100,044	$4,498,444
2017	$2,493,096	$2,182,960	$4,676,056
2018	$2,600,483	$2,276,989	$4,877,472
2019	$2,658,814	$2,328,064	$4,986,877
2020	$2,721,782	$2,383,199	$5,104,980
Average	***$2,103,240***	***$1,841,601***	***$3,944,841***

Source: RESI

Figure 253: BeSMART—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	2.2	0.8	3.0
2012	1.0	0.4	1.3
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	-0.1	-0.1	-0.1
2016	-0.1	-0.1	-0.1
2017	-0.1	0.0	-0.1
2018	-0.1	-0.1	-0.1
2019	0.0	0.0	-0.1
2020	0.0	0.0	-0.1
Average	***0.3***	***0.1***	***0.3***

Source: RESI

Figure 254: BeSMART—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$179,261	$56,030	$235,291
2012	$77,424	$24,200	$101,624
2013	-$2,093	-$654	-$2,747
2014	-$2,790	-$872	-$3,662
2015	-$6,975	-$2,180	-$9,155
2016	-$6,975	-$2,180	-$9,155
2017	-$6,975	-$2,180	-$9,155
2018	-$6,975	-$2,180	-$9,155
2019	-$4,185	-$1,308	-$5,493
2020	-$4,185	-$1,308	-$5,493
Average	***$19,594***	***$6,124***	***$25,718***

Source: RESI

Figure 255: BeSMART—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$84,748	$26,489	$111,237
2012	$42,200	$13,190	$55,389
2013	$4,883	$1,526	$6,409
2014	$1,744	$545	$2,289
2015	-$349	-$109	-$458
2016	-$1,046	-$327	-$1,373
2017	-$1,395	-$436	-$1,831
2018	-$2,441	-$763	-$3,204
2019	-$2,093	-$654	-$2,747
2020	-$2,441	-$763	-$3,204
Average	***$11,255***	***$3,518***	***$14,773***

Source: RESI

Figure 256: BeSMART—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.1	0.1
2014	0.2	0.1	0.3
2015	0.0	0.1	0.1
2016	0.0	-0.1	-0.1
2017	0.0	0.0	0.0
2018	0.0	0.1	0.1
2019	-0.2	-0.2	-0.4
2020	-0.2	-0.2	-0.5
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 257: BeSMART—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$15,679	$14,839	$30,518
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$1,425***	***$1,349***	***$2,774***

Source: RESI

Figure 258: Main Street—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$7,839	$7,419	$15,259
2018	-$7,839	-$7,419	-$15,259
2019	$7,839	$7,419	$15,259
2020	$7,839	$7,419	$15,259
Average	***$1,425***	***$1,349***	***$2,774***

Source: RESI

Figure 259: Weatherization and Energy Efficiency for Low-Income Houses—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	24.2	9.1	33.3
2013	24.4	9.3	33.7
2014	24.2	9.2	33.4
2015	-0.4	-0.4	-0.8
2016	-1.0	-1.0	-2.1
2017	-1.4	-1.3	-2.7
2018	-1.4	-1.3	-2.7
2019	-1.2	-1.2	-2.4
2020	-1.0	-1.0	-2.0
Average	***6.0***	***1.9***	***8.0***

Source: RESI

Figure 260: Weatherization and Energy Efficiency for Low-Income Houses—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$1,966,457	$629,978	$2,596,436
2013	$1,981,018	$634,643	$2,615,662
2014	$1,981,712	$634,865	$2,616,577
2015	-$72,113	-$23,102	-$95,215
2016	-$137,291	-$43,983	-$181,274
2017	-$165,027	-$52,868	-$217,896
2018	-$169,187	-$54,201	-$223,389
2019	-$151,159	-$48,426	-$199,585
2020	-$131,744	-$42,206	-$173,950
Average	***$463,879***	***$148,609***	***$612,488***

Source: RESI

Figure 261: Weatherization and Energy Efficiency for Low-Income Houses—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$956,880	$306,548	$1,263,428
2013	$1,036,620	$332,094	$1,368,713
2014	$1,106,999	$354,640	$1,461,639
2015	$92,568	$29,655	$122,223
2016	$23,575	$7,553	$31,128
2017	-$21,148	-$6,775	-$27,924
2018	-$49,231	-$15,772	-$65,002
2019	-$61,018	-$19,548	-$80,566
2020	-$64,485	-$20,659	-$85,144
Average	***$274,614***	***$87,976***	***$362,590***

Source: RESI

Figure 262: Weatherization and Energy Efficiency for Low-Income Houses—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.8	0.8	1.6
2013	0.2	0.4	0.6
2014	0.7	0.7	1.5
2015	-0.5	-0.5	-0.9
2016	-0.3	-0.2	-0.5
2017	0.3	0.0	0.3
2018	0.3	0.3	0.6
2019	0.1	0.0	0.1
2020	0.4	0.0	0.4
Average	***0.2***	***0.1***	***0.3***

Source: RESI

Figure 263: Weatherization and Energy Efficiency for Low-Income Houses—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	-$51,756	-$39,797	-$91,553
2013	-$69,008	-$53,063	-$122,070
2014	-$34,504	-$26,531	-$61,035
2015	-$34,504	-$26,531	-$61,035
2016	-$34,504	-$26,531	-$61,035
2017	$0	$0	$0
2018	$0	$0	$0
2019	$34,504	$26,531	$61,035
2020	$34,504	$26,531	$61,035
Average	***-$14,115***	***-$10,854***	***-$24,969***

Source: RESI

Figure 264: Weatherization and Energy Efficiency for Low-Income Houses—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$17,252	$13,266	$30,518
2013	$8,626	$6,633	$15,259
2014	$8,626	$6,633	$15,259
2015	-$8,626	-$6,633	-$15,259
2016	-$8,626	-$6,633	-$15,259
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$1,568***	***$1,206***	***$2,774***

Source: RESI

A.6 Land Use

Figure 265: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 266: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 267: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 268: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	40.5	37.6	78.2
2011	118.9	110.7	229.6
2012	-1.1	-1.2	-2.3
2013	-3.6	-3.3	-6.9
2014	-4.0	-3.8	-7.8
2015	-4.9	-4.7	-9.6
2016	-4.6	-4.1	-8.8
2017	-3.8	-3.6	-7.3
2018	-3.3	-3.1	-6.3
2019	-2.4	-2.1	-4.6
2020	-2.0	-1.9	-3.8
Average	***11.8***	***11.0***	***22.8***

Source: RESI

Figure 269: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$2,387,047	$2,221,107	$4,608,154
2011	$6,971,442	$6,486,810	$13,458,252
2012	-$189,699	-$176,512	-$366,211
2013	-$363,590	-$338,314	-$701,904
2014	-$379,398	-$353,024	-$732,422
2015	-$442,631	-$411,861	-$854,492
2016	-$411,015	-$382,442	-$793,457
2017	-$347,782	-$323,605	-$671,387
2018	-$316,165	-$294,186	-$610,352
2019	-$221,316	-$205,930	-$427,246
2020	-$221,316	-$205,930	-$427,246
Average	***$587,780***	***$546,919***	***$1,134,699***

Source: RESI

Figure 270: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$932,687	$867,850	$1,800,537
2011	$2,805,966	$2,610,904	$5,416,870
2012	$158,083	$147,093	$305,176
2013	$31,617	$29,419	$61,035
2014	-$31,617	-$29,419	-$61,035
2015	-$94,850	-$88,256	-$183,105
2016	-$118,562	-$110,320	-$228,882
2017	-$110,658	-$102,965	-$213,623
2018	-$102,754	-$95,611	-$198,364
2019	-$86,945	-$80,901	-$167,847
2020	-$79,041	-$73,547	-$152,588
Average	***$300,357***	***$279,477***	***$579,834***

Source: RESI

Figure 271: Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 272: Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 273: Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 274: Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	34.5	33.4	67.9
2011	31.7	30.7	62.4
2012	28.6	28.1	56.7
2013	26.4	25.9	52.3
2014	24.5	23.7	48.2
2015	22.3	21.8	44.1
2016	21.1	20.8	41.9
2017	20.5	19.9	40.4
2018	19.0	18.8	37.8
2019	18.1	18.0	36.0
2020	17.2	16.9	34.0
Average	***24.0***	***23.4***	***47.4***

Source: RESI

Figure 275: Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$570,994	-$558,156	-$1,129,150
2011	-$709,885	-$693,924	-$1,403,809
2012	-$864,208	-$844,777	-$1,708,984
2013	-$987,666	-$965,459	-$1,953,125
2014	-$1,064,827	-$1,040,886	-$2,105,713
2015	-$1,172,853	-$1,146,483	-$2,319,336
2016	-$1,234,582	-$1,206,824	-$2,441,406
2017	-$1,265,447	-$1,236,994	-$2,502,441
2018	-$1,327,176	-$1,297,336	-$2,624,512
2019	-$1,327,176	-$1,297,336	-$2,624,512
2020	-$1,358,041	-$1,327,506	-$2,685,547
Average	***-$1,080,260***	***-$1,055,971***	***-$2,136,230***

Source: RESI

Figure 276: Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$432,104	$422,388	$854,492
2011	$416,672	$407,303	$823,975
2012	$408,955	$399,760	$808,716
2013	$378,091	$369,590	$747,681
2014	$347,226	$339,419	$686,646
2015	$331,794	$324,334	$656,128
2016	$308,646	$301,706	$610,352
2017	$300,929	$294,163	$595,093
2018	$293,213	$286,621	$579,834
2019	$270,065	$263,993	$534,058
2020	$254,633	$248,907	$503,540
Average	***$340,212***	***$332,562***	***$672,774***

Source: RESI

Figure 277: Land Use Planning GHG Benefits—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	118.7	43.8	162.5
2011	275.4	102.9	378.3
2012	0.8	0.4	1.2
2013	-3.8	-3.7	-7.5
2014	-6.3	-6.2	-12.5
2015	-7.3	-7.1	-14.4
2016	-7.4	-6.9	-14.2
2017	-6.1	-6.1	-12.3
2018	-5.4	-5.2	-10.6
2019	-4.2	-3.8	-8.0
2020	-2.8	-2.8	-5.7
Average	***32.0***	***9.6***	***41.5***

Source: RESI

Figure 278: Land Use Planning GHG Benefits —Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$9,649,523	$2,893,202	$12,542,725
2011	$22,468,596	$6,736,726	$29,205,322
2012	-$117,391	-$35,197	-$152,588
2013	-$563,476	-$168,946	-$732,422
2014	-$774,779	-$232,301	-$1,007,080
2015	-$892,170	-$267,498	-$1,159,668
2016	-$892,170	-$267,498	-$1,159,668
2017	-$798,257	-$239,340	-$1,037,598
2018	-$751,301	-$225,261	-$976,563
2019	-$563,476	-$168,946	-$732,422
2020	-$422,607	-$126,710	-$549,316
Average	***$2,394,772***	***$718,021***	***$3,112,793***

Source: RESI

Figure 279: Land Use Planning GHG Benefits —Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$4,496,067	$1,348,049	$5,844,116
2011	$10,917,343	$3,273,331	$14,190,674
2012	$716,084	$214,702	$930,786
2013	$316,955	$95,032	$411,987
2014	$23,478	$7,039	$30,518
2015	-$152,608	-$45,756	-$198,364
2016	-$258,260	-$77,434	-$335,693
2017	-$293,477	-$87,993	-$381,470
2018	-$328,694	-$98,552	-$427,246
2019	-$293,477	-$87,993	-$381,470
2020	-$258,260	-$77,434	-$335,693
Average	***$1,353,196***	***$405,727***	***$1,758,922***

Source: RESI

Figure 280: Land Use Planning GHG Benefits —Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	255.2	237.0	492.2
2011	252.3	234.7	487.1
2012	244.8	228.2	473.0
2013	237.2	221.7	458.8
2014	229.6	214.6	444.1
2015	-24.2	-22.7	-46.9
2016	-29.8	-27.7	-57.5
2017	-29.9	-27.9	-57.8
2018	-27.2	-24.9	-52.1
2019	-22.5	-20.4	-42.9
2020	-17.0	-15.4	-32.4
Average	***97.1***	***90.7***	***187.8***

Source: RESI

Figure 281: Land Use Planning GHG Benefits —Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$14,977,974	$13,983,208	$28,961,182
2011	$14,662,316	$13,688,514	$28,350,830
2012	$14,031,000	$13,099,127	$27,130,127
2013	$13,304,986	$12,421,332	$25,726,318
2014	$12,673,670	$11,831,945	$24,505,615
2015	-$2,588,396	-$2,416,487	-$5,004,883
2016	-$2,967,186	-$2,770,119	-$5,737,305
2017	-$2,967,186	-$2,770,119	-$5,737,305
2018	-$2,809,357	-$2,622,772	-$5,432,129
2019	-$2,399,001	-$2,239,671	-$4,638,672
2020	-$2,020,211	-$1,886,039	-$3,906,250
Average	***$4,899,874***	***$4,574,447***	***$9,474,321***

Source: RESI

Figure 282: Land Use Planning GHG Benefits —Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$5,823,891	$5,437,095	$11,260,986
2011	$6,179,006	$5,768,626	$11,947,632
2012	$6,392,075	$5,967,544	$12,359,619
2013	$6,510,447	$6,078,054	$12,588,501
2014	$6,668,276	$6,225,401	$12,893,677
2015	$118,372	$110,510	$228,882
2016	-$426,138	-$397,836	-$823,975
2017	-$749,688	-$699,897	-$1,449,585
2018	-$907,517	-$847,244	-$1,754,761
2019	-$899,625	-$839,877	-$1,739,502
2020	-$812,819	-$758,836	-$1,571,655
Average	***$2,536,025***	***$2,367,595***	***$4,903,620***

Source: RESI

Figure 283: GHG Benefits from Priority Funding Areas and Other Growth Boundaries—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	12,067.7	2,026.7	14,094.4
2011	10,209.2	303.6	10,512.8
2012	8,842.8	-975.8	7,867.0
2013	7,705.1	-2,017.5	5,687.6
2014	6,879.4	-2,671.5	4,208.0
2015	6,232.2	-3,161.7	3,070.5
2016	5,736.2	-3,513.5	2,222.7
2017	5,380.1	-3,738.8	1,641.3
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***7,881.6***	***-1,718.6***	***6,163.0***

Source: RESI

Figure 284: GHG Benefits from Priority Funding Areas and Other Growth Boundaries—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$601,829,438	$605,445,953	$1,207,275,391
2011	$474,252,551	$477,102,430	$951,354,980
2012	$377,725,559	$379,995,388	$757,720,947
2013	$297,993,808	$299,784,513	$597,778,320
2014	$244,002,587	$245,468,848	$489,471,436
2015	$202,912,059	$204,131,398	$407,043,457
2016	$172,972,718	$174,012,146	$346,984,863
2017	$153,134,862	$154,055,080	$307,189,941
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$315,602,948***	***$317,499,469***	***$633,102,417***

Source: RESI

Figure 285: GHG Benefits from Priority Funding Areas and Other Growth Boundaries—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$342,484,460	$344,542,518	$687,026,978
2011	$337,433,717	$339,461,424	$676,895,142
2012	$331,546,255	$333,538,584	$665,084,839
2013	$322,829,161	$324,769,106	$647,598,267
2014	$320,273,363	$322,197,950	$642,471,313
2015	$318,463,007	$320,376,715	$638,839,722
2016	$317,960,975	$319,871,667	$637,832,642
2017	$319,299,726	$321,218,462	$640,518,188
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$326,286,333***	***$328,247,053***	***$654,533,386***

Source: RESI

Figure 286: GHG Benefits from Priority Funding Areas and Other Growth Boundaries—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	1,479.6	1,363.6	2,843.1
2018	1,864.3	1,719.2	3,583.4
2019	2,033.2	1,874.2	3,907.4
2020	2,090.0	1,924.2	4,014.3
Average	***1,866.8***	***1,720.3***	***3,587.1***

Source: RESI

Figure 287: GHG Benefits from Priority Funding Areas and Other Growth Boundaries—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$97,324,072	$89,687,646	$187,011,719
2018	$121,432,744	$111,904,658	$233,337,402
2019	$132,677,105	$122,266,742	$254,943,848
2020	$136,996,973	$126,247,656	$263,244,629
Average	***$122,107,724***	***$112,526,676***	***$234,634,399***

Source: RESI

Figure 288: GHG Benefits from Priority Funding Areas and Other Growth Boundaries—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$46,224,170	$42,597,241	$88,821,411
2018	$63,344,821	$58,374,539	$121,719,360
2019	$73,564,801	$67,792,620	$141,357,422
2020	$79,734,906	$73,478,595	$153,213,501
Average	***$65,717,175***	***$60,560,749***	***$126,277,924***

Source: RESI

A.7 Innovative Initiatives

Figure 289: Leadership-by-Example-Local Government—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	123.3	45.3	168.6
2011	125.5	47.0	172.5
2012	124.3	46.1	170.4
2013	122.6	44.7	167.2
2014	120.0	42.4	162.4
2015	116.9	40.3	157.2
2016	114.6	38.9	153.6
2017	113.1	37.9	151.0
2018	111.2	37.1	148.4
2019	109.8	35.9	145.7
2020	109.2	35.3	144.5
Average	***117.3***	***41.0***	***158.3***

Source: RESI

Figure 290: Leadership-by-Example-Local Government—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$9,656,407	$3,374,599	$13,031,006
2011	$9,814,709	$3,429,920	$13,244,629
2012	$9,746,865	$3,406,211	$13,153,076
2013	$9,565,949	$3,342,986	$12,908,936
2014	$9,430,262	$3,295,568	$12,725,830
2015	$9,271,960	$3,240,247	$12,512,207
2016	$9,136,273	$3,192,829	$12,329,102
2017	$9,091,044	$3,177,023	$12,268,066
2018	$9,045,815	$3,161,216	$12,207,031
2019	$9,045,815	$3,161,216	$12,207,031
2020	$9,045,815	$3,161,216	$12,207,031
Average	***$9,350,083***	***$3,267,548***	***$12,617,631***

Source: RESI

Figure 291: Leadership-by-Example-Local Government—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$4,500,293	$1,572,705	$6,072,998
2011	$4,918,662	$1,718,911	$6,637,573
2012	$5,178,729	$1,809,796	$6,988,525
2013	$5,348,338	$1,869,069	$7,217,407
2014	$5,551,869	$1,940,197	$7,492,065
2015	$5,721,478	$1,999,469	$7,720,947
2016	$5,879,780	$2,054,791	$7,934,570
2017	$6,038,081	$2,110,112	$8,148,193
2018	$6,207,690	$2,169,385	$8,377,075
2019	$6,332,070	$2,212,851	$8,544,922
2020	$6,433,836	$2,248,415	$8,682,251
Average	***$5,646,439***	***$1,973,246***	***$7,619,684***

Source: RESI

Figure 292: Leadership-by-Example-Local Government—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2020	1,484.9	352.5	1,837.4
2021	289.1	1,417.1	1,706.1
2022	1,372.2	247.9	1,620.1
2023	1,340.2	218.3	1,558.5
2024	1,317.2	197.8	1,514.9
2025	1,300.6	183.6	1,484.2
Average	***1,184.0***	***436.2***	***1,620.2***

Source: RESI

Figure 293: Leadership-by-Example-Local Government—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2020	$79,885,067	$29,428,898	$109,313,965
2021	$73,685,165	$27,144,913	$100,830,078
2022	$69,358,615	$25,551,053	$94,909,668
2023	$66,325,569	$24,433,708	$90,759,277
2024	$64,095,389	$23,612,131	$87,707,520
2025	$62,534,262	$23,037,027	$85,571,289
Average	***$69,314,011***	***$25,534,621***	***$94,848,633***

Source: RESI

Figure 294: Leadership-by-Example-Local Government—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2020	$75,413,555	$27,781,635	$103,195,190
2021	$78,613,864	$28,960,599	$107,574,463
2022	$81,535,401	$30,036,865	$111,572,266
2023	$84,256,221	$31,039,189	$115,295,410
2024	$86,865,532	$32,000,435	$118,865,967
2025	$89,541,749	$32,986,327	$122,528,076
Average	***$82,704,387***	***$30,467,508***	***$113,171,895***

Source: RESI

Figure 295: Leadership-by-Example-Federal Government—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	77.3	28.6	105.9
2011	78.5	29.4	108.0
2012	77.9	28.8	106.8
2013	77.0	28.2	105.2
2014	75.4	27.0	102.5
2015	73.0	25.2	98.2
2016	72.0	24.6	96.6
2017	70.6	23.5	94.1
2018	69.1	22.8	91.9
2019	68.1	22.2	90.3
2020	67.3	21.2	88.5
Average	***73.3***	***25.6***	***98.9***

Source: RESI

Figure 296: Leadership-by-Example-Federal Government—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$6,061,465	$2,117,246	$8,178,711
2011	$6,151,935	$2,148,846	$8,300,781
2012	$6,106,700	$2,133,046	$8,239,746
2013	$6,016,230	$2,101,445	$8,117,676
2014	$5,970,996	$2,085,645	$8,056,641
2015	$5,790,056	$2,022,444	$7,812,500
2016	$5,744,822	$2,006,643	$7,751,465
2017	$5,699,587	$1,990,843	$7,690,430
2018	$5,654,352	$1,975,043	$7,629,395
2019	$5,654,352	$1,975,043	$7,629,395
2020	$5,563,882	$1,943,442	$7,507,324
Average	***$5,855,852***	***$2,045,426***	***$7,901,278***

Source: RESI

Figure 297: Leadership-by-Example-Federal Government—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$2,827,176	$987,521	$3,814,697
2011	$3,064,659	$1,070,473	$4,135,132
2012	$3,256,907	$1,137,625	$4,394,531
2013	$3,369,994	$1,177,125	$4,547,119
2014	$3,517,007	$1,228,476	$4,745,483
2015	$3,584,859	$1,252,177	$4,837,036
2016	$3,697,946	$1,291,678	$4,989,624
2017	$3,811,033	$1,331,179	$5,142,212
2018	$3,912,812	$1,366,729	$5,279,541
2019	$3,969,355	$1,386,480	$5,355,835
2020	$4,014,590	$1,402,280	$5,416,870
Average	***$3,547,849***	***$1,239,249***	***$4,787,098***

Source: RESI

Figure 298: Leadership-by-Example-Federal Government—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2020	977.8	280.6	1,258.4
2021	283.9	936.7	1,220.6
2022	939.1	246.1	1,185.2
2023	920.0	229.0	1,149.1
2024	903.0	214.4	1,117.4
2025	888.8	202.3	1,091.1
Average	***818.8***	***351.5***	***1,170.3***

Source: RESI

Figure 299: Leadership-by-Example-Federal Government—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2020	$64,437,579	$27,664,472	$92,102,051
2021	$62,814,896	$26,967,819	$89,782,715
2022	$61,192,214	$26,271,165	$87,463,379
2023	$59,569,531	$25,574,512	$85,144,043
2024	$58,117,657	$24,951,190	$83,068,848
2025	$56,921,996	$24,437,867	$81,359,863
Average	***$60,508,979***	***$25,977,837***	***$86,486,816***

Source: RESI

Figure 300: Leadership-by-Example-Federal Government—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2020	$48,114,673	$20,656,689	$68,771,362
2021	$51,285,310	$22,017,913	$73,303,223
2022	$53,762,036	$23,081,226	$76,843,262
2023	$55,704,985	$23,915,377	$79,620,361
2024	$57,413,071	$24,648,696	$82,061,768
2025	$58,971,701	$25,317,850	$84,289,551
Average	***$54,208,629***	***$23,272,958***	***$77,481,588***

Source: RESI

Figure 301: Leadership-by-Example-Maryland Colleges and Universities—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	74.4	27.5	101.9
2011	75.7	28.6	104.3
2012	75.0	27.8	102.9
2013	74.4	27.5	101.9
2014	72.9	26.2	99.1
2015	70.5	24.6	95.0
2016	69.2	23.8	93.0
2017	68.1	22.8	91.0
2018	67.1	22.4	89.4
2019	65.4	21.1	86.5
2020	65.2	20.6	85.8
Average	***70.7***	***24.8***	***95.5***

Source: RESI

Figure 302: Leadership-by-Example-Maryland Colleges and Universities—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$5,806,837	$2,036,180	$7,843,018
2011	$5,942,405	$2,083,718	$8,026,123
2012	$5,874,621	$2,059,949	$7,934,570
2013	$5,806,837	$2,036,180	$7,843,018
2014	$5,761,648	$2,020,335	$7,781,982
2015	$5,603,485	$1,964,874	$7,568,359
2016	$5,513,106	$1,933,183	$7,446,289
2017	$5,467,917	$1,917,337	$7,385,254
2018	$5,467,917	$1,917,337	$7,385,254
2019	$5,422,727	$1,901,491	$7,324,219
2020	$5,377,538	$1,885,646	$7,263,184
Average	***$5,640,458***	***$1,977,839***	***$7,618,297***

Source: RESI

Figure 303: Leadership-by-Example-Maryland Colleges and Universities—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$2,722,661	$954,707	$3,677,368
2011	$2,937,311	$1,029,974	$3,967,285
2012	$3,129,366	$1,097,319	$4,226,685
2013	$3,264,934	$1,144,856	$4,409,790
2014	$3,377,907	$1,184,471	$4,562,378
2015	$3,468,286	$1,216,162	$4,684,448
2016	$3,547,367	$1,243,892	$4,791,260
2017	$3,660,341	$1,283,507	$4,943,848
2018	$3,773,314	$1,323,121	$5,096,436
2019	$3,818,504	$1,338,967	$5,157,471
2020	$3,886,288	$1,362,735	$5,249,023
Average	***$3,416,934***	***$1,198,156***	***$4,615,090***

Source: RESI

Figure 304: Leadership-by-Example-Maryland Colleges and Universities—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2020	78.0	18.1	96.0
2021	14.4	74.4	88.8
2022	71.6	12.2	83.9
2023	69.7	10.6	80.3
2024	68.7	9.6	78.4
2025	68.4	9.3	77.7
Average	***61.8***	***22.4***	***84.2***

Source: RESI

Figure 305: Leadership-by-Example-Maryland Colleges and Universities—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2020	$78.0	$18.1	$96.0
2021	$14.4	$74.4	$88.8
2022	$71.6	$12.2	$83.9
2023	$69.7	$10.6	$80.3
2024	$68.7	$9.6	$78.4
2025	$68.4	$9.3	$77.7
Average	**$61.8**	**$22.4**	**$84.2**

Source: RESI

Figure 306: Leadership-by-Example-Maryland Colleges and Universities—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2020	$3,955,194	$1,431,158	$5,386,353
2021	$4,168,080	$1,508,189	$5,676,270
2022	$4,302,535	$1,556,840	$5,859,375
2023	$4,459,398	$1,613,600	$6,072,998
2024	$4,571,443	$1,654,143	$6,225,586
2025	$4,750,715	$1,719,011	$6,469,727
Average	***$4,367,894***	***$1,580,490***	***$5,948,385***

Source: RESI

Figure 307: State of Maryland Initiative to Lead by Example—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	16.5	8.2	24.7
2011	20.3	11.3	31.6
2012	15.7	9.6	25.3
2013	0.2	0.0	0.2
2014	-0.8	-0.9	-1.7
2015	-1.4	-1.4	-2.7
2016	-1.5	-1.5	-3.0
2017	-1.4	-1.4	-2.8
2018	-1.2	-1.2	-2.3
2019	-0.9	-0.9	-1.8
2020	-0.6	-0.6	-1.3
Average	***4.1***	***1.9***	***6.0***

Source: RESI

Figure 308: State of Maryland Initiative to Lead by Example—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$1,213,538	$571,741	$1,785,278
2011	$1,508,520	$710,718	$2,219,238
2012	$1,181,177	$556,494	$1,737,671
2013	$8,713	$4,105	$12,817
2014	-$75,302	-$35,477	-$110,779
2015	-$121,976	-$57,467	-$179,443
2016	-$131,933	-$62,158	-$194,092
2017	-$121,976	-$57,467	-$179,443
2018	-$103,306	-$48,671	-$151,978
2019	-$77,169	-$36,357	-$113,525
2020	-$56,009	-$26,388	-$82,397
Average	***$293,116***	***$138,097***	***$431,213***

Source: RESI

Figure 309: State of Maryland Initiative to Lead by Example—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$536,135	$252,592	$788,727
2011	$688,916	$324,573	$1,013,489
2012	$568,807	$267,985	$836,792
2013	$55,387	$26,095	$81,482
2014	-$3,734	-$1,759	-$5,493
2015	-$43,252	-$20,377	-$63,629
2016	-$65,967	-$31,079	-$97,046
2017	-$74,679	-$35,184	-$109,863
2018	-$75,613	-$35,624	-$111,237
2019	-$67,834	-$31,959	-$99,792
2020	-$57,876	-$27,268	-$85,144
Average	***$132,754***	***$62,545***	***$195,299***

Source: RESI

Figure 310: State of Maryland Initiative to Lead by Example—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	90.5	66.3	156.8
2011	168.5	138.3	306.8
2012	211.4	177.8	389.2
2013	237.2	201.4	438.7
2014	248.5	210.1	458.6
2015	249.9	210.1	460.0
2016	245.0	204.1	449.1
2017	235.1	193.2	428.4
2018	220.2	178.0	398.2
2019	199.0	156.8	355.8
2020	177.0	134.6	311.7
Average	***207.5***	***170.1***	***377.6***

Source: RESI

Figure 311: State of Maryland Initiative to Lead by Example—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$5,316,565	$4,357,508	$9,674,072
2011	$10,716,987	$8,783,746	$19,500,732
2012	$14,373,173	$11,780,391	$26,153,564
2013	$17,174,013	$14,075,987	$31,250,000
2014	$19,371,079	$15,876,723	$35,247,803
2015	$20,997,915	$17,210,093	$38,208,008
2016	$22,205,463	$18,199,811	$40,405,273
2017	$23,178,209	$18,997,084	$42,175,293
2018	$23,916,155	$19,601,911	$43,518,066
2019	$24,318,671	$19,931,817	$44,250,488
2020	$24,419,300	$20,014,294	$44,433,594
Average	***$18,726,139***	***$15,348,124***	***$34,074,263***

Source: RESI

Figure 312: State of Maryland Initiative to Lead by Example—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$2,171,909	$1,780,117	$3,952,026
2011	$4,209,646	$3,450,266	$7,659,912
2012	$5,610,066	$4,598,064	$10,208,130
2013	$6,582,813	$5,395,337	$11,978,149
2014	$7,303,987	$5,986,418	$13,290,405
2015	$7,740,046	$6,343,816	$14,083,862
2016	$7,916,147	$6,488,150	$14,404,297
2017	$7,924,533	$6,495,023	$14,419,556
2018	$7,706,503	$6,316,324	$14,022,827
2019	$7,119,501	$5,835,211	$12,954,712
2020	$6,389,941	$5,237,257	$11,627,197
Average	***$6,425,008***	***$5,265,999***	***$11,691,007***

Source: RESI

Figure 313: State of Maryland Carbon and Footprint Initiatives—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 314: State of Maryland Carbon and Footprint Initiatives—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 315: State of Maryland Carbon and Footprint Initiatives—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 316: State of Maryland Carbon and Footprint Initiatives—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	780.5	365.4	1,146.0
2011	583.3	168.6	752.0
2012	561.6	146.3	708.0
2013	549.1	134.3	683.4
2014	541.8	130.1	671.9
2015	540.3	131.7	672.0
2016	542.8	137.4	680.2
2017	548.5	145.7	694.2
2018	555.8	155.7	711.6
2019	565.1	165.5	730.6
2020	576.5	176.4	753.0
Average	***576.9***	***168.8***	***745.7***

Source: RESI

Figure 317: State of Maryland Carbon and Footprint Initiatives—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$74,979,560	$21,944,268	$96,923,828
2011	$36,710,710	$10,744,124	$47,454,834
2012	$34,444,326	$10,080,821	$44,525,146
2013	$32,862,578	$9,617,891	$42,480,469
2014	$32,343,198	$9,465,884	$41,809,082
2015	$32,343,198	$9,465,884	$41,809,082
2016	$32,673,713	$9,562,616	$42,236,328
2017	$33,287,525	$9,742,260	$43,029,785
2018	$34,326,285	$10,046,274	$44,372,559
2019	$35,128,963	$10,281,194	$45,410,156
2020	$36,167,722	$10,585,207	$46,752,930
Average	***$37,751,616***	***$11,048,766***	***$48,800,382***

Source: RESI

Figure 318: State of Maryland Carbon and Footprint Initiatives—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$29,923,360	$8,757,670	$38,681,030
2011	$22,864,516	$6,691,758	$29,556,274
2012	$22,829,104	$6,681,394	$29,510,498
2013	$22,687,455	$6,639,938	$29,327,393
2014	$22,958,949	$6,719,396	$29,678,345
2015	$23,395,700	$6,847,220	$30,242,920
2016	$23,867,864	$6,985,408	$30,853,271
2017	$24,517,089	$7,175,416	$31,692,505
2018	$25,402,395	$7,434,519	$32,836,914
2019	$26,193,269	$7,665,984	$33,859,253
2020	$27,161,204	$7,949,270	$35,110,474
Average	***$24,709,173***	***$7,231,634***	***$31,940,807***

Source: RESI

Figure 319: GHG Early Voluntary Reduction—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.5	0.3	0.8
2011	0.5	0.3	0.7
2012	0.2	0.1	0.4
2013	0.2	0.0	0.3
2014	0.5	0.2	0.6
2015	0.2	0.1	0.3
2016	0.7	0.3	1.0
2017	0.5	0.0	0.4
2018	0.2	-0.2	0.0
2019	0.5	0.2	0.7
2020	-0.1	-0.2	-0.3
Average	0.4	0.1	0.4

Source: RESI

Figure 320: GHG Early Voluntary Reduction—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$48,375	$12,661	$61,035
2011	$24,187	$6,330	$30,518
2012	$24,187	$6,330	$30,518
2013	$24,187	$6,330	$30,518
2014	$48,375	$12,661	$61,035
2015	$0	$0	$0
2016	$48,375	$12,661	$61,035
2017	$0	$0	$0
2018	$0	$0	$0
2019	$48,375	$12,661	$61,035
2020	$0	$0	$0
Average	***$24,187***	***$6,330***	***$30,518***

Source: RESI

Figure 321: GHG Early Voluntary Reduction—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$12,094	$3,165	$15,259
2011	$12,094	$3,165	$15,259
2012	$0	$0	$0
2013	$12,094	$3,165	$15,259
2014	$12,094	$3,165	$15,259
2015	$12,094	$3,165	$15,259
2016	$24,187	$6,330	$30,518
2017	$24,187	$6,330	$30,518
2018	$12,094	$3,165	$15,259
2019	$24,187	$6,330	$30,518
2020	$24,187	$6,330	$30,518
Average	***$15,392***	***$4,028***	***$19,420***

Source: RESI

Figure 322: GHG Early Voluntary Reduction—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	1.2	0.8	2.0
2012	1.4	1.3	2.7
2013	1.7	1.7	3.4
2014	2.7	2.1	4.9
2015	2.3	1.9	4.2
2016	3.0	2.4	5.4
2017	2.9	2.4	5.2
2018	2.8	2.5	5.3
2019	2.8	2.6	5.4
2020	2.3	1.9	4.3
Average	***2.1***	***1.8***	***3.9***

Source: RESI

Figure 323: GHG Early Voluntary Reduction—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$99,292	$83,814	$183,105
2012	$165,486	$139,690	$305,176
2013	$198,583	$167,628	$366,211
2014	$281,326	$237,473	$518,799
2015	$264,777	$223,504	$488,281
2016	$297,875	$251,442	$549,316
2017	$297,875	$251,442	$549,316
2018	$330,972	$279,380	$610,352
2019	$364,069	$307,318	$671,387
2020	$297,875	$251,442	$549,316
Average	***$236,194***	***$199,376***	***$435,569***

Source: RESI

Figure 324: GHG Early Voluntary Reduction—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$24,823	$20,953	$45,776
2012	$41,371	$34,922	$76,294
2013	$66,194	$55,876	$122,070
2014	$74,469	$62,860	$137,329
2015	$82,743	$69,845	$152,588
2016	$99,292	$83,814	$183,105
2017	$115,840	$97,783	$213,623
2018	$99,292	$83,814	$183,105
2019	$124,114	$104,767	$228,882
2020	$124,114	$104,767	$228,882
Average	***$77,477***	***$65,400***	***$142,878***

Source: RESI

Figure 325: Job Creation and Economic Development Initiatives—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 326: Job Creation and Economic Development Initiatives—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 327: Job Creation and Economic Development Initiatives—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 328: Job Creation and Economic Development Initiatives—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 329: Job Creation and Economic Development Initiatives—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 330: Job Creation and Economic Development Initiatives—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 331: Public Health Initiatives Related to Climate Changes—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	26.5	10.0	36.5
2011	27.3	10.7	37.9
2012	0.8	0.7	1.4
2013	-0.1	0.1	0.0
2014	0.1	-0.3	-0.2
2015	-0.4	-0.6	-1.0
2016	-0.2	-0.4	-0.6
2017	0.1	-0.2	-0.1
2018	0.3	0.0	0.3
2019	0.3	0.3	0.6
2020	0.4	0.2	0.6
Average	***5.0***	***1.9***	***6.8***

Source: RESI

Figure 332: Public Health Initiatives Related to Climate Changes—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$2,042,627	$764,990	$2,807,617
2011	$2,064,830	$773,305	$2,838,135
2012	$44,405	$16,630	$61,035
2013	-$44,405	-$16,630	-$61,035
2014	-$22,202	-$8,315	-$30,518
2015	-$88,810	-$33,260	-$122,070
2016	-$88,810	-$33,260	-$122,070
2017	-$44,405	-$16,630	-$61,035
2018	-$44,405	-$16,630	-$61,035
2019	$44,405	$16,630	$61,035
2020	$0	$0	$0
Average	***$351,203***	***$131,530***	***$482,733***

Source: RESI

Figure 333: Public Health Initiatives Related to Climate Changes—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$932,504	$349,235	$1,281,738
2011	$999,111	$374,180	$1,373,291
2012	$66,607	$24,945	$91,553
2013	$55,506	$20,788	$76,294
2014	-$11,101	-$4,158	-$15,259
2015	-$11,101	-$4,158	-$15,259
2016	-$44,405	-$16,630	-$61,035
2017	-$11,101	-$4,158	-$15,259
2018	-$22,202	-$8,315	-$30,518
2019	-$22,202	-$8,315	-$30,518
2020	$0	$0	$0
Average	***$175,601***	***$65,765***	***$241,366***

Source: RESI

Figure 334: Public Health Initiatives Related to Climate Changes—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-5.0	-4.3	-9.3
2011	25.6	23.9	49.5
2012	25.9	24.4	50.3
2013	25.6	24.1	49.8
2014	25.1	23.4	48.5
2015	23.9	22.1	46.0
2016	23.0	21.4	44.4
2017	22.7	20.9	43.6
2018	22.1	20.4	42.5
2019	21.3	20.0	41.3
2020	20.8	19.2	40.0
Average	***21.0***	***19.6***	***40.6***

Source: RESI

Figure 335: Public Health Initiatives Related to Climate Changes—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$505,055	-$471,508	-$976,563
2011	$1,167,940	$1,090,361	$2,258,301
2012	$1,215,288	$1,134,565	$2,349,854
2013	$1,199,506	$1,119,830	$2,319,336
2014	$1,183,723	$1,105,096	$2,288,818
2015	$1,104,808	$1,031,423	$2,136,230
2016	$1,073,242	$1,001,954	$2,075,195
2017	$1,041,676	$972,484	$2,014,160
2018	$1,010,110	$943,015	$1,953,125
2019	$1,041,676	$972,484	$2,014,160
2020	$978,544	$913,546	$1,892,090
Average	***$955,587***	***$892,114***	***$1,847,701***

Source: RESI

Figure 336: Public Health Initiatives Related to Climate Changes—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	-$149,938	-$139,979	-$289,917
2011	$449,815	$419,936	$869,751
2012	$528,729	$493,609	$1,022,339
2013	$552,404	$515,711	$1,068,115
2014	$568,187	$530,446	$1,098,633
2015	$583,970	$545,181	$1,129,150
2016	$591,861	$552,548	$1,144,409
2017	$607,644	$567,283	$1,174,927
2018	$615,536	$574,650	$1,190,186
2019	$615,536	$574,650	$1,190,186
2020	$615,536	$574,650	$1,190,186
Average	***$507,207***	***$473,517***	***$980,724***

Source: RESI

Figure 337: Title V Permits for GHG Sources—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	1.0	0.4	1.5
2013	0.8	0.4	1.3
2014	0.8	0.2	1.0
2015	0.8	0.3	1.0
2016	1.0	0.5	1.5
2017	0.8	0.2	1.0
2018	1.0	0.5	1.5
2019	0.5	0.1	0.6
2020	0.5	0.0	0.5
Average	***0.7***	***0.2***	***0.9***

Source: RESI

Figure 338: Title V Permits for GHG Sources—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$88,984	$33,086	$122,070
2013	$66,738	$24,815	$91,553
2014	$88,984	$33,086	$122,070
2015	$44,492	$16,543	$61,035
2016	$88,984	$33,086	$122,070
2017	$88,984	$33,086	$122,070
2018	$44,492	$16,543	$61,035
2019	$88,984	$33,086	$122,070
2020	$44,492	$16,543	$61,035
Average	***$58,649***	***$21,807***	***$80,455***

Source: RESI

Figure 339: Title V Permits for GHG Sources—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$44,492	$16,543	$61,035
2013	$33,369	$12,407	$45,776
2014	$33,369	$12,407	$45,776
2015	$33,369	$12,407	$45,776
2016	$55,615	$20,679	$76,294
2017	$44,492	$16,543	$61,035
2018	$44,492	$16,543	$61,035
2019	$44,492	$16,543	$61,035
2020	$33,369	$12,407	$45,776
Average	***$33,369***	***$12,407***	***$45,776***

Source: RESI

Figure 340: Title V Permits for GHG Sources—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	6.2	2.0	8.2
2012	5.5	1.6	7.1
2013	4.9	1.3	6.2
2014	4.7	0.7	5.4
2015	3.6	-0.2	3.4
2016	3.4	-0.2	3.2
2017	3.3	-0.3	3.0
2018	3.2	-0.3	2.9
2019	2.7	-0.5	2.1
2020	2.7	-0.7	2.0
Average	***3.7***	***0.3***	***4.0***

Source: RESI

Figure 341: Title V Permits for GHG Sources—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$507,891	$41,425	$549,316
2012	$423,243	$34,521	$457,764
2013	$310,378	$25,315	$335,693
2014	$310,378	$25,315	$335,693
2015	$112,865	$9,206	$122,070
2016	$112,865	$9,206	$122,070
2017	$112,865	$9,206	$122,070
2018	$112,865	$9,206	$122,070
2019	$112,865	$9,206	$122,070
2020	$56,432	$4,603	$61,035
Average	***$197,513***	***$16,110***	***$213,623***

Source: RESI

Figure 342: Title V Permits for GHG Sources—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$268,054	$21,863	$289,917
2012	$282,162	$23,014	$305,176
2013	$282,162	$23,014	$305,176
2014	$268,054	$21,863	$289,917
2015	$239,838	$19,562	$259,399
2016	$225,729	$18,411	$244,141
2017	$253,946	$20,713	$274,658
2018	$253,946	$20,713	$274,658
2019	$211,621	$17,260	$228,882
2020	$239,838	$19,562	$259,399
Average	***$229,577***	***$18,725***	***$248,302***

Source: RESI

Figure 343: Outreach and Public Education—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.0	0.0	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	0.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0
2020	0.0	0.0	0.0
Average	***0.0***	***0.0***	***0.0***

Source: RESI

Figure 344: Outreach and Public Education—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 345: Outreach and Public Education—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
Average	***$0***	***$0***	***$0***

Source: RESI

Figure 346: Outreach and Public Education—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	0.1	0.0	0.1
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	-0.1	-0.1
2017	0.3	0.1	0.4
2018	0.3	0.1	0.4
2019	0.0	0.2	0.3
2020	0.1	0.0	0.1
Average	***0.1***	***0.0***	***0.1***

Source: RESI

Figure 347: Outreach and Public Education—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$23,703	$6,815	$30,518
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$47,406	$13,629	$61,035
2020	$47,406	$13,629	$61,035
Average	***$10,774***	***$3,098***	***$13,872***

Source: RESI

Figure 348: Outreach and Public Education—Operation Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$0	$0	$0
2017	$11,851	$3,407	$15,259
2018	$0	$0	$0
2019	$23,703	$6,815	$30,518
2020	$11,851	$3,407	$15,259
Average	***$4,310***	***$1,239***	***$5,549***

Source: RESI

Figure 349: Prevention of Significant Deterioration Program—Investment Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	1.0	0.4	1.5
2013	0.8	0.4	1.3
2014	0.8	0.2	1.0
2015	0.8	0.3	1.0
2016	1.0	0.5	1.5
2017	0.8	0.2	1.0
2018	1.0	0.5	1.5
2019	0.5	0.1	0.6
2020	0.5	0.0	0.5
Average	***0.7***	***0.2***	***0.9***

Source: RESI

Figure 350: Prevention of Significant Deterioration Program—Investment Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$88,984	$33,086	$122,070
2013	$66,738	$24,815	$91,553
2014	$88,984	$33,086	$122,070
2015	$44,492	$16,543	$61,035
2016	$88,984	$33,086	$122,070
2017	$88,984	$33,086	$122,070
2018	$44,492	$16,543	$61,035
2019	$88,984	$33,086	$122,070
2020	$44,492	$16,543	$61,035
Average	***$58,649***	***$21,807***	***$80,455***

Source: RESI

Figure 351: Prevention of Significant Deterioration Program—Investment Phase, Wage Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$44,492	$16,543	$61,035
2013	$33,369	$12,407	$45,776
2014	$33,369	$12,407	$45,776
2015	$33,369	$12,407	$45,776
2016	$55,615	$20,679	$76,294
2017	$44,492	$16,543	$61,035
2018	$44,492	$16,543	$61,035
2019	$44,492	$16,543	$61,035
2020	$33,369	$12,407	$45,776
Average	***$33,369***	***$12,407***	***$45,776***

Source: RESI

Figure 352: Prevention of Significant Deterioration Program—Operation Phase, Employment Impacts

Fiscal Year	Direct	Spinoff	Total
2010	0.0	0.0	0.0
2011	0.0	0.0	0.0
2012	2.0	0.7	2.7
2013	1.7	0.7	2.4
2014	1.7	0.4	2.1
2015	0.9	-0.3	0.6
2016	0.8	-0.4	0.5
2017	0.9	-0.5	0.4
2018	0.8	-0.3	0.5
2019	0.5	-0.5	0.0
2020	0.5	-0.6	-0.1
Average	***0.9***	***-0.1***	***0.8***

Source: RESI

Figure 353: Prevention of Significant Deterioration Program—Operation Phase, Output Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$196,503	-$13,398	$183,105
2013	$163,753	-$11,165	$152,588
2014	$163,753	-$11,165	$152,588
2015	$0	$0	$0
2016	$0	$0	$0
2017	$0	$0	$0
2018	$0	$0	$0
2019	$65,501	-$4,466	$61,035
2020	$0	$0	$0
Average	***$53,592***	***-$3,654***	***$49,938***

Source: RESI

Figure 354: Prevention of Significant Deterioration Program—Operation Phase, Wages Impacts

Fiscal Year	Direct	Spinoff	Total
2010	$0	$0	$0
2011	$0	$0	$0
2012	$114,627	-$7,815	$106,812
2013	$114,627	-$7,815	$106,812
2014	$81,876	-$5,582	$76,294
2015	$81,876	-$5,582	$76,294
2016	$81,876	-$5,582	$76,294
2017	$65,501	-$4,466	$61,035
2018	$81,876	-$5,582	$76,294
2019	$81,876	-$5,582	$76,294
2020	$65,501	-$4,466	$61,035
Average	***$69,967***	***-$4,770***	***$65,197***

Source: RESI

Appendix B—Methodology

B.1 General Overview

Several Maryland state agencies have several strategies and subprograms in place to aid The State in meeting its greenhouse gas emissions reduction goals. In some cases, state government agencies associated with these subject areas are developing enhancements to their strategies and subprograms to bridge the gap between achieved emissions reductions and emissions reduction targets.

Greenhouse gas emission reductions are calculated for each strategy/subprogram, but data is supplied by each state agency that is responsible the given strategy. As such, RESI, in coordination with MDE, developed a methodology to analyze the reported data. MDE assisted in the development and finalization of all assumptions used in the economic modeling for the task order. Through this coordinated effort, RESI and MDE determined two phases to be modeled for each strategy and subprogram: an investment phase and an operation phase.

Investment Phase

The investment phase refers to the entire period during which a strategy and its subprograms are being developed, invested in, and enacted. In other words, it is the period during which the implementing entity or entities, whether it be state government agency or agencies, a business entity or entities required to comply, and/or some other individual or group(s), will invest funds and effort into the appropriate sector(s) of the economy to achieve the requirements outlined for the strategy and subprograms.

In all cases, the investment values were discussed with state agencies and data was provided that could best describe that period of time. Some strategies are categorized as "funded," "awaiting funding," or "potentially funded." Those that are funded are currently being implemented and data could be established for those policies from previous years. Strategies listed as "awaiting funding" have approved funding but may have not started their investment phases yet. Yearly totals of investment are then calculated based on the data provided by agencies. Unless other data on spending and implementation of the plans was provided, the total amount of funding was split across the years the agency expects it will take for the policy to go from start to finish for investment. Some agencies provided specific data on what level of investment would take place in each year. Certain programs required a larger initial investment that decreases in future years. Finally, strategies listed as "potential funding" are those that if they had the adequate funding this is how they may effect Maryland's economy. The programs that are listed at "potential funding" are not evaluated in this report.

In addition, it should be noted that "investment" is not necessarily modeled as a positive inflow of capital for all industry sectors identified in Section B.3. In some cases, "investment" is the outflow of capital for those industries for which strategy compliance is mandated. This causes an inflow of capital for all industry sectors experiencing a positive change due to other industries' mandated compliance. In some cases, investment originates in the private sector. This may lead to increases or decreases in employment, output, or wages during the investment

phase. Interactions among agencies and their ability to impact Maryland's economy will determine the level of change to these economic indicators.
In other words, some industry sectors are more responsive to variations in the economy, which determines the degree to which employment, output, and wages are impacted. If a more sensitive sector experiences a negative change (or an outflow of capital), the associated negative impacts outweigh the positive change experienced by a less sensitive, benefitting sector (one experiencing an inflow of capital).

Operation Phase
The operation phase refers to the period during which a strategy and its subprograms have already been implemented and the "end user" cost savings (or other monetary benefits) are being realized. In other words, it is the period during which the goals of the strategy and subprograms have been achieved and individuals and/or business entities are realizing cost savings, increased income, etc.

In most cases, this phase is modeled based on the level of savings, increased earnings, or some other measure as calculated from data included in the strategy write-ups supplied by MDE, the implementing agencies, and external research. Therefore, the economic impacts represented are the total actual annual economic impacts unless otherwise specified.

An example of the steps undertaken by RESI and their results for one strategy with all of its subprograms for both phases can be found in Section B.2.

Exclusions and Limitations
Due to lack of data provided by certain agencies, some strategies have been modeled using all external data and assumptions. While impacts resulting from such inputs will not be as accurate as they could be, they will serve as a general frame of reference for potential impacts. Overall, many agencies were very helpful in providing accurate cost/funding data for both the investment and operation phases. For more detailed information regarding the steps undertaken and sources used to model specific strategies, please refer to Appendix C.

B.2 REMI PI+ Model

Overview
To achieve the most concise analysis of program interaction and other factors, RESI will use the Regional Economic Models, Inc. (REMI) PI+ model to analyze data for the 2012 report. The REMI model is a dynamic modeling tool used by various government agencies and state departments in economic policy analysis. REMI will help RESI to build from its base model in the previous report to create a sophisticated model that is calibrated to the specific demographic features of Maryland.

The REMI model features the ability to capture price effects, wage changes, and behavioral effects through time. The model will also allow RESI to capture the effects occurring between industries and minimize the potential for double counting in employment, output, and wages. The ability to capture effects across time will give MDE a detailed representation of the GGRA programs and their effects on Maryland in the longer term.

The model details the impacts based on two categories: direct and spinoff effects. The spinoff effects are defined as intermediate effects plus induced effects.
REMI defines the intermediate effects as the purchase of intermediate goods associated with production. For example, a company may be hired to manufacture blue recycling bins that will be used in office buildings associated with the *Recycling and Source Reduction* policy. The purchase of the bins would be considered a direct effect, but the purchase of the materials to produce the bins is considered an intermediate effect.

REMI defines the induced effects as the economic effects that occur from the spending of wages. For example, an employee hired under the *Voluntary Stationary Source Reductions* policy earns a wage, and with this new wage may go out to dinner once a week. The spending of the employee's wage on dinner is considered an induced effect.

Using the REMI model, RESI will create a dynamic impact analysis detailing the levels of employment, output, and wages associated with each policy for each year from 2008 to 2025.

Reading the Results
REMI uses a regional control based on historical Bureau of Economic Analysis data to forecast values for employment, wages, and output. When economic values are decreased or increased based on parameters from the user in the regional simulation, the forecast is then altered to reflect the changes made by the user.

REMI reports cumulative and non-cumulative results based on the different economic factors being reviewed. In REMI, the results that would be reported as non-cumulative would be population and employment. All other results are viewed as cumulative.

For example, for a policy that increases government spending in 2010 and 2011, the results report an increase of 100 jobs in 2010 and 120 jobs in 2011. These new jobs are the difference from the baseline for that year, not the subsequent year. Therefore, the 100 jobs in 2010 are 100 new jobs for 2010, and the 120 jobs in 2011 are 120 new jobs in 2011. The difference, 20 jobs, would be the estimated increase between the years in the simulation. The 100 jobs would be considered retained employment.

Wages and output are cumulative and build from one year to the next in the REMI model. If the previously mentioned policy notes that the wages in 2010 were $250,000 and then grew to $500,000 in 2011, this would be an increase of $500,000 from the previous year. The model has taken into account the change in the wages from the previous year, and the new number reported would be the increase on an annual basis. When reading this result you would say, "Wages in 2011 increased by $500,000."

Figure 355: Sampling of REMI PI+ Users

Academic Institutions	**State Government**
Arizona State University	Connecticut Department of Economic and Community Development
Ball State University	District of Columbia
Costal Rivers Water Planning and Policy Center	Empire State Development Corporation
Florida State University	Florida Agency for Workforce Innovation
Georgia State University	Florida Legislature
Massachusetts Institute of Technology	Hawaii Department of Business, Economic Development & Tourism
Michigan Small Business & Technology Development Center	Illinois Department of Commerce and Economic Opprotunity
Michigan Technological University	Illinois Department of Revenue
Pennsylvania State University	Indiana Department of Transportation
Southwestern Oklahoma State University	Iowa Department of Revenue
University of Southren Maine	
University New Hampshire	**Private Consulting Firms**
University of Arkansas at Little Rock	Alliance Transportation Group
University of California, Davis	Bechtel SAIC Company, LLC.
University of Connecticut	Cambridge Systematics, Inc.
University of Nevada, Las Vegas	CSA Planning
University of Pittsburgh	Economic & Policy Resources
University of South Dakota	Economic Development Research Group
University of Westren Florida	Economic Research Associates
University South Florida	ERG
York College of Pennsylvania	Ernst & Young
	HR&A Advisors, Inc.
Federal Government	ICF International
U.S. Army Corps of Engineers	Kavet, Rockler & Associates, Inc.
U.S. Environmental Protection Agency	NERA Economic Consulting
	Northern Economics
State Government	REMI-Northwest
Arizona Department of Commerce	RKG Associates, Inc.
Arizona Department of Planning	Stratus Consulting
Arizona Joint Legislative Budget Committee	Wilbur Smith Assoicates

Source: REMI

B.3 REMI PI+ Industry Sectors

RESI determined the industry sectors which would be affected by strategy implementation for both the investment phase and the operation phase for each strategy and subprogram. A complete list of these sectors can be found in Figures 356 and 357.

Figure 356: REMI PI+ Industry Codes—Investment Phase

Strategy	Subprogram	Code	Description
Energy			
3.1.1	Regional Greenhouse Gas Initiative	63	State Government Spending
3.1.2	Greenhouse Gas Reductions from Imported Power	-	*No Investment Costs Specified*
3.1.3	Greenhouse Gas New Source Performance Standard	63	State Government Spending
3.1.4	Maximum Achievable Control Technology (MACT)	63	State Government Spending
3.1.5	EmPOWER Maryland Empowering Finance Initiative	98 63	Investment Spending (Residential) State Government Spending
	EmPOWER Maryland Residential Incentives	98	Investment Spending (Residential)
	MEA Home Performance Rebate Program	63 98	State Government Spending Investment Spending (Residential)
	DHCD Weatherization	98	Investment Spending (Residential)
	Clean Energy Communities Grant	63 98	State Government Spending Investment Spending (Residential)
	Maryland Home Energy Loan Subprogram	98	Investment Spending (Residential)
	Energy Workforce Training	98	Investment Spending (Residential)
	State Energy Efficiency Appliance Rebate Program	98 63	Investment Spending (Residential) State Government Spending
3.1.6	Maryland Save Energy Now	63	State Government Spending
	Jane E. Lawton Conservation Loan Program	63	State Government Spending
	Energy Efficiency and Conservation Block Grant Program	63	State GovernmentSpending
	State Agencies Loan Program	63	State Government Spending
3.1.7	Energy Efficiency Appliances and Other Products	45	Residential Capital
3.1.8	Energy Efficiency in the Power Sector – General	X7809	Production costs, Electrical power distribution, transmission, and generation
3.1.9	Maryland Renewable Energy Portfolio Standard	EQP 13	Producer's Durable Equipment Investment, Electric distribution, transmission, and generation
3.1.10	Commercial Clean Energy Grant Program	63	State Government Spending
	Residential Clean Energy Grants Program	63	State Government Spending
	Clean Energy Incentive Tax Credit Program	63	State Government Spending
	Generating Clean Horizons Program	63	State Government Spending
	Project Sunburst	63	State Government Spending
	Biomass Programs	63	State Government Spending

Strategy	Subprogram	Code	Description
	Land-based Wind Programs	63	State Government Spending
3.1.11	Offshore Wind Initiatives to Support Renewable Energy	X7809	Production costs, Electrical power distribution, transmission, and generation
Transportation			
3.2.1	Maryland Clean Cars Program	63	State Government Spending
		601	Consumer Spending, autos
3.2.2	National Fuel Efficiency and Emissions Standards for Medium- and Heavy-Duty Trucks	X6653	Intermediate Demand, Motor vehicle parts manufacturing
		X7653	Value added (with no effect on sales or employment), Motor vehicle parts manufacturing
		X7851	Production costs, Motor vehicle manufacturing
3.2.3	Clean Fuel Standard	X6653	Intermediate Demand, Motor vehicle parts manufacturing
		X7653	Value added (with no effect on sales or employment), Motor vehicle parts manufacturing
		X7851	Production costs, Motor vehicle manufacturing
3.2.4	Transportation and Climate Initiative	63	State Government Spending
3.2.5	Charm City Circulator and Hampden Neighborhood Shuttle	-	*No Investment Spending Specified*
	Locally Operated Transit Systems	63	State Government Spending
		68	Government Spending including Non-Pecuniary (Amenity) Aspects
	Smart Card Implementation	68	Government Spending including Non-Pecuniary (Amenity) Aspects
	Transit-Oriented Development	-	*No Investment Spending Specified*
	Maryland Commuter Tax Credit	-	*No Investment Spending Specified*
	Guaranteed Ride Home	-	*No Investment Spending Specified*
	College Pass	68	Government Spending including Non-Pecuniary (Amenity) Aspects
	Ride Share	-	*No Investment Spending Specified*
	Commuter Connections – Washington, D.C. Region	-	*No Investment Spending Specified*
	Baltimore Collegetown Network	-	*No Investment Spending Specified*
	Hunt Valley Shuttle	-	*No Investment Specified*
	Kent Street Transit Plaza	-	*No Investment Specified*
	University of Maryland College Park Carpool Program and Shuttle Bus Service	-	*No Investment Specified*
	PlanMaryland	-	*No Investment Specified*
3.2.6	MARC East Baltimore Station	68	Government Spending including Non-Pecuniary (Amenity) Aspects
	Expanded Transit (Purple Line, Corridor Cities Transitway, Red Line)	68	Government Spending including Non-Pecuniary (Amenity) Aspects

Strategy	Subprogram	Code	Description
	MARC Growth and Investment Plan	68	Government Spending including Non-Pecuniary (Amenity) Aspects
3.2.7	MARC Station Parking Enhancements	63	State Government Spending
		68	Government Spending including Non-Pecuniary (Amenity) Aspects
	Refurbishing MARC and Other Rail Vehicles	68	Government Spending including Non-Pecuniary (Amenity) Aspects
	Update on Maryland High Speed Rail	68	Government Spending including Non-Pecuniary (Amenity) Aspects
3.2.8	Bicycle/Pedestrian Enhancements	68	Government Spending including Non-Pecuniary (Amenity) Aspects
	Bike Racks on Buses, MARC, Subway, Light Rail	-	*No Investment Specified*
	Construction of Bike Lanes and Bike Paths	-	*No Investment Specified*
	East Coast Greenway	-	*No Investment Specified*
	Bike Stations	-	*No Investment Specified*
	Bike Rentals	-	*No Investment Specified*
	Bike Racks	-	*No Investment Specified*
3.2.9	Electronic Toll Collection	-	*No Investment Specified*
	High Occupancy Toll Lanes	68	Government Spending including Non-Pecuniary (Amenity) Aspects
	VMT Fees	-	*No Investment Specified*
	Congestion Pricing and Managed Lanes	-	*No Investment Specified*
	Parking Impact Fees	-	*No Investment Specified*
	Employer Commute Incentives	-	*No Investment Specified*
3.2.10	Traffic Flow Improvements	68	Government Spending including Non-Pecuniary (Amenity) Aspects
	Truck Stop Electrification	-	*No Investment Specified*
	Timing of Highway Construction Schedules	-	*No Investment Specified*
	Electronic Toll Collection	-	*No Investment Specified*
	Traffic Signal Synchronization	-	*No Investment Specified*
	Variable Message Signs	63	State Government Spending
	Telework Partnership With Employers	-	*No Investment Specified*
	Smart Card Implementation	-	*No Investment Specified*
	Light-Emitting Diode Traffic Signals	63	State Government Spending
	Vehicle Technologies	-	*No Investment Specified*
	Transportation Fuels	-	*No Investment Specified*
	Other Areas	-	*No Investment Specified*
3.2.11	Vehicle-to-Grid (V2G)	-	*No Investment Specified*
	Electric Vehicles	-	*No Investment Specified*
	Maryland Electric Vehicles Initiative	68	Government Spending including Non-Pecuniary (Amenity) Aspects
	Maryland Transit Administration Support for Howard County Electric Bus Project	-	*No Investment Specified*
	Clean and Efficient Strategies	-	*No Investment Specified*

Strategy	Subprogram	Code	Description
	Baltimore City Electric Vehicles Infrastructure	68	Government Spending including Non-Pecuniary (Amenity) Aspects
3.2.12	Howard Transit Paratransit Fleet Replacement Vehicles	63	State Government Spending
	Clean and Efficient Strategies	-	*No Investment Specified*
3.2.13	*Evaluating GHG Emissions Impacts of Major Projects*	*OMITTED*	*OMITTED*
3.2.14	Compressed Natural Gas Buses	-	*No Investment Specified*
	Air Emissions Reductions	-	*No Investment Specified*
	BWI Energy Audit	-	*No Investment Specified*
	BWI Utility Master Plan	-	*No Investment Specified*
	BWI Energy Efficiency	-	*No Investment Specified*
	Enhanced Access to BWI by Other Travel Modes	-	*No Investment Specified*
	BWI's Periodic Air Quality Assessments	-	*No Investment Specified*
3.2.15	Port of Baltimore Initiatives	63	State Government Spending
3.2.16	Auxiliary Power Units for Existing Locomotives	-	*No Investment Specified*
	Technology Advances for Non-highway Vehicles	-	*No Investment Specified*
3.2.17	Renewable Fuels Standard	-	*No Investment Specified*
3.2.18	Café Standards: Model Years 2008-2011	-	*No Investment Specified*
3.2.19	Promoting Hybrid and Electric Vehicles	63	State Government Spending
3.2.20	Pay-As-You-Drive Insurance	-	*No Investment Specified*
Agriculture			
3.3.1	Managing Forests to Capture Carbon	X6403	Exogenous Final Demand (Support activities for agriculture and forestry)
3.3.2	Wetland Markets	X6532	Exogenous Final Demand (Other professional, scientific, and technical services
	Stream and Waterway Markets	X6532	Exogenous Final Demand (Other professional, scientific, and technical services
	Forest Markets	X6532	Exogenous Final Demand (Other professional, scientific, and technical services
	Critical Area Markets	X6532	Exogenous Final Demand (Other professional, scientific, and technical services
	Species and Habitat Markets	X6532	Exogenous Final Demand (Other professional, scientific, and technical services
	Nutrient Markets	X6532	Exogenous Final Demand (Other professional, scientific, and technical services
	Carbon Markets: RGGI and Maryland CO2	X6532	Exogenous Final Demand (Other professional, scientific, and

Strategy	Subprogram	Code	Description
	Budget Trading Program Offsets		technical services
	Carbon Markets: GGRA of 2009 - Offsets and Early Reductions	X6532	Exogenous Final Demand (Other professional, scientific, and technical services
	Carbon Markets: GGRA of 2009 - Nutrient Trading with Carbon Co-benefits	X6532	Exogenous Final Demand (Other professional, scientific, and technical services
	Biomass Markets	X6532	Exogenous Final Demand (Other professional, scientific, and technical services
3.3.3	Increasing Urban Trees to Capture Carbon	X6412	Exogenous Final Demand (Construction)
		X6526	Exogenous Final Demand (Architecural, engineering, and related services)
		X3203	Exogenous Final Demand (Support activities for agriculture)
3.3.4	Creating and Protecting Wetlands and Waterway Borders to Capture Carbon	63	State Government Spending
3.3.5	Geological Opportunities to Store Carbon	X6530	Exogenous Final Demand (Scientific and professional services)
3.3.6	Planting Forests in Maryland	X3203	Industry Sales, Support activities for agriculture
3.3.7	Expanded Use of Forests and Feedstocks for Energy Production	63	State Government Spending
3.3.8	Conservation of Agricultural Land for GHG Benefits	63	State Government Spending
3.3.9	Buy Local for GHG Benefits	63	State Government Spending
3.3.10	Nutrient Trading for GHG Benefits	63	State Government Spending
Recycling			
3.4.1	Recycling and Source Reduction	-	*No Investment Specified*
Buildings			
3.5.1	Green Buildings	47	Non-residential Capital Investment
3.5.2	Building and Trade Codes in Maryland	63	State Government Spending
3.5.3	BeSMART	63	State Government Spending
3.5.4	Energy Efficiency for Affordable Housing	63	State Government Spending
Land Use			
3.6.1	Maryland Sustainable Growth Commission	-	*No Investment Costs Specified*
	PlanMaryland	-	*No Investment Costs Specified*
3.6.2	Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations	-	*No Investment Costs Specified*
3.6.3	Funding Mechanisms for Smart Growth	63	State Government Spending
3.6.4	GHG Benefits from Priority Funding Areas and	63	State Government Spending

Strategy	Subprogram	Code	Description
	Other Growth Boundaries		
Innovative Initiatives			
3.7.1	Leadership-by-Example - Local Government	63	State Government Spending
3.7.2	Leadership-by-Example - Federal Government	94	Federal Government Spending
3.7.3	Leadership-by-Example – Maryland Colleges and Universities	63	State Government Spending
3.7.4	Greenhouse Gas Early Voluntary Reductions	63	State Government Spending
3.7.5	High Performance Buildings	99	Investment Spending, Non-residential
		68	Government Spending including Non-Pecuniary (Amenity) Aspects
	Green Maryland Act of 2010	-	*No Investment Costs Specified*
3.7.6	Maryland Environmental Footprint	-	*No Investment Costs Specified*
3.7.7	Job Creation and Economic Development Initiatives	-	*No Investment Costs Specified*
3.7.8	Public Health Initiatives Related to Climate Change	68	Government Spending including Non-Pecuniary (Amenity) Aspects
3.7.9	Title V Permits for GHG Sources	63	State Government Spending
3.7.10	Outreach and Public Education	63	State GovernmentSpending
3.7.11	GHG Prevention of Significant Deterioration Permitting Program	63	State Government Spending
Not Quantified			
3.8.1	*Greenhouse Gas Emissions Inventory Development*	*OMITTED*	*OMITTED*
3.8.2	*Program Analysis, Goals, and Overall Implementation*	*OMITTED*	*OMITTED*

Source: REMI PI+

Figure 357: REMI PI+ Industry Codes—Operation Phase

Strategy	Subprogram	Code	Description
Energy			
3.1.1	Regional Greenhouse Gas Initiative	X7809	Production costs, Electric power distribution, generation and transmission
3.1.2	Greenhouse Gas Reductions from Imported Power	X7809	Production costs, Electric power distribution, generation and transmission
3.1.3	Greenhouse Gas New Source Performance Standard	X7809	Production costs, Electric power distribution, generation and transmission
3.1.4	Maximum Achievable Control Technology (MACT)	X7809	Production costs, Electric power distribution, generation and transmission
3.1.5	EmPOWER Maryland Empowering Finance Initiative	640 78	Consumer spending (electricity) Consumption reallocation
	EmPOWER Maryland Residential Incentives	640 78	Consumer spending (electricity) Consumption reallocation
	MEA Home Performance Rebate Program	640 78	Consumer spending (electricity) Consumption reallocation
	DHCD Weatherization	640 78	Consumer spending (electricity) Consumption reallocation
	Clean Energy Communities Grant	640 78	Consumer spending (electricity) Consumption reallocation
	Maryland Home Energy Loan Program	640 78	Consumer spending (electricity) Consumption reallocation
	Energy Workforce Training	78	Consumption reallocation
	State Energy Efficiency Appliance Rebate Program	640 78	Consumer spending (electricity) Consumption reallocation
3.1.6	Maryland Save Energy Now	80	Electricity (Industrial Sector) Fuel Costs, All Industrial Sectors
		82	Electricity (Commercial Sector) Fuel Costs, All Commercial Sectors
	Jane E. Lawton Conservation Loan Program	80	Electricity (Industrial Sector) Fuel Costs, All Industrial Sectors
		82	Electricity (Commercial Sector) Fuel Costs, All Commercial Sectors
	Energy Efficiency and Conservation Block Grant Program	80	Electricity (Industrial Sector) Fuel Costs, All Industrial Sectors
		82	Electricity (Commercial Sector) Fuel Costs, All

Strategy	Subprogram	Code	Description
			Commercial Sectors
	State Agencies Loan Program	80	Electricity (Industrial Sector) Fuel Costs, All Industrial Sectors
		82	Electricity (Commercial Sector) Fuel Costs, All Commercial Sectors
3.1.7	Energy Efficiency Appliances and Other Products	640	Consumer spending (electricity)
		78	Consumption reallocation
3.1.8	Energy Efficiency in the Power Sector – General	X7809	Production costs, Electric power distribution, generation and transmission
3.1.9	Maryland Renewable Energy Portfolio Standard	EQP 13	Producer's Durable Equipment Investment, Electric distribution, transmission, and generation
3.1.10	Commercial Clean Energy Grant Program	82	Electricity (Commercial Sector) Fuel Costs, All Commercial Sectors
	Residential Clean Energy Grants Program	640	Consumer spending (electricity)
		78	Consumption reallocation
	Clean Energy Incentive Tax Credit Program	-	*No additional costs/benefits associated with program*
	Generating Clean Horizons Program	640	Consumer spending (electricity)
		78	Consumption reallocation
	Project Sunburst	640	Consumer spending (electricity)
		78	Consumption reallocation
	Biomass Programs	640	Consumer spending (electricity)
		78	Consumption reallocation
	Land-based Wind Programs	640	Consumer spending (electricity)
		78	Consumption reallocation
3.1.11	Offshore Wind Initiatives to Support Renewable Energy	X7809	Production costs, Electric power distribution, generation and transmission
3.1.12	BeSMART	82	Electricity (Commercial Sector) Fuel Costs, All Commercial Sectors
		640	Consumer spending (electricity)
		78	Consumption reallocation
3.1.13	Energy Efficiency for Affordable Housing	640	Consumer spending (electricity)
		642	Consumer spending (fuel and oil)
		78	Consumption reallocation
Transportation			
3.2.1	Maryland Clean Cars Program	623	Consumer spending (gas)
		78	Consumption reallocation
3.2.2	National Fuel Efficiency and Emissions Standards for Medium-	623	Consumer spending (gas)

Strategy	Subprogram	Code	Description
	and Heavy-Duty Trucks	78	Consumption reallocation
3.2.3	Clean Fuel Standard	623	Consumer spending (gas)
		78	Consumption reallocation
3.2.4	Transportation and Climate Initiative	-	*No additional benefits or costs have been associated with this program*
3.2.5	Charm City Circulator and Hampden Neighborhood Shuttle	623	Consumer spending (gas)
		78	Consumption reallocation
		651	Consumer spending (intercity bus)
		603	Consumer spending (other motor vehicles)
		648	Consumer spending (Auto insurance, less claims paid)
	Locally Operated Transit Systems	623	Consumer spending (gas)
		78	Consumption reallocation
		651	Consumer spending (intercity bus)
		603	Consumer spending (other motor vehicles)
		648	Consumer spending (Auto insurance, less claims paid)
	Smart Card Implementation	673	Consumer spending (Bank service charges, trust services, and safe deposit box rentals)
		78	Consumption reallocation
	Transit-Oriented Development	623	Consumer spending (gas)
		78	Consumption reallocation
	Maryland Commuter Tax Credit	63	State Government Spending
	Guaranteed Ride Home	653	Consumer spending (taxicabs)
		78	Consumption reallocation
		68	Government Spending including Non-Pecuniary (Amenity) Aspects
	College Pass	623	Consumer spending (gas)
		78	Consumption reallocation
		651	Consumer spending (intercity bus)
	Ride Share	623	Consumer spending (gas)
		78	Consumption reallocation
		68	Government Spending including Non-Pecuniary (Amenity) Aspects
	Commuter Connections – Washington, D.C. Region	623	Consumer spending (gas)
		78	Consumption reallocation
	Baltimore Collegetown Network	623	Consumer spending (gas)
		78	Consumption reallocation
	Hunt Valley Shuttle	623	Consumer spending (gas)

Strategy	Subprogram	Code	Description
		78	Consumption reallocation
	Kent Street Transit Plaza	623	Consumer spending (gas)
		78	Consumption reallocation
		651	Consumer spending (intercity bus)
		648	Consumer spending (Auto insurance, less claims paid)
	University of Maryland College Park Carpool Program and Shuttle Bus Service	623	Consumer spending (gas)
		78	Consumption reallocation
		651	Consumer spending (intercity bus)
		648	Consumer spending (Auto insurance, less claims paid)
3.2.6	MARC East Baltimore Station	652	Intercity mass transit
		648	Consumer spending (Auto insurance, less claims paid)
		603	Consumer spending (Other motor vehicles)
		78	Consumption reallocation
	Expanded Transit (Purple Line, Corridor Cities Transitway, Red Line)	652	Intercity mass transit
		648	Consumer spending (Auto insurance, less claims paid)
		603	Consumer spending (Other motor vehicles)
		78	Consumption reallocation
	MARC Growth and Investment Plan	652	Intercity mass transit
		648	Consumer spending (Auto insurance, less claims paid)
		603	Consumer spending (Other motor vehicles)
		78	Consumption reallocation
3.2.7	MARC Station Parking Enhancements	652	Intercity mass transit
		623	Consumer spending (gas)
		648	Consumer spending (Auto insurance, less claims paid)
		603	Consumer spending (Other motor vehicles)
	Refurbishing MARC and Other Rail Vehicles	652	Intercity mass transit
		623	Consumer spending (gas)
		648	Consumer spending (Auto insurance, less claims paid)
		603	Consumer spending (Other motor vehicles)
	Update on Maryland High Speed Rail	652	Intercity mass transit
		623	Consumer spending (gas)
		648	Consumer spending (Auto insurance, less claims paid)
		603	Consumer spending (Other motor vehicles)
3.2.8	Bicycle/Pedestrian Enhancements	623	Consumer spending (gas)
		78	Consumption reallocation
	Bike Racks on Buses, MARC, Subway, Light Rail	623	Consumer spending (gas)
		78	Consumption reallocation

Strategy	Subprogram	Code	Description
	Construction of Bike Lanes and Bike Paths	623 78	Consumer spending (gas) Consumption reallocation
	East Coast Greenway	623 78	Consumer spending (gas) Consumption reallocation
	Bike Stations	623 78	Consumer spending (gas) Consumption reallocation
	Bike Rentals	623 78	Consumer spending (gas) Consumption reallocation
	Bike Racks	623 78	Consumer spending (gas) Consumption reallocation
3.2.9	Electronic Toll Collection	623 78	Consumer spending (gas) Consumption reallocation
	High Occupancy Toll Lanes	623 78	Consumer spending (gas) Consumption reallocation
	VMT Fees	623 78	Consumer spending (gas) Consumption reallocation
	Congestion Pricing and Managed Lanes	623 78	Consumer spending (gas) Consumption reallocation
	Parking Impact Fees	623 78	Consumer spending (gas) Consumption reallocation
	Employer Commute Incentives	623 78	Consumer spending (gas) Consumption reallocation
3.2.10	Traffic Flow Improvements	623 78	Consumer spending (gas) Consumption reallocation
	Truck Stop Electrification	623 78	Consumer spending (gas) Consumption reallocation
	Timing of Highway Construction Schedules	623 78	Consumer spending (gas) Consumption reallocation
	Electronic Toll Collection	623 78	Consumer spending (gas) Consumption reallocation
	Traffic Signal Synchronization	623 78	Consumer spending (gas) Consumption reallocation
	Variable Message Signs	623 78	Consumer spending (gas) Consumption reallocation
	Telework Partnership With Employers	623 78	Consumer spending (gas) Consumption reallocation
	Smart Card Implementation	673	Consumer spending (Bank service charges, trust

Strategy	Subprogram	Code	Description
			services, and safe deposit box rentals)
		78	Consumption reallocation
	Light-Emitting Diode Traffic Signals	X6409	Exogenous final demand, Electric power generation, distribution and transmission
		63	State Government Spending
	Vehicle Technologies	648	Consumer spending (Auto insurance, less claims paid)
		78	Consumption reallocation
	Transportation Fuels	623	Consumer spending (gas)
		78	Consumption reallocation
3.2.11	Vehicle-to-Grid (V2G)	X6409	Exogenous final demand, Electric power generation, distribution and transmission
	Electric Vehicles	623	Consumer spending (gas)
		78	Consumption reallocation
	Maryland Electric Vehicles Initiative	623	Consumer spending (gas)
		78	Consumption reallocation
	Maryland Transit Administration Support for Howard County Electric Bus Project	63	State Government Spending
	Clean and Efficient Strategies	623	Consumer spending (gas)
		78	Consumption reallocation
	Baltimore City Electric Vehicles Infrastructure	623	Consumer spending (gas)
		78	Consumption reallocation
3.2.12	Howard Transit Paratransit Fleet Replacement Vehicles	623	Consumer spending (gas)
		78	Consumption reallocation
	Clean and Efficient Strategies	623	Consumer spending (gas)
		78	Consumption reallocation
3.2.13	*Evaluating GHG Emissions Impacts of Major Projects*	*OMITTED*	*OMITTED*
3.2.14	Compressed Natural Gas Buses	63	State Government Spending
	Air Emissions Reductions	63	State Government Spending
	BWI Energy Audit	63	State Government Spending
	BWI Utility Master Plan	63	State Government Spending
	BWI Energy Efficiency	63	State Government Spending
	Enhanced Access to BWI by Other Travel Modes	63	State Government Spending
	BWI's Periodic Air Quality Assessments	63	State Government Spending
3.2.15	Port of Baltimore Initiatives	63	State Government Spending
3.2.16	Auxiliary Power Units for Existing Locomotives	63	State Government Spending
		623	Consumer spending (gas)
		78	Consumption reallocation

Strategy	Subprogram	Code	Description
3.2.17	Renewable Fuels Standard	623 78	Consumer spending (gas) Consumption reallocation
3.2.18	CAFÉ Standards: Model Years 2008-2011	623 78	Consumer spending (gas) Consumption reallocation
3.2.19	Promoting Hybrid and Electric Vehicles	623 78	Consumer spending (gas) Consumption reallocation
3.2.20	Pay-As-You-Drive Insurance	648 78	Consumer spending (auto insurance) Consumption reallocation
Agriculture			
3.3.1	Managing Forests to Capture Carbon	X5401	Forestry; fishing, hunting, trapping, Sales
3.3.2	Wetland Markets	63 X7802 X7801	State Government Spending Production costs, Logging Production costs, Forestry, fishing, hunting, trapping
	Stream and Waterway Markets	63 X7802 X7801	State Government Spending Production costs, Logging Production costs, Forestry, fishing, hunting, trapping
	Forest Markets	63 X7802 X7801	State Government Spending Production costs, Logging Production costs, Forestry, fishing, hunting, trapping
	Critical Area Markets	63 X7802 X7801	State Government Spending Production costs, Logging Production costs, Forestry, fishing, hunting, trapping
	Species and Habitat Markets	63 X7802 X7801	State Government Spending Production costs, Logging Production costs, Forestry, fishing, hunting, trapping
	Nutrient Markets	63 X7802 X7801	State Government Spending Production costs, Logging Production costs, Forestry, fishing, hunting, trapping
	Carbon Markets: RGGI and Maryland CO2 Budget Trading Program Offsets	63 X7802 X7801	State Government Spending Production costs, Logging Production costs, Forestry, fishing, hunting, trapping
	Carbon Markets: GGRA of 2009 - Offsets and Early Reductions	63 X7802 X7801	State Government Spending Production costs, Logging Production costs, Forestry, fishing, hunting, trapping
	Carbon Markets: GGRA of 2009 - Nutrient Trading with Carbon Co-benefits	63 X7802 X7801	State Government Spending Production costs, Logging Production costs, Forestry, fishing, hunting, trapping

Strategy	Subprogram	Code	Description
	Biomass Markets	63 X7802 X7801	State Government Spending Production costs, Logging Production costs, Forestry, fishing, hunting, trapping
3.3.3	Increasing Urban Trees to Capture Carbon	640 78 82	Consumer spending (electricity) Consumption reallocation Electricty (Commerical Sector) Fuel Costs, All Commerical Sectors
3.3.4	Creating and Protecting Wetlands and Waterway Borders to Capture Carbon	TOUR1	Tourism spending
3.3.5	Geological Opportunities to Store Carbon	80 84 88	Electricty (Industrial Sector) Fuel Costs, All Industrial Sectors Natural Gas (Industrial Sector) Fuel Costs, All Industrial Sectors Residual (Industrial Sector) Fuel Costs, All Industrial Sector
3.3.6	Planting Forests in Maryland	640 78	Consumer spending (electricity) Consumption reallocation
3.3.7	Expanded Use of Forests and Feedstocks for Energy Production	X7809	Production costs, Electric power distribution, generation and transmission
3.3.8	Conservation of Agricultural Land for GHG Benefits	104	Farm output (total)
3.3.9	Buy Local for GHG Benefits	104 63	Farm output (total) State Government Spending
3.3.10	Nutrient Trading for GHG Benefits	63 99 106	State Government Spending Investment spending, Non-residential Farm Value Added, with no effect on sales or employment
Recycling			
3.4.1	Recycling and Source Reduction	X7939 63	Production costs, Waste management and remediation services State Government Spending
Buildings			
3.5.1	Green Buildings	X6409 63	Exogenous final demand, Electric power generation, transmission, and distribution State Government Spending
3.5.2	Building and Trade Codes in Maryland	X933	Industry Employment, Management of companies and enterprises

Strategy	Subprogram	Code	Description
Land Use			
3.6.1	Maryland Sustainable Growth Commission	X5412	Industry Sales, Construction
	PlanMaryland	-	*No additional benefits or costs associated with this program*
3.6.2	Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations	641 78	Consumer spending (gas) Consumption reallocation
3.6.3	Funding Mechanisms for Smart Growth	X3612	Firm Employment, Construction
3.6.4	GHG Benefits from Priority Funding Areas and Other Growth Boundaries	X3211	Industry Sales, Water, sewage, and other systems
Innovative Initiatives			
3.7.1	Leadership-by-Example - Local Government	X3209 65	Industry sales, Electrical power generation, transmission, and distribution Local Government Spending
3.7.2	Leadership-by-Example - Federal Government	X6409 94	Exogenous final demand, Electric power generation, distribution, and transmission Federal Government Spending
3.7.3	Leadership-by-Example - Maryland Colleges and Universities	X3209 63	Industry sales, Electrical power generation, transmission, and distribution State Government Spending
3.7.4	Greenhouse Gas Early Voluntary Reductions	X7809	Production costs, Electrical power distribution, transmission, and generation
3.7.5	High Performance Buildings	X10540 X10564	Electrical Fuel Costs (Individual Industry), Elementary and secondary schools; Junior colleges, colleges, universities, and professional schools; Other educational services Electrical Fuel Costs (Individual Industry), Civic, social, professional, and similar organizations
	Green Maryland Act of 2010	-	*No additional costs or benefits associated with this program*
3.7.6	Maryland Environmental Footprint	X6409 68	Exogenous final demand, Electric power generation, distribution, and transmission Government Spending including Non-Pecuniary (Amenity) Aspects
3.7.7	Job Creation and Economic Development Initiatives	X7165	Private households, Compensation
3.7.8	State Climate Change Environmental Health and Protection Advisory Council	662 78	Consumer spending (health insurance) Consumption reallocation

Strategy	Subprogram	Code	Description
3.7.9	Title V Permits for GHG Sources	X7809	Production costs, Electrical power distribution, transmission, and generation
		63	State Government Spending
3.7.10	Outreach and Public Education	63	State Government Spending
3.7.11	GHG Prevention of Significant Deterioration Permitting Program	X7809	Production costs, Electrical power distribution, transmission, and generation
		63	State Government Spending
Not Quantified			
3.8.1	*Greenhouse Gas Emissions Inventory Development*	*OMITTED*	*OMITTED*
3.8.2	*Program Analysis, Goals, and Overall Implementation*	*OMITTED*	*OMITTED*

Source: REMI PI+

B.4 Modeling Example

Overview

For the purpose of providing a transparent and accessible analysis, an example of the steps undertaken by RESI (the modeling assumptions) and their results for one strategy and its subprograms are presented below. First, RESI determined the REMI industry codes which would be affected by the strategy and its subprograms. Next, RESI determined the dollar values to be applied for the investment phase as well as the operation phase. The strategy modeled as an example is “Intercity Transportation Initiatives,” under Transportation.

According to the strategy write-up provided by MDE, three subprograms have been designed for this strategy: MARC Station Parking Enhancements, Refurbishing MARC and Other Rail Vehicles, and Update on Maryland High Speed Rail. The subprograms were modeled separately as each involves unique goals.

Assumptions

Investment Phase

1. Determine relevant REMI sectors for each program under the policy.
    a. **MARC Station Parking Enhancements**
        i. 63—State Government Spending
        ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
    b. **Refurbishing MARC and Other Rail Vehicles**
        i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
    c. **Update on Maryland High Speed Rail**
        i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
2. Determine overall cost of policy implementation for each program under the policy.
    a. **MARC Station Parking Enhancements**
        i. 63—$3,214,166.67 per Year from 2011,2015—2016
        ii. 63—$3,794,500 per Year from 2012—2014
        iii. 68—$3,251,666.67 per Year from 2011—2016
    b. **Refurbishing MARC and Other Rail Vehicles**
        i. $1,076,000 per Year from 2011—2017
    c. **Update on Maryland High Speed Rail**
        i. $10,000,000 per Year from 2011—2016
        ii. $41,560,000 per Year from 2012—2020[2]
3. Input investment by sector into REMI model and run impacts.
4. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI sectors.
    a. **MARC Station Parking Enhancements**
        i. 652 – Intercity Mass Transit
        ii. 623—Consumer Spending—Gasoline and oil
        iii. 648—Consumer Spending—Auto insurance less claims paid

[2] Unfunded

- **iv.** 603—Consumer Spending—Other motor vehicles
- **b. Refurbishing MARC and Other Rail Vehicles**
    - i. 652 – Intercity Mass Transit
    - ii. 623—Consumer Spending—Gasoline and oil
    - iii. 648—Consumer Spending—Auto insurance less claims paid
    - iv. 603—Consumer Spending—Other motor vehicles
- **c. Update on Maryland High Speed Rail**
    - i. 652 – Intercity Mass Transit

2. Determine part of program to be affected by savings (from strategy write-up).
    - **a. MARC Station Parking Enhancements**
        - i. Phase I—428 new parking spaces
        - ii. Odenton station feasibility study—2,500 additional parking spaces
    - **b. Refurbishing MARC and Other Rail Vehicles**
        - i. 23 cars scheduled to be overhauled between FY 2005 and FY 2012
    - **c. Update on Maryland High Speed Rail**
        - i. $9.4 million allocation to MDOT for high-speed stimulus to complete environmental and engineering work to replace BWI Station as of Sept. 2010
3. Research savings data for each policy according to part of program to be affected by savings.
    - **a. MARC Station Parking Enhancements**
        - i. Average cost of monthly MARC pass[3]—$349/month (Transit Link Card)
        - ii. Average cost savings of using public transit[4]—$9,383/year for Baltimore City
        - iii. Average cost of MARC station parking[5]—$6.39/day average (between 7 stations and not including outliers)
        - iv. Note about Transit Link Card data use: A Monthly Transit Link pass is used in the calculations of all rail passes. Often users of the MARC system traveling in and around the metropolitan region of Maryland/Washington, D.C. will wish to visit areas within the city which are accessible through walking or easy-to-navigate light rail systems. Instead of purchasing separate fares for each point of travel, most individuals prefer having one card designated for travel within the region. The average cost of monthly fares for MARC has been calculated using the transit link pass over a span of stations from Aberdeen to Washington, D.C.
    - **b. Refurbishing MARC and Other Rail Vehicles**
        - i. Average cost of monthly MARC pass[6]—$349/month (Transit Link Card)

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[3] MARC Train Service Order Form. CommuterDirect.com®. 2011. MARC. 14 Nov. 2011 <https://www.commuterpage.com/orderforms/transitorders_v3.cfm?sysid=12>.
[4] "Riding Public Transit Saves Individuals $9,242 Annually." APTA Homepage. 1 Dec. 2010. American Public Transportation Association (APTA). 14 Nov. 2011 <http://www.apta.com/mediacenter/pressreleases/2010/Pages/100112_Transit_Savings.aspx>.
[5] MARC Parking Details | Maryland Transit Administration. Home | Maryland Transit Administration. Nov. 2011. Maryland Transit Administration (MTA). 14 Nov. 2011 <http://mta.maryland.gov/marc-parking-details>.

    ii. Capacity of MARC train cars (single-level and bi-level)[7]—121 seats (average)
    iii. Note about Transit Link Card data use: A Monthly Transit Link pass is used in the calculations of all rail passes. Often users of the MARC system traveling in and around the metropolitan region of Maryland/Washington, D.C. will wish to visit areas within the city which are accessible through walking or easy-to-navigate light rail systems. Instead of purchasing separate fares for each point of travel, most individuals prefer having one card designated for travel within the region. The average cost of monthly fares for MARC has been calculated using the transit link pass over a span of stations from Aberdeen to Washington, D.C.

  c. **Update on Maryland High Speed Rail**
    i. Average cost of monthly MARC pass for BWI Rail Station between stations for Baltimore City and Washington, D.C[8].—$227/month (Transit Link Card)
    ii. Number of parking spots at BWI Rail Station[9]—3,187 spots
    iii. Cost of MARC station parking at BWI Rail Station[10]—$9/day
    iv. Cost of BWI Garage (daily)[11]—$12/day
    v. Note about Transit Link Card data use: A Monthly Transit Link pass is used in the calculations of all rail passes. Often users of the MARC system traveling in and around the metropolitan region of Maryland/Washington, D.C. will wish to visit areas within the city which are accessible through walking or easy-to-navigate light rail systems. Instead of purchasing separate fares for each point of travel, most individuals prefer having one card designated for travel within the region. The average cost of fare for the BWI Rail Station has been calculated under the assumption that most tourists will travel from BWI to Baltimore and BWI to Washington, D.C.

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
  a. **MARC Station Parking Enhancements**
    i. 652 – Intercity Mass Transit – $12,262,464 [(428 new Phase I parking spots + 2,500 new Odenton parking spots (assume 1 vehicle parked per day) * $349/month (assume all buy monthly pass) * 12 months)]

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[6] MARC Train Service Order Form. CommuterDirect.com®. 2011. MARC. 14 Nov. 2011 <https://www.commuterpage.com/orderforms/transitorders_v3.cfm?sysid=12>.
[7] Dresser, Michael. "New cars may ease MARC crowding - Baltimore Sun." Featured Articles From The Baltimore Sun. 20 Aug. 2008. The Baltimore Sun. 14 Nov. 2011 <http://articles.baltimoresun.com/2008-08-20/news/0808190131_1_marc-new-cars-passenger-cars>.
[8] MARC Train Service Order Form. CommuterDirect.com®. 2011. MARC. 14 Nov. 2011 <https://www.commuterpage.com/orderforms/transitorders_v3.cfm?sysid=12>.
[9] MARC Parking Details | Maryland Transit Administration. Home | Maryland Transit Administration. Nov. 2011. Maryland Transit Administration (MTA). 14 Nov. 2011 <http://mta.maryland.gov/marc-parking-details>.
[10] Ibid.
[11] Parking. Baltimore Washington International Thurgood Marshall Airport. 11 Nov. 2011. < http://www.bwiairport.com/en/parking/information-rates/daily-garage>.

ii. 652–Intercity Mass Transit–$6,829,120.80 [((2,500 new Odenton parking spots + 428 Phase I parking spots)(assume 1 vehicle parked per day) * $6.39/day on average (assume all park at station garage) * 365 days)]=annual increase in revenue
iii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$3,712,871.82 [(2,928 Passengers * 2 minutes idle per trip * 2 trips per Day * 365 trips per year * $0.032 conversion to $)]=Value of Fuel Saved per Year by Passengers
iv. 648—Consumer Spending—Auto insurance less claims paid, 78—Consumption Reallocation—All Consumption Categories $6,307,585.44 [((2,928 passengers * 365 days * 2 trips * 13 miles)/1.34 average persons per vehicle trip) * $0.304 Insurance per Mile]=Value of Insurance Saved by Passengers per Year from 2015—2020
v. 603—Consumer Spending—Other motor vehicles, 78—Consumption Reallocation—All Consumption Categories $6,307,585.44 [((2,928 passengers * 365 days * 2 trips * 13 miles)/1.34 average persons per vehicle trip) * $0.304 driving cost per mile less insurance less fuel]=Value of Driving Cost (less fuel less insurance) Saved by Passengers per Year from 2015—2020

b. **Refurbishing MARC and Other Rail Vehicles**
i. 652 – Intercity Mass Transit—$11,655,204 [(23 cars refurbished (assume still in use in addition to newer cars) * 121 seats per car on average * $349/month (assume all buy monthly pass) * 12 months]=annual increase in revenue per year from 2010—2020

c. **Update on Maryland High Speed Rail**
i. 652 – Intercity Mass Transit—$16,138,968 [(3,187 spots at BWI Rail Station (assume 1 vehicle parked per day) * $227/month (assume all buy monthly pass) * 12 months)] + [(3,187 spots at BWI Rail Station (assume 1 vehicle parked per day) * $9/day (assume all park at station) * 260 days)] = annual increase in revenue
ii. 652 – Intercity Mass Transit—$2,485,860 (3,187 spots at BWI Rail Station (assume 1 vehicle parked per day) *$3/day savings (comparing $12/day and $9/day parking fees) * 260 days = annual savings for riders)
iii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Categories—$879,279.15 [0.002 unfunded mmt CO2e * 405,821,147.4 conversion]=Total value of fuel saved per year from 2012—2020

5. Input savings by sector into REMI model and run impacts.
6. Export impacts and analyze.

Refined Economic Impact Analysis for the Greenhouse Gas Emissions Reduction Act 2012 Plan—Appendices C through E

Prepared for
Maryland Department of the Environment

June 15, 2013

Regional Economic Studies Institute

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Appendix C—Modeling Steps

C.1 Energy

3.1.1 Regional Greenhouse Gas Initiatives

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
   a. **Regional Greenhouse Gas Initiatives**
      i. 63—State Government Spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Regional Greenhouse Gas Initiatives**
      i. $90,000 per year (per MDE)
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Regional Greenhouse Gas Initiatives**
      i. 100% - State Government Spending
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors.
   a. **Regional Greenhouse Gas Initiatives**
      i. X7809-Production Costs-Electric power generation, transmission, and distribution
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Regional Greenhouse Gas Initiatives**
      i. Total allowances yearly by the state of Maryland for GHG—28,000,000 metric tons
      ii. Cost of Allowance-$1.86/allowance
      iii. Number of Auctions to Date-17 auctions (4 per year, first year only one)
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Regional Greenhouse Gas Initiatives**
      i. Proceeds From Auctions[1]—$52,080,000
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
   a. **Regional Greenhouse Gas Initiatives**
      i. X7809—$12,254,118 [($52,080,000 total proceeds from auctions to date / 4.25 years)]=annual increase in production costs to electricity generation firms
5. Input cost/savings by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

[1] "Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Auction 13." Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Welcome. 7 Sept. 2011. 11 Nov. 2011 <http://www.rggi.org/market/co2_auctions/results/auction_13>.

3.1.2 GHG Emission Reductions from Imported Power

Investment Phase

No investment costs were specified by the agency for this policy.

Operation Phase

1. Determine relevant REMI PI+ sectors.
    a. **GHG Emission Reductions from Imported Power**
        i. X7809-Production Costs-Electric power generation, transmission, and distribution
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **GHG Emission Reductions from Imported Power**
        i. 30% Energy is Imported from Outside of Maryland
        ii. Target to be achieved by 2020—2.75 Million Metric Tons
        iii. Number of years until Target—8 years
        iv. Average Reductions per year—343,750 allowances annually
        v. Average reduction per allowance—91.4 Metric Tons
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **GHG Emission Reductions from Imported Power**
        i. Average GHG emissions associated with Electricity[2]—31.43 million metric tons
        ii. Allowances Sold to Date[3]— 68,507,184
        iii. Total Proceeds from Auctions to date[4]—$169,600,423.80 total proceeds
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
    a. **GHG Emission Reductions from Imported Power**
        i. $2.48 [($169,600,423.80 total proceeds from auctions to date / 68,507,184 total carbon allowances sold to date)]=average cost of carbon allowances
        ii. $77,809,961.07 [(31,430,000 total carbon allowances sold * $2.48 per allowance for electricity)]=average carbon credits sold annually to firms
        iii. 31,086,250 [(31,430,000 total carbon allowances sold—343,750 proposed annual reduction target)]=average annual carbon credit to be purchased under reductions
        iv. $76,958,953.30 [(31,086,250 average annual carbon credits purchased under reduction target * $2.48 average cost per carbon credit allowance)]=average cost to firm for carbon credits under new reduction target

[2] "Maryland Energy Consumption Data." ERedux Energy: Sustainable Geoscial Products and Services Network. 11 Nov. 2011. Maryland Energy Portal - Maryland's Carbon Footprint. 11 Nov. 2011 <http://www.eredux.com/states/state_detail.php?id=1129>.

[3] "Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Auction 13." Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Welcome. 7 Sept. 2011. 11 Nov. 2011 <http://www.rggi.org/market/co2_auctions/results/auction_13>.

[4] See note 3.

v. X7809—$851,007.77 [($77,809,961.07 current average annual carbon credit costs - $76,958,953.30 average carbon credit costs under target reduction policy)]=reduction in costs to firms

5. Input savings by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.1.3 GHG New Source Performance Standard

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **GHG New Source Performance Standard**
      i. 63—State Government Spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **GHG New Source Performance Standard**
      i. $60,000 (per year provided by MDE)
3. Distribute inputs among identified REMI PI+ sectors.
   a. **GHG New Source Performance Standard**
      i. 100% for government administrative costs/responsibilities—$60,000 per year
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors.
   a. **GHG New Source Performance Standard**
      i. X7809— Production Costs-Electric power generation, transmission, and distribution
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **GHG New Source Performance Standard**
      i. Annual Reduction Target by 2020—4.48 million metric tons
      ii. Number of years until Target—8 years
      iii. Average Reductions per year—128,750 allowances annually
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **GHG New Source Performance Standard**
      i. Average GHG emissions associated with Electricity[5]—31.43 million metric tons
      ii. Allowances Sold to Date[6]— 68,507,184
      iii. Total Proceeds from Auctions to date[7]—$169,600,423.80 total proceeds

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[5] "Maryland Energy Consumption Data." ERedux Energy: Sustainable Geoscial Products and Services Network. 11 Nov. 2011. Maryland Energy Portal - Maryland's Carbon Footprint. 11 Nov. 2011 <http://www.eredux.com/states/state_detail.php?id=1129>.

[6] MD Proceeds by Auction. Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Welcome. Regional Greenhouse Gas Initiative CO2 Budget Trading Program, 2011. Web. 14 Nov. 2011. <http://rggi.org/docs/MD_Proceeds_by_Auction.pdf>.

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **GHG New Source Performance Standard**
      i. $2.48 [($169,600,423.80 total proceeds from auctions to date / 68,507,184 total carbon allowances sold to date)]=average cost of carbon allowances
      ii. $77,809,961.07 [(31,430,000 total carbon allowances sold *$2.48 per allowance for electricity)]=average carbon credits sold annually to firms
      iii. 30,825,000 [(31,430,000 total carbon allowances sold—605,000 proposed annual reduction target)]=average annual carbon credit to be purchased under reductions
      iv. $76,312,187.40 [(30,825,000 average annual carbon credits purchased under reduction target * $2.48 average cost per carbon credit allowance)]=average cost to firm for carbon credits under new reduction target
      v. X7809—$1,497,773.67 [($77,809,961.07 current average annual carbon credit costs - $76,312,187.40 average carbon credit costs under target reduction policy)]=savings to firms from reductions
5. Input savings by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.1.4 Maximum Achievable Control Technology (MACT)

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **Boiler Maximum Achievable Control Technology (MACT)**
      i. 63—State Government Spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Boiler Maximum Achievable Control Technology (MACT)**
      i. $40,000 (per year provided by MDE)
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Boiler Maximum Achievable Control Technology (MACT)**
      i. 100% for government administrative costs/responsibilities—$40,000 per year
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).

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[7] MD Proceeds by Auction. Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Welcome. Regional Greenhouse Gas Initiative CO2 Budget Trading Program, 2011. Web. 14 Nov. 2011. <http://rggi.org/docs/MD_Proceeds_by_Auction.pdf>.

   a. **Boiler Maximum Achievable Control Technology (MACT)**
      i. X7809— Production Costs-Electric power generation, transmission, and distribution
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Boiler Maximum Achievable Control Technology (MACT)**
      i. Target to 25 combined, 10 of single HAP
      ii. Base Cost - $200 for license + $52.23 per ton
      iii. Target by 2020—.10 million metric tons of CO2 emissions
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Boiler Maximum Achievable Control Technology (MACT)**
      i. Number of Boilers (Nationally)[8] —13,500 boilers
      ii. Number of Boilers in Maryland[9]—16
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **Boiler Maximum Achievable Control Technology (MACT)**
      i. 12,500 [(10 million metric tons of CO2 emissions / 8 years)]=average reduction of CO2 emissions per year
      ii. $914,025,200.00 [(17.5 metric tons of HAPs * $52.23 per metric ton) + $200.00 base fee)]=average credit purchase annually from firms
      iii. X7809—$10,446,000.00 [($15,039,337.50 cost to purchase HAP not under rule)] -[(17,500,000 average metric tons HAP output - 17,487,500 average output in metric tons from rule)] * [($52.23 per metric ton)] + [($200.00 base fee)] * [(16 boilers Maryland)]=average annual HAP credits to be purchased under new rule
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.1.5 Energy Efficiency in the Residential Sector

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **EmPOWER Maryland Empowering Finance Initiative**
      i. 63—State Government Spending
      ii. 98—Investment Spending (Residential)
   b. **EmPOWER Maryland Residential Incentives**
      i. 98—Investment Spending (Residential)

[8] "Maryland Energy Consumption Data." ERedux Energy: Sustainable Geoscial Products and Services Network. 11 Nov. 2011. Maryland Energy Portal - Maryland's Carbon Footprint. 11 Nov. 2011 <http://www.eredux.com/states/state_detail.php?id=1129>.

[9] Princeton Energy Resources International, LLC, and Exter Associates, Inc. "The Potential for Biomass Cofiring in Maryland." Maryland Powerplant Research Program. Mar. 2006. Maryland Department of Natural Resources (DNR). 11 Nov. 2011 <http://esm.versar.com/pprp/bibliography/PPES_06_02/PPES_06_02.pdf>.

c. **MEA Home Performance Rebate Program**
   i. 63—State Government Spending
   ii. 98—Investment Spending (Residential)
d. **DHCD Weatherization**
   i. 98—Investment Spending (Residential)
e. **Clean Energy Communities**
   i. 63—State Government Spending
   ii. 98—Investment Spending (Residential)
f. **Maryland Home Energy Loan Program**
   i. 98—Investment Spending (Residential)
g. **Energy Workforce Training**
   i. 98—Investment Spending (Residential)
h. **State Energy Efficiency Appliance Rebate Program**
   i. 63—State Government Spending
   ii. 98—Investment Spending (Residential)

2. Determine overall cost of policy implementation for each program under the policy.
   a. **EmPOWER Maryland Empowering Finance Initiative**[10]
      i. 2010—$44,104,681.87
      ii. 2011—$25,243,359.59
      iii. 2012—$32,753,320.79
      iv. 2013—$34,166,457.70
      v. 2014—$36,831,168.45
      vi. 2015—$37,422,974.39
      vii. 2016—$23,013,551.42
      viii. 2017—$23,013,551.42
      ix. 2018—$23,013,551.42
      x. 2019—$23,013,551.42
      xi. 2020—$23,013,551.42
   b. **EmPOWER Maryland Residential Incentives**
      i. 2010—$40,704,681.87
      ii. 2011—$25,243,359.59
      iii. 2012—$32,753,320.79
      iv. 2013—$34,166,457.70
      v. 2014—$36,831,168.45
      vi. 2015—$37,422,974.39
      vii. 2016—$23,013,551.42
      viii. 2017—$23,013,551.42
      ix. 2018—$23,013,551.42
      x. 2019—$23,013,551.42
      xi. 2020—$23,013,551.42
   c. **MEA Home Performance Rebate Program**[11]
      i. 2010—$42,204,681.87

[10] Program received ARRA funds in 2010.
[11] Program received ARRA funds in 2010.

ii. 2011—$25,243,359.59
iii. 2012—$32,753,320.79
iv. 2013—$34,166,457.70
v. 2014—$36,831,168.45
vi. 2015—$37,422,974.39
vii. 2016—$23,013,551.42
viii. 2017—$23,013,551.42
ix. 2018—$23,013,551.42
x. 2019—$23,013,551.42
xi. 2020—$23,013,551.42

d. **DHCD Weatherization**

i. 2010—$40,704,681.87
ii. 2011—$25,243,359.59
iii. 2012—$32,753,320.79
iv. 2013—$34,166,457.70
v. 2014—$36,831,168.45
vi. 2015—$37,422,974.39
vii. 2016—$23,013,551.42
viii. 2017—$23,013,551.42
ix. 2018—$23,013,551.42
x. 2019—$23,013,551.42
xi. 2020—$23,013,551.42

e. **Clean Energy Communities**[12]

i. $2010—$45,504,681.87
ii. 2011—$26,843,359.59
iii. 2012—$32,753,320.79
iv. 2013—$34,166,457.70
v. 2014—$36,831,168.45
vi. 2015—$37,422,974.39
vii. 2016—$23,013,551.42
viii. 2017—$23,013,551.42
ix. 2018—$23,013,551.42
x. 2019—$23,013,551.42
xi. 2020—$23,013,551.42

f. **Maryland Home Energy Loan Program**

i. 2010—$40,704,681.87
ii. 2011—$25,243,359.59
iii. 2012—$32,753,320.79
iv. 2013—$34,166,457.70
v. 2014—$36,831,168.45
vi. 2015—$37,422,974.39
vii. 2016—$23,013,551.42
viii. 2017—$23,013,551.42

[12] Program received funding from 2010 through 2011.

ix. 2018—$23,013,551.42
x. 2019—$23,013,551.42
xi. 2020—$23,013,551.42

g. Energy Workforce Training

i. 2010—$40,704,681.87
ii. 2011—$25,243,359.59
iii. 2012—$32,753,320.79
iv. 2013—$34,166,457.70
v. 2014—$36,831,168.45
vi. 2015—$37,422,974.39
vii. 2016—$23,013,551.42
viii. 2017—$23,013,551.42
ix. 2018—$23,013,551.42
x. 2019—$23,013,551.42
xi. 2020—$23,013,551.42

h. State Energy Efficiency Appliance Rebate Program[13]

i. 2010—$45,804,681.87
ii. 2011—$26,543,359.59
iii. 2012—$32,753,320.79
iv. 2013—$34,166,457.70
v. 2014—$36,831,168.45
vi. 2015—$37,422,974.39
vii. 2016—$23,013,551.42
viii. 2017—$23,013,551.42
ix. 2018—$23,013,551.42
x. 2019—$23,013,551.42
xi. 2020—$23,013,551.42

3. Distribute inputs among identified REMI PI+ sectors.

a. EmPOWER Maryland Empowering Finance Initiative

i. 92% from utilities compliance with EmPOWER (2010)
ii. 8% American Recovery and Reinvestment Act Funds (2010)
iii. 100% from utilities compliance with EmPOWER through subsequent years (2011-2020)

b. EmPOWER Maryland Residential Incentives

i. 100% from utilities compliance with EmPOWER

c. MEA Home Performance Rebate Program

i. 96% from utilities compliance with EmPOWER (2010)
ii. 4% American Recovery and Reinvestment Act Funds (2010)
iii. 100% from utilities compliance with EmPOWER through subsequent years (2011-2020)

d. DHCD Weatherization

i. 100% from utilities compliance with EmPOWER

[13] Program received funding from 2010-2011.

e. **Clean Energy Communities**
    i. 88% from utilities compliance with EmPOWER (2010)
    ii. 12% American Recovery and Reinvestment Act Funds (2010)
    iii. 94% from utilities compliance with EmPOWER (2011)
    iv. 6% American Recovery and Reinvestment Act Funds (2011)
    v. 100% from utilities compliance with EmPOWER through subsequent years (2012-2020)

f. **Maryland Home Energy Loan Program**
    i. 100% from utilities compliance with EmPOWER through subsequent years (2012-2020)

g. **Energy Workforce Training**
    i. 100% from utilities compliance with EmPOWER through subsequent years (2012-2020)

h. **State Energy Efficiency Appliance Rebate Program**
    i. 87% from utilities compliance with EmPOWER (2010)
    ii. 13% American Recovery and Reinvestment Act Funds (2010)
    iii. 95% from utilities compliance with EmPOWER (2011)
    iv. 5% American Recovery and Reinvestment Act Funds (2011)
    v. 100% from utilities compliance with EmPOWER through subsequent years (2012-2020)

4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors.
    a. **EmPOWER Maryland Empowering Finance Initiative**
        i. 640—Consumer Spending (electricity)
        ii. 78—Consumption Reallocation (all categories)
    b. **EmPOWER Maryland Residential Incentives**
        i. 640—Consumer Spending (electricity)
        ii. 78—Consumption Reallocation (all categories)
    c. **MEA Home Performance Rebate Program**
        i. 640—Consumer Spending (electricity)
        ii. 78—Consumption Reallocation (all categories)
    d. **DHCD Weatherization**
        i. 640—Consumer Spending (electricity)
        ii. 78—Consumption Reallocation (all categories)
    e. **Clean Energy Communities**
        i. 640—Consumer Spending (electricity)
        ii. 78—Consumption Reallocation (all categories)
    f. **Maryland Home Energy Loan Program**
        i. 640—Consumer Spending (electricity)
        ii. 78—Consumption Reallocation (all categories)
    g. **Energy Workforce Training**
        i. 78—Consumption Reallocation (all categories)

h. **State Energy Efficiency Appliance Rebate Program**
    i. 640—Consumer Spending (electricity)
    ii. 78—Consumption Reallocation (all categories)

2. Determine part of program to be affected by savings (from strategy write-up).
    a. **EmPOWER Maryland Empowering Finance Initiative** (http://energy.maryland.gov/facts/empower.html)
        i. CFL Light Replacement=$130
        ii. Blow in Wall-Insulation=$90
        iii. Seal Ductwork=$85
        iv. Repair Ceiling Leaks=$80
        v. Upgrade to Energy Star Washer=$50
        vi. Upgrade Attic Insulation=$40
        vii. Upgrade refrigerator to Energy Star=$40
        viii. Energy Star Room Air=$30
        ix. Low Flow Showerhead=$30
    b. **EmPOWER Maryland Residential Incentives**
        i. CFL Light Replacement=$130
        ii. Blow in Wall-Insulation=$90
        iii. Seal Ductwork=$85
        iv. Repair Ceiling Leaks=$80
        v. Upgrade to Energy Star Washer=$50
        vi. Upgrade Attic Insulation=$40
        vii. Upgrade refrigerator to Energy Star=$40
        viii. Energy Star Room Air=$30
        ix. Low Flow Showerhead=$30
        x. Annual Sum of Savings=$575
        xi. Number of Awards since 2009[14]=5,703
        xii. Number of Awards that are only Residential=5,609
    c. **MEA Home Performance Rebate Program**
        i. Money available for rebate=$1,500,000.00
    d. **DHCD Weatherization**
        i. Cost Incurred=$1,234,223 (from strategy write up)
    e. **Clean Energy Communities Grant**
        i. Grants available to State and Local Governments (from MEA website) =2.13 million
    f. **Maryland Home Energy Loan Program**
        i. Total Awarded thus Far=400,000
    g. **Energy Workforce Training**
    h. **State Energy Efficiency Appliance Rebate Program**
        i. Total allocated=$5,400,000
3. Research savings data for each policy according to part of program to be affected by savings.

[14] Residential Clean Energy Grant Program. Maryland Energy Administration. Maryland Energy Administration, 2011. Web. 16 Nov. 2011. <http://energy.maryland.gov/Residential/cleanenergygrants/index.html#updates>.

- **a. EmPOWER Maryland Empowering Finance Initiative**
- **b. EmPOWER Maryland Residential Incentives**
- **c. MEA Home Performance Rebate Program**
- **d. DHCD Weatherization**
  - i. Number of Assist/Completions Yearly[15]=6,164
  - ii. Average Savings Yearly in Energy Bills[16]=$437
- **e. Clean Energy Communities**
- **f. Maryland Home Energy Loan Program**
  - i. Loans Average of Those Possible Max[17]=$11,250
  - ii. Total Homes Applied=36
  - iii. Replacement period=10 years
  - iv. Average Interest Rate on Loan=8.49%
  - v. Total Loan=$12,205.125
  - vi. Total Owed every year on loan=$1,220.51
  - vii. Annual Savings from Programmable Thermostat—$150
  - viii. Annual Savings from Plugging Leaks—$440
- **g. Energy Workforce Training**
  - i. Total Trained to date=1,000 (assumed since 2009)
  - ii. Avg. Trained Yearly=333 (total trained to date/3 years since program initiated)
  - iii. Avg. Income of Green Job[18]=$47,000
- **h. State Energy Efficiency Appliance Rebate Program**

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   - **a. EmPOWER Maryland Empowering Finance Initiative**
     - i. 640—$3,278,650 [($575 Average Annual Savings from Energy Efficiency Measures in Household * 5,702 Applicants since 2009)]=Average Savings Associated from Program to All Applicants
     - ii. 78—$3,278,650 [(Reallocation of savings across other consumption categories.)]
   - **b. EmPOWER Maryland Residential Incentives**
     - i. 640—$3,225,175 [($575 Average Annual Savings from Energy Efficiency Measures in Households * 5,609 Residential Applicants for MEA Grants since 2009)]=Average Savings Associated with Program Since 2009 for Residential Sector

[15] StateStat. Maryland StateStat Report. Department of Housing & Community Development, July 2011. Web. 11 Nov. 2011. <http://www.statestat.maryland.gov/reports/20110825_DHCD_Template.pdf>.
[16] Weatherization and Intergovernmental Program: Weatherization Assistance Program. EERE: EERE Server Maintenance. U.S. Department of Energy, 25 Apr. 2011. Web. 11 Nov. 2011. <http://www1.eere.energy.gov/wip/wap.html>.
[17] Maryland Home Energy Loan Program. Maryland Home Energy Loan Program. Maryland Clean Energy Centre, 2010. Web. 16 Nov. 2011. <http://www.mcecloans.com/Module/Ext/ExtInfo.aspx?ModulePageAdmin=0fe789d7-d5fc-4297-9917-db58ccb8a660&&ModulePageVisitor=4b0b3b8a-4f4a-4192-98e8-4f0e35b75d90>.
[18] 2009 County Business Patterns. Censtats Database. NAICS, 2009. Web. 11 Nov. 2011. <http://censtats.census.gov/cgi-bin/cbpnaic/cbpsect.pl>.

   ii. 78—$3,225,175 [(Reallocation of savings across other consumption categories.)]

c. **MEA Home Performance Rebate Program**
   i. 640–$1,500,000 [(From Strategy Write Up, Money Available for Grants)]
   ii. 78—$1,500,000 [(Reallocation of savings across other consumption categories.)]

d. **DHCD Weatherization**
   i. $200.23 [($1,234,223 Cost Incurred for All Units to be Weatherized / 6,164 Units to be Completed Yearly)]=Average per Unit Cost of Weatherization
   ii. $236.77 [($437 Average Annual Savings from Weatherization - $200.23 Cost per Unit of Weatherization)]=Average Annual Savings of Weatherization
   iii. 640—$1,459,445 [($236.77 Average Annual Savings of Weatherization per unit * 6,164 Units to be treated)]=Average Savings Across All Households
   iv. 78—$1,459,445 [(Reallocation of savings across other consumption categories.)]

e. **Clean Energy Communities**
   i. 640—$2,130,000 [(Grant Money Available per strategy write up)]
   ii. 78—$2,130,000 [(Reallocation of savings across other consumption categories.)]

f. **Maryland Home Energy Loan Program**
   i. $1,220.51 [($12,205 Average Loan made through Program / 10 Year Payback period)] = Average Annual Loan Payment without Interest
   ii. $955 [($1,220.51 Average Annual Loan Payment Without Interest * 8.49% Interest Rate Associated with Loan Program)]=Average Annual Interest Paid on Loans
   iii. 432—$34,385 [($955 Average Annual Interest Paid on Loans * 36 Applicants for Program)]=Average Annual Revenue Received by Government from Loans
   iv. 640–$21,240 [(36 Applicants * $590 Overall Savings from Program Annually)]=Average Annual Savings to Households that Applied
   v. 78—$21,240 [(Reallocation of savings across other consumption categories.)]

g. **Energy Workforce Training**
   i. 78–$15,666,666.67 [(333 Newly Trained Energy Workforce Labor Every Year * $47,000 Average Annual Income of Green Job)]=Average Additional Income to Households Annually

h. **State Energy Efficiency Appliance Rebate Program**
   i. 640— $5,400,000 [(Allocated per Strategy Write Up)]
   ii. 78—$5,400,000 [(Reallocation of savings across other consumption categories.)]

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.1.6 Energy Efficiency in the Commercial and Industrial Sectors

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
   a. **Maryland Save Energy Now**
      i. 63—State Government Spending
   b. **Jane E. Lawton Conservation Loan Program**
      i. 63—State Government Spending
   c. **Energy Efficiency and Conservation Block Grant Program**
      i. 63—State Government Spending
   d. **State Agencies Loan Program**
      i. 63—State Government Spending
2. Determine overall cost of policy implementation for each program under the policy.[19]
   a. **Maryland Save Energy Now**
      i. 2010—$0
      ii. 2011—$533,765
      iii. 2012—$533,765
      iv. 2013—$150,000
      v. 2014—$150,000
      vi. 2015—$150,000
      vii. 2016—$150,000
      viii. 2017—$150,000
      ix. 2018—$150,000
      x. 2019—$150,000
      xi. 2020—$150,000
   b. **Jane E. Lawton Conservation Loan Program**
      i. 2010—$0
      ii. 2011—$1,335,000
      iii. 2012—$2,500,000
      iv. 2013—$2,500,000
      v. 2014—$2,500,000
      vi. 2015—$2,500,000
      vii. 2016—$2,500,000
      viii. 2017—$2,500,000
      ix. 2018—$2,500,000
      x. 2019—$2,500,000
      xi. 2020—$2,500,000
   c. **Energy Efficiency and Conservation Block Grant Program**
      i. 2010—$3,190,000
      ii. 2011—$3,190,000
      iii. 2012—$3,190,000
   d. **State Agencies Loan Program**
      i. 2010—$0

[19] Costs provided for this policy can be found in the *EmPOWERing Maryland: Clean Energy Programs FY2012* published by MEA. http://energy.maryland.gov/documents/FY12ProgramBook.pdf

ii. 2011—$2,500,000
iii. 2012—$2,500,000
iv. 2013—$2,500,000
v. 2014—$2,500,000
vi. 2015—$2,500,000
vii. 2016—$2,500,000
viii. 2017—$2,500,000
ix. 2018—$2,500,000
x. 2019—$2,500,000
xi. 2020—$2,500,000

3. Distribute inputs among identified REMI PI+ sectors.
   a. **Maryland Save Energy Now**
      i. 100% for government administrative costs/responsibilities
   b. **Jane E. Lawton Conservation Loan Program**
      i. 100% for government administrative costs/responsibilities
   c. **Energy Efficiency and Conservation Block Grant Program**
      i. 100% for government administrative costs/responsibilities
   d. **State Agencies Loan Program**
      i. 100% for government administrative costs/responsibilities
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Maryland Save Energy Now**
      i. 80—Electricity (Industrial Sector) Fuel Costs, All Industrial Sectors
      ii. 82—Electricity (Commercial Sector) Fuel Costs, All Commercial Sectors
   b. **Jane E. Lawton Conservation Loan Program**
      i. 80—Electricity (Industrial Sector) Fuel Costs, All Industrial Sectors
      ii. 82—Electricity (Commercial Sector) Fuel Costs, All Commercial Sectors
   c. **Energy Efficiency and Conservation Block Grant Program**
      i. 80—Electricity (Industrial Sector) Fuel Costs, All Industrial Sectors
      ii. 82—Electricity (Commercial Sector) Fuel Costs, All Commercial Sectors
   d. **State Agencies Loan Program**
      i. 80—Electricity (Industrial Sector) Fuel Costs, All Industrial Sectors
      ii. 82—Electricity (Commercial Sector) Fuel Costs, All Commercial Sectors
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Maryland Save Energy Now**
   b. **Jane E. Lawton Conservation Loan Program**
      i. Total Energy Used by Government in 2009—1,500,000,000 kilowatts
   c. **Energy Efficiency and Conservation Block Grant Program**
      i. Potential Energy Reduction from Program—4,200,000 kilowatts
      ii. Potential Energy Reduction from Program in Natural Gas (in kilowatts)—967,135 kilowatts

            iii. Potential Energy Reductions from Program in Oil (in gallons)—35,000 kilowatts
        d. **State Agencies Loan Program**
            i. Savings in kilowatts from program—11,000,000 kilowatts
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Maryland Save Energy Now**
    b. **Jane E. Lawton Conservation Loan Program**
    c. **Energy Efficiency and Conservation Block Grant Program**
    d. **State Agencies Loan Program**
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).[20]
    a. **Maryland Save Energy Now**
        i. $128,605,000 [(Savings from 2010-2020 from this program)]
        ii. 80—Annual Savings
            1. 2010—$2,018,774
            2. 2011—$4,067,822
            3. 2012—$6,357,604
            4. 2013—$9,170,329
            5. 2014—$12,474,832
            6. 2015—$15,752,591
            7. 2016—$15,752,591
            8. 2017—$15,752,591
            9. 2018—$15,752,591
            10. 2019—$15,752,591
            11. 2020—$15,752,591
        iii. 82—Annual Savings
            1. 2010—$2,018,774
            2. 2011—$4,067,822
            3. 2012—$6,357,604
            4. 2013—$9,170,329
            5. 2014—$12,474,832
            6. 2015—$15,752,591
            7. 2016—$15,752,591
            8. 2017—$15,752,591
            9. 2018—$15,752,591
            10. 2019—$15,752,591
            11. 2020—$15,752,591
    b. **Jane E. Lawton Conservation Loan Program**
        i. $128,605,000 [(Savings from 2010-2020 from this program)]
        ii. 80—Annual Savings
            1. 2010—$2,018,774

[20] Reduction data provided by MEA from utilities for this program and an average was taken across the programs to determine the value of these programs.

2. 2011—$4,067,822
3. 2012—$6,357,604
4. 2013—$9,170,329
5. 2014—$12,474,832
6. 2015—$15,752,591
7. 2016—$15,752,591
8. 2017—$15,752,591
9. 2018—$15,752,591
10. 2019—$15,752,591
11. 2020—$15,752,591

iii. 82—Annual Savings
1. 2010—$2,018,774
2. 2011—$4,067,822
3. 2012—$6,357,604
4. 2013—$9,170,329
5. 2014—$12,474,832
6. 2015—$15,752,591
7. 2016—$15,752,591
8. 2017—$15,752,591
9. 2018—$15,752,591
10. 2019—$15,752,591
11. 2020—$15,752,591

c. **Energy Efficiency and Conservation Block Grant Program**

i. $128,605,000 [(Savings from 2010-2020 from this program)]

ii. 80—Annual Savings
1. 2010—$2,018,774
2. 2011—$4,067,822
3. 2012—$6,357,604
4. 2013—$9,170,329
5. 2014—$12,474,832
6. 2015—$15,752,591
7. 2016—$15,752,591
8. 2017—$15,752,591
9. 2018—$15,752,591
10. 2019—$15,752,591
11. 2020—$15,752,591

iii. 82—Annual Savings
1. 2010—$2,018,774
2. 2011—$4,067,822
3. 2012—$6,357,604
4. 2013—$9,170,329
5. 2014—$12,474,832
6. 2015—$15,752,591
7. 2016—$15,752,591
8. 2017—$15,752,591

9. 2018—$15,752,591
10. 2019—$15,752,591
11. 2020—$15,752,591

d. State Agencies Loan Program

i. $128,605,000 [(Savings from 2010-2020 from this program)]
ii. 80—Annual Savings
1. 2010—$2,018,774
2. 2011—$4,067,822
3. 2012—$6,357,604
4. 2013—$9,170,329
5. 2014—$12,474,832
6. 2015—$15,752,591
7. 2016—$15,752,591
8. 2017—$15,752,591
9. 2018—$15,752,591
10. 2019—$15,752,591
11. 2020—$15,752,591

iii. 82—Annual Savings
1. 2010—$2,018,774
2. 2011—$4,067,822
3. 2012—$6,357,604
4. 2013—$9,170,329
5. 2014—$12,474,832
6. 2015—$15,752,591
7. 2016—$15,752,591
8. 2017—$15,752,591
9. 2018—$15,752,591
10. 2019—$15,752,591
11. 2020—$15,752,591

5. Input savings by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.1.7 Energy Efficiency Appliances and Other Products

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. Energy Efficiency Appliances and Other Products
   i. 45—Residential Capital
2. Determine overall cost of policy implementation for each program under the policy.
   a. Energy Efficiency Appliances and Other Products
   i. 2010—$21,116,830
   ii. 2011—$20,901,270
   iii. 2012—$17,380,320
   iv. 2013—$18,140,110
   v. 2014—$23,300,840

vi. 2015—$19,872,100

3. Distribute inputs among identified REMI PI+ sectors.
    - **a. Energy Efficiency Appliances and Other Products**
        - i. 100% spent by households to upgrade existing capital within the home
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors.
    - a. **Energy Efficiency Appliances and Other Products**
        - i. 640—Consumer Spending (electricity)
        - ii. 78—Consumption Reallocation (all categories)
2. Determine part of program to be affected by savings (from strategy write-up).
    - a. **Energy Efficiency Appliances and Other Products**
3. Research savings data for each policy according to part of program to be affected by savings.
    - a. **Energy Efficiency Appliances and Other Products**
        - i. Avg. purchase price of an incandescent bulb[21]—0.25
        - ii. Avg. purchase price of a CFL bulb[22]—5
        - iii. Lifetime of Incandescent Bulb[23]—1,000 hours
        - iv. Lifetime of a CFL Bulb[24]—8,000 hours
        - v. Price per hour of Incandescent bulb[25]—0.00025
        - vi. Price per hour of CFL Bulb[26]—0.000625
        - vii. Number of replacements in 7 years - Incandescent[27]—7
        - viii. Number of replacements in 7 year - CFL[28]—7
        - ix. Avg. Cost per kwh[29]—0.11
        - x. Amount of Watts of Incandescent[30]—60
        - xi. Amount of Equivalent CLF[31]—13
        - xii. Annual Savings in KWH change from Inca to CFL[32]—51
        - xiii. Number of Households[33]—2,092,538

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[21] Innovation. Performance. Savings. ENERGY STAR. United States Department of Energy, 2011. Web. 16 Nov. 2011. <http://www.energystar.gov/ia/partners/manuf_res/CFL_PRG_FINAL.pdf>.
[22] Ibid.
[23] Ibid.
[24] Ibid.
[25] Ibid.
[26] Ibid.
[27] Ibid.
[28] Ibid.
[29] Strong Finish to 2011 Natural Gas Storage Injection Season. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration (EIA), Oct. 2011. Web. 14 Nov. 2011. <http://www.eia.gov/>.
[30] Innovation. Performance. Savings. ENERGY STAR. United States Department of Energy, 2011. Web. 16 Nov. 2011. <http://www.energystar.gov/ia/partners/manuf_res/CFL_PRG_FINAL.pdf>.
[31] Ibid.
[32] Ibid.
[33] Maryland QuickFacts from the US Census Bureau. State and County QuickFacts. U.S. Census Bureau, 13 Oct. 2011. Web. 11 Nov. 2011. <http://quickfacts.census.gov/qfd/states/24000.html>.

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **Energy Efficiency Appliances and Other Products**
      i. $1.75 [(7 Number of replacements in 7 years incandescent * 0.25 Avg. purchase price of an incandescent bulb)]=Total Cost in 7 Years on Replacements Incandescent
      ii. $0 [(0 Number of replacements in 7 years CFL * 5 Avg. purchase price of an CFL bulb)]=Total Cost in 7 Years on Replacements CFL
      iii. 0.714285714 [(5 Avg. purchase price of an CFL bulb / 7)]=Total Cost Over Lifetime of CFL per year
      iv. $0.71 [(5 Avg. purchase price of an CFL bulb / 7)]=Cost of CFL Annually
      v. 5.8191 [(51 Annual Savings in kwh change from Inca to CFL * 0.11 Avg. Cost per kwh)]=Savings from CFL Annually
      vi. $5.11 [(5.8191 Savings from CFL Annually - 0.714285714 Savings from CFL Annually)]=Savings from ONE CFL Bulb
      vii. $10,682,017.88 [(2,092,538 Number of Households * 5.10481 Savings from ONE CFL Bulb)]=Savings Annually
      viii. 604–$10,682,017.88 [(2,092,538 Number of Households * 5.10481 Savings from ONE CFL Bulb)]=Savings Annually
      ix. 78—$10,682,017.88 [(Reallocation of consumer savings across other consumption categories)]
5. Input savings by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.1.8 Energy Efficiency in the Power Sector—General

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **Energy Efficiency in the Power Sector—General**
      i. EQP 13—Producer's Durable Equipment Investment, Electrical transmission, distribution, generation
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Energy Efficiency in the Power Sector—General** [34]
      i. 2010—$242,655,500
      ii. 2011—$153,864,300
      iii. 2012—$199,639,289
      iv. 2013—$208,252,695
      v. 2014—$267,544,800
      vi. 2015—$228,101,939
      vii. 2016—$216,676,420
      viii. 2017—$216,676,420
      ix. 2018—$216,676,420
      x. 2019—$216,676,420

[34] All data was provided by MEA from utility companies regarding this program.

xi. 2020—$216,676,420

3. Distribute inputs among identified REMI PI+ sectors.
   a. **Energy Efficiency in the Power Sector—General**
      i. 100% towards private sector in power generation to implement new strategies
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Energy Efficiency in the Power Sector—General**
      i. X7809—Production Cost, Electrical power generation, distribution, transmission
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Energy Efficiency in the Power Sector—General**
      i. Potential Biomass=2,700,000 in tons
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Energy Efficiency in the Power Sector—General**
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).[35]
   a. **Energy Efficiency in the Power Sector—General**
      i. X7809—Annual Savings to Power Sector
         1. 2010—$17,133,600
         2. 2011—$19,077,100
         3. 2012—$23,688,900
         4. 2013—$36,847,500
         5. 2014—$54,334,000
         6. 2015—$72,374,100
         7. 2016—$37,242,510
         8. 2017—$37,242,510
         9. 2018—$37,242,510
         10. 2019—$37,242,510
         11. 2020—$37,242,510
5. Input savings by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.1.9 Maryland Renewable Energy Portfolio Standard

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).

[35] Reduction data provided by utilities to MEA.

   a. **Maryland Renewable Energy Portfolio Standard**
      i. EQP 13—Producer's Durable Equipment Investment, Electrical generation, distribution, transmission
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Maryland Renewable Energy Portfolio Standard**[36]
      i. 2010—$23,290,000
      ii. 2011—$345,600,000
      iii. 2012—$125,190,000
      iv. 2013—$310,440,000
      v. 2014—$188,680,000
      vi. 2015—$536,200,000
      vii. 2016—$368,860,000
      viii. 2017—$1,941,270,000
      ix. 2018—$1,705,000,000
      x. 2019—$914,610,000
      xi. 2020—$265,600,000
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Maryland Renewable Energy Portfolio Standard**
      i. 100% for private producers of electricity to move towards new alternative sources.
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors.
   a. **Maryland Renewable Energy Portfolio Standard**
      i. X7009—Compensation, Electrical power distribution, generation, transmission
      ii. X7809—Production Cost, Electrical power distribution, generation, transmission
      iii. X10009—Capital Cost, Electrical power distribution, generation, transmission
2. Determine part of program to be affected by ongoing costs for maintenance.
   a. **Maryland Renewable Energy Portfolio Standard**
3. Research costs data for each policy according to part of program to be affected by program.
   a. **Maryland Renewable Energy Portfolio Standard**[37]
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
   a. **Maryland Renewable Energy Portfolio Standard**
      i. X7009—Annual costs to firm
         1. 2010—$6,610,000
         2. 2011—$6,460,000

[36] Funding levels for RPS have been provided on an annual basis by MEA.
[37] All data regarding maintenance and operation estimations have been provided courtesy of MEA.

            3. 2012—$6,730,000
            4. 2013—$6,730,000
            5. 2014—$6,730,000
            6. 2015—$14,470,000
            7. 2016—$14,470,000
            8. 2017—$14,470,000
            9. 2018—$15,170,000
            10. 2019—$15,170,000
            11. 2020—$15,170,000
        ii. X7809—Annual costs to firm
            1. 2010—$33,205,000
            2. 2011—$33,000,000
            3. 2012—$33,205,000
            4. 2013—$34,540,000
            5. 2014—$34,860,000
            6. 2015—$38,015,000
            7. 2016—$38,675,000
            8. 2017—$70,700,000
            9. 2018—$91,310,000
            10. 2019—$95,340,000
            11. 2020—$96,255,000
        iii. X10009—Annual costs to firm
            1. 2010—$33,205,000
            2. 2011—$33,000,000
            3. 2012—$33,205,000
            4. 2013—$34,540,000
            5. 2014—$34,860,000
            6. 2015—$38,015,000
            7. 2016—$38,675,000
            8. 2017—$70,700,000
            9. 2018—$91,310,000
            10. 2019—$95,340,000
            11. 2020—$96,255,000

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.1.10 Incentives and Grant Programs to Support Renewable Energy

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
    a. **Commercial Clean Energy Grant Program**
        i. 63—State Govt. Spending
    b. **Residential Clean Energy Grants Program**
        i. 63—State Govt. Spending

- **c. Clean Energy Incentive Tax Credit Program**
  - i. 63—State Govt. Spending
- **d. Generating Clean Horizons Program**
  - i. 45—Residential Capital Investment
- **e. Project Sunburst**
  - i. 63—State Govt. Spending
- **f. Biomass Program**
  - i. 63—State Govt. Spending
- **g. Land-based Wind Programs**
  - i. 63—State Govt. Spending

2. Determine overall cost of policy implementation for each program under the policy.
   - **a. Commercial Clean Energy Grant Program**
     - i. 2010—$0
     - ii. 2011—$1,500,000
     - iii. 2012—$1,500,000
     - iv. 2013—$1,000,000
     - v. 2014—$1,000,000
     - vi. 2015—$1,000,000
     - vii. 2016—$1,000,000
     - viii. 2017—$1,000,000
     - ix. 2018—$1,000,000
     - x. 2019—$1,000,000
     - xi. 2020—$1,000,000
   - **b. Residential Clean Energy Grants Program**
     - i. 2010—$0
     - ii. 2011—$5,600,000
     - iii. 2012—$5,600,000
     - iv. 2013—$4,200,000
     - v. 2014—$4,200,000
     - vi. 2015—$4,200,000
     - vii. 2016—$4,200,000
     - viii. 2017—$4,200,000
     - ix. 2018—$4,200,000
     - x. 2019—$4,200,000
     - xi. 2020—$4,200,000
   - **c. Clean Energy Incentive Tax Credit Program**[38]
     - i. 2010—$2,500,000
     - ii. 2011—$2,500,000
     - iii. 2012—$2,500,000
     - iv. 2013—$2,500,000
     - v. 2014—$2,500,000
     - vi. 2015—$2,500,000

[38] "Clean Energy Production Tax Credit," *Maryland Energy Administration*, accessed October 17, 2012.

- **d. Generating Clean Horizons Program**[39]
  - i. 2010—$106,700,000
  - ii. 2011—$106,700,000
  - iii. 2012—$106,700,000
- **e. Project Sunburst**[40]
  - i. 2010—$4,690,565
  - ii. 2011—$4,690,565
- **f. Biomass Program**
  - i. 2010—$1,000,500
  - ii. 2011—$1,000,500
  - iii. 2012—$1,000,500
  - iv. 2013—$1,000,500
  - v. 2014—$1,000,500
  - vi. 2015—$1,000,500
  - vii. 2016—$1,000,500
  - viii. 2017—$1,000,500
- **g. Land-based Wind Programs**[41]
  - i. 2010—$100,000
  - ii. 2011—$100,000
  - iii. 2012—$100,000
  - iv. 2013—$100,000
  - v. 2014—$100,000
  - vi. 2015—$100,000
  - vii. 2016—$100,000
  - viii. 2017—$100,000

3. Distribute inputs among identified REMI PI+ sectors.
   - **a. Commercial Clean Energy Grant Program**
     - i. 100% spent by government (from SEIF funds) in form of grants to businesses
   - **b. Residential Clean Energy Grants Program**
     - i. 100% spent by government (from SEIF funds) in form of grants to residential investment
   - **c. Clean Energy Incentive Tax Credit Program**
     - i. 100% spent by government towards reduction of investment costs in clean energy
   - **d. Generating Clean Horizons Program**
     - i. 100% spent by households to improve household energy savings
   - **e. Project Sunburst**
     - i. 100% spent by government in form of grants

[39] Maryland Energy Administration, "Maryland Governor Martin O'Malley Celebrates the Completion of the Largest Solar Farm in the State" (press release, Emmitsburg, Maryland, 2012)
[40] "Project Sunburst," *Maryland Energy Administration*, accessed October 17, 2012.
[41] "Windswept Grant Program," *Maryland Energy Administration*, accessed October 17, 2012.

- **f. Biomass Program**
  - i. 100% spent by government in form of research regarding biomass
- **g. Land-based Wind Programs**
  - i. 100% spent by government to further initiatives in land-based wind

4. Input sales by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors.
   - **a. Commercial Clean Energy Grant Program**
     - i. 82—Electrical (Commercial Sector) Fuel Costs, All Commercial Sectors
   - **b. Residential Clean Energy Grants Program**
     - i. 640—Consumer Spending, (electricity)
     - ii. 78—Consumption Reallocation (all categories)
   - **c. Clean Energy Incentive Tax Credit Program**
     - i. No additional costs or benefits specified
   - **d. Generating Clean Horizons Program**
     - i. 640—Consumer Spending, (electricity)
     - ii. 78—Consumption Reallocation (all categories)
   - **e. Project Sunburst**
     - i. 640—Consumer Spending, (electricity)
     - ii. 78—Consumption Reallocation (all categories)
   - **f. Biomass Program**
     - i. 640—Consumer Spending, (electricity)
     - ii. 78—Consumption Reallocation (all categories)
   - **g. Land-based Wind Programs**
     - i. 640—Consumer Spending, (electricity)
     - ii. 78—Consumption Reallocation (all categories)
2. Determine part of program to be affected by savings (from strategy write-up).
   - **a. Commercial Clean Energy Grant Program**
   - **b. Residential Clean Energy Grants Program**
   - **c. Clean Energy Incentive Tax Credit Program**
   - **d. Generating Clean Horizons Program**
     - i. Total Energy Used by Government in 2009—1,500,000,000 kilowatts
     - ii. Reduction Goal by 2016—16%
   - **e. Project Sunburst**
   - **f. Biomass Program**
   - **g. Land-based Wind Programs**
     - i. Total Wind Energy Generated Annually—120,000 kilowatts
     - ii. Total Wind Energy Generation Added Since Project Windswept—421 kilowatts
     - iii. Average Annual Wind Energy Generated—120,421 kilowatts
3. Research savings data for each policy according to part of program to be affected by savings.

- **a. Commercial Clean Energy Grant Program**
  - i. Potential Savings from Clean Energy Grant—$575
  - ii. Total Applicants for Grants (from MEA website)—42 Businesses
- **b. Residential Clean Energy Grants Program**
  - i. Total Applicants for Grants (from MEA website)–5,609 Residential Applicants
  - ii. Average Grantees A Year—1,870 Residential Grantees a year
  - iii. Potential Savings from Clean Energy Grant—$575
- **c. Clean Energy Incentive Tax Credit Program**
  - i. Number of Business Tax Credit Applicants (From MEA website)—42
- **d. Generating Clean Horizons Program**
  - i. Maryland Electricity cost (in KWh)[42]—$0.11 per kW/h
- **e. Project Sunburst**
  - i. Total Awardees (from MEA website)—17
  - ii. Total Money Granted (from MEA website)—$9,381,130.00
- **f. Biomass Program**
  - i. Annual Savings from Biomass Production—$4,282,740.00 (from DNR)
- **g. Land-based Wind Programs**
  - i. Maryland Electricity cost (in KWh)[43]—$0.11 per kW/h

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   - **a. Commercial Clean Energy Grant Program**
     - i. 82—$24,150 [(42 Applicants to date for Commercial Clean Energy Grants * $575 Annual Savings Associated with Clean Energy Initiatives)]=Average Annual Savings from Strategy
   - **b. Residential Clean Energy Grants Program**
     - i. 640—$1,075,058 [(1,870 Residential Applicants Annually for Grants * $575 Potential Energy Savings from Grants)]=Average Annual Savings to Households
     - ii. 78—$1,075,058 [(Reallocation of savings across other consumption categories)]
   - **c. Clean Energy Incentive Tax Credit Program**
     - i. No Additional Costs or Benefits associated with this program
   - **d. Generating Clean Horizons Program**
     - i. $171,150,000.00 [(1,500,000,000 kilowatts of Energy used by Government in 2009 * $0.11 Average Cost of Electricity per kwh)]=Average Cost to Government in 2009 for Energy Consumption
     - ii. 240,000,000 [(1,500,000,000 kilowatts of Energy used by Government in 2009 * 16% Reduction goal by 2016)]=Kilowatt Consumption Reduction Goal by 2016

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[42] Average Energy Prices in the Washington-Baltimore Area. Mid-Atlantic Information Office. 27 Sept. 2011. U.S. Bureau of Labor Statistics (BLS). 11 Nov. 2011 <http://www.bls.gov/ro3/apwb.htm#wb_energy_table1>.
[43] Ibid.

iii. 60,000,000 [(240,000,000 Kilowatt Consumption Reduction Goal by 2016 / 4 Years until 2016 Deadline)]=Average Annual Reduction Goal until 2016
iv. 1,440,000,000 [(1,500,000,000 kilowatts of Energy used by Government in 2009—60,000,000 Average Annual Reduction Goal Until 2016)]=Average Annual Amount to be used by Government in Next Year
v. $164,304,000.00 [(1,440,000,000 Average Annual Amount to be used by Government in Next Year * $0.11 Average Cost per kilowatt hour)]=Average Annual Cost to Government in Next Year
vi. 640—$6,846,000.00 [($171,150,000.00 Average Annual Cost of Electricity in 2009 to Government - $164,304,000.00 Average Annual Cost of Electricity Next Year to Government)]=Average Annual Savings Associated with Reduction
vii. 78 — $6,846,000 [(Reallocation of savings across all other consumption categories.)]

e. **Project Sunburst**
   i. 640—$9,381,130.00 [(Total Money Granted Under this Project Via the MEA website)]
   ii. 78—$9,381,130 [(Reallocation of savings to other consumption categories.)]

f. **Biomass Program**
   i. 640—$4,282,740.00 [(Biomass Savings Annually provided by DNR)]
   ii. 78 — $4,282,740 [(Reallocation of savings across all other consumption categories.)]

g. **Land-based Wind Programs**
   i. $13,740.04 [($0.11 Average Cost per kwh of Electricity * 120,421 kilowatts generated by Wind Energy)]=Average Annual Savings to Consume Wind Energy
   ii. 640—$13,740
   iii. 78 — $13,740 [(Reallocation of savings across all other consumption categories.)]

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.1.11 Offshore Wind Initiatives to Support Renewable Energy

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **Offshore Wind Initiative to Support Renewable Energy**
      i. X7809—Production Cost, Electrical power distribution, generation, transmission
2. Determine overall cost of policy implementation for each program under the policy.

- **a. Offshore Wind Initiative to Support Renewable Energy**[44]
  - i. $639,000,000 (to be allocated for investment in 2017, provided by MEA.)

3. Distribute inputs among identified REMI PI+ sectors.
   - **a. Offshore Wind Initiative to Support Renewable Energy**
     - i. 100% paid by private industry towards investment in offshore wind energy production
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors.
   - **a. Offshore Wind Initiative to Support Renewable Energy**
     - i. X7809—Production Cost, Electrical power distribution, generation, transmission
2. Determine part of program to be affected by savings (from strategy write-up).
   - a. **Offshore Wind Initiative to Support Renewable Energy**
     - i. Reduction Total by 2020—20%
3. Research savings data for each policy according to part of program to be affected by savings.
   - a. **Offshore Wind Initiative to Support Renewable Energy**
     - i. Continued operation and maintenance costs annually after 2017 could average $36,940,000 per year. (Data provided courtesy of MEA)
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
   - a. **Offshore Wind Initiative to Support Renewable Energy**
     - i. X7809—annual costs from 2017-2020
       1. 2017 — $36,940,000
       2. 2018 — $36,940,000
       3. 2019 — $36,940,000
       4. 2020 — $36,940,000
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

C.2 Transportation

3.2.1 Maryland Clean Cars Program

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
   - **a. Maryland Clean Cars Program**
     - i. 63—State Govt. Spending
     - ii. 601—Consumer Spending (autos)
2. Determine overall cost of policy implementation for each program under the policy.

[44] Maryland Energy Administration, "Maryland Offshore Wind Energy Act of 2012 Facts & Figures" (Press release, Annapolis, Maryland, 2012).

a. **Maryland Clean Cars Program**
    i. Number of clean cars sold to date—362,955 (provided by MDE)
    ii. Number of clean cars needed to achieve GGRA—3,751,245 (provided by MDE)
    iii. Number of clean cars goal for 2013—325,728 (provided by MDE)
    iv. Average increase in the private sector of clean cars in cost[45]—$1,280 per vehicle
    v. Average increase in the public sector of clean cars in price[46]—$1,223 per vehicle
    vi. Number of vehicles to be replaced by government annual—800
    vii. Number of vehicles left to be replaced by private sector to reach goal in 2013—324,928
    viii. Average Annual vehicles to be replaced from 2014-2020 to reach target—437,509
    ix. Average annual vehicles replaced by government annually—800
    x. Average annual vehicles replaced by consumers annually—436,709

3. Distribute inputs among identified REMI PI+ sectors.
    a. **Maryland Clean Cars Program**
        i. 63—Average annual spending by state government on clean cars for replacement fleet
            1. 2012—$303,200
            2. 2013—$978,000
            3. 2014—$978,000
            4. 2015—$978,000
            5. 2016—$978,000
            6. 2017—$978,000
            7. 2018—$978,000
            8. 2019—$978,000
            9. 2020—$978,000
        ii. 601—Average annual spending by consumers on clean cars
            1. 2012—$463,558,400
            2. 2013—$415,907,840
            3. 2014—$558,987,520
            4. 2015—$558,987,520
            5. 2016—$558,987,520
            6. 2017—$558,987,520
            7. 2018—$558,987,520
            8. 2019—$558,987,520
            9. 2020—$558,987,520
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

[45] Motor Vehicle Administration, "2011 Car Sales Statistics," *Department of Transportation*, accessed October 17, 2012.
[46] Ibid.

Operation Phase

1. Determine relevant REMI PI+ sectors.
    a. **Maryland Clean Cars Program**
        i. 623—Consumer spending (gas)
        ii. 78—Consumption reallocation
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **Maryland Clean Cars Program**
        i. New CAFE average standards for MPG[47]—29 mpg
        ii. Average MPG of NONPVEC vehicles[48]—27.05
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Maryland Clean Cars Program**
        i. Average savings per mile—1.95 gallons per mile
        ii. Average fuel price per gallon (regular unleaded)[49]—$3.63 per gallon
        iii. Total VMT Driven By Maryland Population in 2011[50]—55,600,000,000 miles
        iv. Average annual growth rate of vehicle miles traveled by MD residents[51]—1.80%
        v. Number of vehicles registered in Maryland—2,221,000
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
    a. **Maryland Clean Cars Program**
        i. 56,600,800,000 miles [((55,600,000,000 miles driven by MD residents in 2011 * 1.80% growth) + 55,600,000,000 miles driven in 2011=new potential total miles traveled by MD residents in 2012
        ii. 25,484 miles [(55,600,800,000 miles in 2012 / 2,221,000 vehicles registered in MD)]=Average number of miles traveled by each vehicle in Maryland in 2012
        iii. $229.96 in 2012 [(25,484 miles in 2012 / 29 miles per gallon)] * [($3.63 per gallon of regular unleaded)]—[(25,484 miles in 2012 / 27.05 miles per gallon)] * [($3.63 per gallon of regular unleaded)]=savings in gasoline by consumer in 2012 if they switched to clean cars
        iv. $83,464,686 [(($229.96 savings for those that switched to clean cars * 362,955 clean cars sold to date)]=average annual savings by clean car consumers in 2012

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[47] Csere, Csaba. "How Automakers Will Meet 2016 CAFE Standards - Feature - Car and Driver." Car Reviews - 2011 Car Reviews and 2012 New Cars at Car and Driver. May 2011. Car and Driver. 11 Nov. 2011 <http://www.caranddriver.com/features/how-automakers-will-meet-2016-cafe-standards>.

[48] Bureau of Transportation Statistics, "Table 4-23: Average Fuel Efficiency of U.S. Light Duty Vehicles," *Research and Innovative Technology Administration*, accessed October 17, 2012.

[49] Daily Fuel Gauge Report--national, state and local average prices for gasoline, diesel and E-85. 11 Nov. 2012. Oil Price Information Service (OPIS). 11 Nov. 2012 <http://fuelgaugereport.aaa.com/?redirectto=http://fuelgaugereport.opisnet.com/index.asp

[50] Maryland Department of Transportation, "Draft 2012 Implementation Play – Appendix." *Maryland Climate Action Plan* (2011), accessed October 17, 2012.

[51] Ibid.

v. 57,619,614,400 miles [((55,600,800,000 miles driven by MD residents in 2011 * 1.80% growth) + 55,600,800,000 miles driven in 2012=new potential total miles traveled by MD residents in 2013
vi. 16,286 vehicles [(325,728 clean car vehicle goal * 5% for new registrations)]=New registrations possibly in Maryland in 2013
vii. 2,237,286 vehicles [(2,221,000 registered vehicles currently + 16,286 potentially new registrations in 2013 if 5% of new clean cars are new registrations)]=Total registered vehicles in 2013
viii. 25,754 miles [(57,619,614,400 miles in 2012 / 2,237,286 vehicles registered in MD)]=Average number of miles traveled by each vehicle in Maryland in 2013
ix. $232.39 in 2013 [(25,754 miles in 2013 / 29 miles per gallon)] * [($3.63 per gallon of regular unleaded)]—[(25,754 miles in 2013 / 27.05 miles per gallon)] * [($3.63 per gallon of regular unleaded)]=savings in gasoline by consumer in 2013 if they switched to clean cars
x. $75,697,201.95 [(($232.39 savings for those that switched to clean cars * 325,728 clean cars goal in 2013)]=Annual savings by clean car consumers in 2013
xi. $159,161,890 [($83,464,686 total savings to clean car consumers in 2012 + $75,697,201.95 total savings to clean car consumers in 2013)]=total savings from clean car consumers between 2012-2013
xii. $79,580,900 [($159,161,890 total savings between 2012-2013 clean car consumers / 2 years)]=Average annual savings from clean cars
xiii. 623—$79,580,900 average annual savings from clean cars from 2012-2020
xiv. 78—$79,580,900 average annual reallocation of savings across other consumption categories

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.2.2 National Fuel Efficiency and Emission Standards for Medium- and Heavy-Duty Trucks

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
   a. **National Fuel Efficiency and Emission Standards for Medium- and Heavy-Duty Trucks**
      i. X6653—Intermediate Demand, Motor vehicle parts manufacturing
      ii. X7653—Value added (with no effect on sales or employment), Motor vehicle parts manufacturing
      iii. X7851—Production costs, Motor vehicle manufacturing
2. Determine overall cost of policy implementation for each program under the policy.

   a. **National Fuel Efficiency and Emission Standards for Medium- and Heavy-Duty Trucks**
      i. Costs from 2012-2016[52]—$170,000,000 annually
3. Distribute inputs among identified REMI PI+ sectors.
   a. **National Fuel Efficiency and Emission Standards for Medium- and Heavy-Duty Trucks**
      1. X6653—$170,000,000 annually from 2012-2016 for new parts to comply with regulation
      2. X7653—($170,000,000) annually from 2012-2016 (offset to ensure no value added since this is not from new sales but a need for technology)
      3. X7851—$170,000,000 increase in production costs to auto manufacturers that are selling a final product to comply with standards
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **National Fuel Efficiency and Emission Standards for Medium- and Heavy-Duty Trucks**
      i. 641—Consumer Spending (gas)
      ii. 78—Consumption reallocation (across all categories)
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **National Fuel Efficiency and Emission Standards for Medium- and Heavy-Duty Trucks**
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **National Fuel Efficiency and Emission Standards for Medium- and Heavy-Duty Trucks**
      i. Total savings for MD consumers from 2020-2025—$138,906,752 (provided by MDE)
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **National Fuel Efficiency and Emission Standards for Medium- and Heavy-Duty Trucks**
      i. 641—$23,151,125 reduction in fuel consumption by MD consumers
      ii. 78—$23,151,125 reallocation of savings across other consumption categories
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

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[52] United States Environmental Protection Agency (2011), "Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles: EPA Response to Comments Document for Join Rulemaking," accessed October 17, 2012.

3.2.3 Clean Fuel Standard

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
    a. **Clean Fuel Standard**
        i. X6653—Intermediate Demand, Motor vehicle parts manufacturing
        ii. X7653—Value added (with no effect on sales or employment), Motor vehicle parts manufacturing
        iii. X7851—Production costs, Motor vehicle manufacturing
2. Determine overall cost of policy implementation for each program under the policy.
    a. **Clean Fuel Standard**
        i. Between 2012-2016 annual costs will be about $27,780,000 to manufacturers[53]
3. Distribute inputs among identified REMI PI+ sectors.
    a. **Clean Fuel Standard**
        1. X6653—$27,780,000 annually from 2012-2016 for new parts to comply with regulation
        2. X7653—($27,780,000) annually from 2012-2016 (offset to ensure no value added since this is not from new sales but a need for technology)
        3. X7851—$27,780,0000 increase in production costs to auto manufacturers that are selling a final product to comply with standards
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **Clean Fuel Standard**
        i. 641—Consumer Spending (gas)
        ii. 78—Consumption reallocation (across all categories)
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **Clean Fuel Standard**
        i. Average annual reduction—2.05% in fuel use
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Clean Fuel Standard**
        i. Average fuel price per gallon (regular unleaded)[54]—$3.43 per gallon
        ii. Average Annual Miles Driven By Population[55]—13,041 miles

[53] "Clean Fuels Standard," *Northeast States for Coordinated Air Use Management*, accessed October 17, 2012.
[54] Daily Fuel Gauge Report--national, state and local average prices for gasoline, diesel and E-85. 11 Nov. 2011. Oil Price Information Service (OPIS). 11 Nov. 2011 <http://fuelgaugereport.aaa.com/?redirectto=http://fuelgaugereport.opisnet.com/index.asp>.

iii. Annual New Vehicle Registration in Maryland (2010)[56]—186,759 (total for cars and light trucks)
iv. Current CAFE standards for MPG(Light Vehicles)[57]—25.5 mpg (average)
v. Note: RESI will assume that new CAFE standards have not been implemented with year one of the policy and thus use current CAFE standards for policy analysis.

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2020-2025).
   a. **Clean Fuel Standard**
      i. 511.41 [(13,401 average miles driven annually by MD drivers / 25.5 average miles per gallon)]=average gas consumed annually by Maryland drivers
      ii. $1,754.14 per year [(13,041 miles in one year / 25.5 miles per gallon)] * [($3.43 per gallon of regular unleaded)]=average cost to new car owners in Maryland for gasoline
      iii. 10.48 [(13,041 miles in one year / 25.5 miles per gallon)]—[(13,041 miles in one year / 25.5 miles per gallon)] * [(2.05% reduction in gallons per year of fuel due to policy)]=savings in gasoline by consumer in gallons
      iv. 500.93 [(511.41 gallons used on average a year—10.48 gallons reduced from clean fuel policy)]=average gallons used in Maryland annually under new policy
      v. $1,718.18 [(500.91 gallons used annually under new policy * $3.43 average per gallon of regular unleaded fuel)]=average annual cost to new car owners in Maryland for gasoline
      vi. $35.96 [($1,754.14 per year on gas for new car owners in Maryland without policy - $1,718.18 per year on gas for new car owners in Maryland with policy)]=annual savings from on gas from implementation of new policy annually
      vii. 641—$6,715,838.37 [(186,759 total new registrations on all light vehicles annually * $35.96 average annual savings in gas from new policy implementation)]=total average annual savings for new vehicle purchases in gas in the state of Maryland from policy
      viii. 78—$6,715,838.37 [(Reallocation of savings across all other consumption categories)]
5. Input savings/costs by sector into REMI PI+ model and run impacts.

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[55] Average Annual Miles per Driver by Age Group. 4 April 2011. U.S. Department of Transportation (USDOT), Federal Highway Administration (FHA), Office of Highway Policy Information (OHPI). Web. 11 Nov. 2011. <http://www.fhwa.dot.gov/ohim/onh00/bar8.htm>.
[56] "Maryland Auto Outlook." Www.mdauto.org. 9 Aug. 2011. Maryland Automobile Dealers Association. 11 Nov. 2011 <http://www.mdauto.org/admin/publications/AutoOutlookQuarter22011.pdf>.
[57] Csere, Csaba. "How Automakers Will Meet 2016 CAFE Standards - Feature - Car and Driver." Car Reviews - 2011 Car Reviews and 2012 New Cars at Car and Driver. May 2011. Car and Driver. 11 Nov. 2011 <http://www.caranddriver.com/features/how-automakers-will-meet-2016-cafe-standards>.

6. Export impacts and analyze.

3.2.4 Transportation and Climate Initiative

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
    - **a. Transportation and Climate Initiative**
        - i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
    - **a. Transportation and Climate Initiative**
        - i. $15,000 annually for oversight of policy (data provided by MDE)
3. Distribute inputs among identified REMI PI+ sectors.
    - **a. Transportation and Climate Initiative**
        - i. 100% paid by government for administrative costs
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

No additional costs or benefits have been identified for this policy.

3.2.5 Public Transportation Initiatives

Investment Phase

1. Determine relevant REMI sectors for each program under the policy.
    - **a. Locally Operated Transit Systems**
        - i. 63—State Government Spending
        - ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
    - **b. Smart Card Implementation**
        - i. 63—State Government Spending
        - ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
    - **c. College Pass**
        - iii. 63—State Government Spending
        - iv. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
    - **b. Charm City Circulator and Hampden Neighborhood Shuttle**
        - i. 63—State Government Spending
        - ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
    - **c. Locally Operated Transit Systems**
        - i. 63—State Government Spending
        - ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
    - **d. Smart Card Implementation**
        - i. 63—State Government Spending
        - ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
    - **e. Transit Oriented Development**
        - i. 63—State Government Spending
        - ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects

   f. **Maryland Commuter Tax Credit**
      i. 63—State Government Spending
      ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   g. **Guaranteed Ride Home**
      i. 63—State Government Spending
      ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   h. **College Pass**
      i. 63—State Government Spending
      ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   i. **Ride Share**
      i. 63—State Government Spending
      ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   j. **Commuter Connections—Washington, D.C. Region**
      i. 63—State Government Spending
      ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   k. **Baltimore Collegetown Network**
      i. 63—State Government Spending
      ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   l. **Hunt Valley Shuttle**
      i. 63—State Government Spending
      ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   m. **Kent Street Transit Plaza**
      i. 63—State Government Spending
      ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   n. **University of Maryland College Park Carpool Program and Shuttle Bus Service**
      i. 63—State Government Spending
      ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
      iii.
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Charm City Circulator and Hampden Neighborhood Shuttle**
      i. $41,054,429
   b. **Locally Operated Transit Systems**
      i. $41,054,429
   c. **Smart Card Implementation**
      i. $41,054,429
   d. **Transit Oriented Development**
      i. $41,054,429
   e. **Maryland Commuter Tax Credit**
      i. $41,054,429
   f. **Guaranteed Ride Home**
      i. $41,054,429
   g. **College Pass**
      i. $41,054,429

- **h. Ride Share**
  - i. $41,054,429
- **i. Commuter Connections—Washington, D.C. Region**
  - i. $41,054,429
- **j. Baltimore Collegetown Network**
  - i. $41,054,429
- **k. Hunt Valley Shuttle**
  - i. $41,054,429
- **l. Kent Street Transit Plaza**
  - i. $41,054,429
- **m. University of Maryland College Park Carpool Program and Shuttle Bus Service**
  - i. $41,054,429

3. Distribute inputs among identified REMI sectors.
   - **a. Charm City Circulator and Hampden Neighborhood Shuttle**
     - i. 2010—$2,571,429
     - ii. 2011—$4,699,548
     - iii. 2012—$4,699,548
     - iv. 2013—$4,699,548
     - v. 2014—$4,699,548
     - vi. 2015—$4,699,548
     - vii. 2016—$4,699,548
     - viii. 2017—$2,571,429
     - ix. 2018—$2,571,429
     - x. 2019—$2,571,429
     - xi. 2020—$2,571,429
   - **b. Locally Operated Transit Systems**
     - i. 2010—$2,571,429
     - ii. 2011—$4,699,548
     - iii. 2012—$4,699,548
     - iv. 2013—$4,699,548
     - v. 2014—$4,699,548
     - vi. 2015—$4,699,548
     - vii. 2016—$4,699,548
     - viii. 2017—$2,571,429
     - ix. 2018—$2,571,429
     - x. 2019—$2,571,429
     - xi. 2020—$2,571,429
   - **c. Smart Card Implementation**
     - i. 2010—$2,571,429
     - ii. 2011—$4,699,548
     - iii. 2012—$4,699,548
     - iv. 2013—$4,699,548
     - v. 2014—$4,699,548
     - vi. 2015—$4,699,548

vii. 2016—$4,699,548
viii. 2017—$2,571,429
ix. 2018—$2,571,429
x. 2019—$2,571,429
xi. 2020—$2,571,429

d. Transit Oriented Development

i. 2010—$2,571,429
ii. 2011—$4,699,548
iii. 2012—$4,699,548
iv. 2013—$4,699,548
v. 2014—$4,699,548
vi. 2015—$4,699,548
vii. 2016—$4,699,548
viii. 2017—$2,571,429
ix. 2018—$2,571,429
x. 2019—$2,571,429
xi. 2020—$2,571,429

e. Maryland Commuter Tax Credit

i. 2010—$2,571,429
ii. 2011—$4,699,548
iii. 2012—$4,699,548
iv. 2013—$4,699,548
v. 2014—$4,699,548
vi. 2015—$4,699,548
vii. 2016—$4,699,548
viii. 2017—$2,571,429
ix. 2018—$2,571,429
x. 2019—$2,571,429
xi. 2020—$2,571,429

f. Guaranteed Ride Home

i. 2010—$2,571,429
ii. 2011—$4,699,548
iii. 2012—$4,699,548
iv. 2013—$4,699,548
v. 2014—$4,699,548
vi. 2015—$4,699,548
vii. 2016—$4,699,548
viii. 2017—$2,571,429
ix. 2018—$2,571,429
x. 2019—$2,571,429
xi. 2020—$2,571,429

g. College Pass

i. 2010—$2,571,429
ii. 2011—$4,699,548
iii. 2012—$4,699,548

iv. 2013—$4,699,548
v. 2014—$4,699,548
vi. 2015—$4,699,548
vii. 2016—$4,699,548
viii. 2017—$2,571,429
ix. 2018—$2,571,429
x. 2019—$2,571,429
xi. 2020—$2,571,429

h. Ride Share

i. 2010—$2,571,429
ii. 2011—$4,699,548
iii. 2012—$4,699,548
iv. 2013—$4,699,548
v. 2014—$4,699,548
vi. 2015—$4,699,548
vii. 2016—$4,699,548
viii. 2017—$2,571,429
ix. 2018—$2,571,429
x. 2019—$2,571,429
xi. 2020—$2,571,429

i. Commuter Connections—Washington, D.C. Region

i. 2010—$2,571,429
ii. 2011—$4,699,548
iii. 2012—$4,699,548
iv. 2013—$4,699,548
v. 2014—$4,699,548
vi. 2015—$4,699,548
vii. 2016—$4,699,548
viii. 2017—$2,571,429
ix. 2018—$2,571,429
x. 2019—$2,571,429
xi. 2020—$2,571,429

j. Baltimore Collegetown Network

i. 2010—$2,571,429
ii. 2011—$4,699,548
iii. 2012—$4,699,548
iv. 2013—$4,699,548
v. 2014—$4,699,548
vi. 2015—$4,699,548
vii. 2016—$4,699,548
viii. 2017—$2,571,429
ix. 2018—$2,571,429
x. 2019—$2,571,429
xi. 2020—$2,571,429

k. **Hunt Valley Shuttle**
   i. 2010—$2,571,429
   ii. 2011—$4,699,548
   iii. 2012—$4,699,548
   iv. 2013—$4,699,548
   v. 2014—$4,699,548
   vi. 2015—$4,699,548
   vii. 2016—$4,699,548
   viii. 2017—$2,571,429
   ix. 2018—$2,571,429
   x. 2019—$2,571,429
   xi. 2020—$2,571,429

l. **Kent Street Transit Plaza**
   i. 2010—$2,571,429
   ii. 2011—$4,699,548
   iii. 2012—$4,699,548
   iv. 2013—$4,699,548
   v. 2014—$4,699,548
   vi. 2015—$4,699,548
   vii. 2016—$4,699,548
   viii. 2017—$2,571,429
   ix. 2018—$2,571,429
   x. 2019—$2,571,429
   xi. 2020—$2,571,429

m. **University of Maryland College Park Carpool Program and Shuttle Bus Service**
   i. 2010—$2,571,429
   ii. 2011—$4,699,548
   iii. 2012—$4,699,548
   iv. 2013—$4,699,548
   v. 2014—$4,699,548
   vi. 2015—$4,699,548
   vii. 2016—$4,699,548
   viii. 2017—$2,571,429
   ix. 2018—$2,571,429
   x. 2019—$2,571,429
   xi. 2020—$2,571,429

4. Input investment by sector into REMI model and run impacts.
5. Export impacts and analyze.

Operation Phase

2. Determine relevant REMI sectors.
   a. **Charm City Circulator and Hampden Neighborhood Shuttle**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All Consumption Categories

iii. 651—Consumer Spending—Intercity bus
iv. 603—Consumer Spending—Other motor vehicles
v. 648—Consumer Spending—Auto insurance less claims paid

b. Locally Operated Transit Systems
i. 623—Consumer Spending—Gasoline and oil
ii. 78—Consumption Reallocation—All Consumption Categories
iii. 651—Consumer Spending—Intercity bus
iv. 603—Consumer Spending—Other motor vehicles
v. 648—Consumer Spending—Auto insurance less claims paid

c. Smart Card Implementation
i. 673—Consumer Spending—Bank service charges, trust services, and safe deposit box rentals
ii. 78—Consumption Reallocation—All Consumption Categories

d. Transit Oriented Development
i. 623—Consumer Spending—Gasoline and oil
ii. 78—Consumption Reallocation—All Consumption Categories

e. Maryland Commuter Tax Credit
i. 63—State Government Spending

f. Guaranteed Ride Home
i. 653—Consumer Spending—Taxicabs
ii. 78—Consumption Reallocation—All Consumption Categories
iii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects

g. College Pass
i. 623—Consumer Spending—Gasoline and oil
ii. 78—Consumption Reallocation—All Consumption Categories
iii. 651—Consumer Spending—Intercity bus

h. Ride Share
i. 623—Consumer Spending—Gasoline and oil
ii. 78—Consumption Reallocation—All Consumption Categories
iii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects

i. Commuter Connections—Washington, D.C. Region
i. 623—Consumer Spending—Gasoline and oil
ii. 78—Consumption Reallocation—All Consumption Categories

j. Baltimore Collegetown Network
i. 623—Consumer Spending—Gasoline and oil
ii. 78—Consumption Reallocation—All Consumption Categories

k. Hunt Valley Shuttle
i. 623—Consumer Spending—Gasoline and oil
ii. 78—Consumption Reallocation—All Consumption Categories

l. Kent Street Transit Plaza
i. 623—Consumer Spending—Gasoline and oil
ii. 78—Consumption Reallocation—All Consumption Categories
iii. 651—Consumer Spending—Intercity bus
iv. 648—Consumer Spending—Auto insurance less claims paid

   m. **University of Maryland College Park Carpool Program and Shuttle Bus Service**
      i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
      ii. 623—Consumer Spending—Gasoline and oil
      iii. 78—Consumption Reallocation—All Consumption Categories
      iv. 63—State Government Spending

3. Determine part of program to be affected by savings (from strategy write-up).
   a. **Charm City Circulator and Hampden Neighborhood Shuttle**
   b. **Locally Operated Transit Systems**
   c. **Smart Card Implementation**
   d. **Transit Oriented Development**
   e. **Maryland Commuter Tax Credit**
   f. **Guaranteed Ride Home**
   g. **College Pass**
   h. **Ride Share**
   i. **Commuter Connections—Washington, D.C. Region**
      i. Number using the commuter Connections Page[58]—20,000
      ii. Total Commuting to Work—20,000
   j. **Baltimore Collegetown Network**
   k. **Hunt Valley Shuttle**
   l. **Kent Street Transit Plaza**
   m. **University of Maryland College Park Carpool Program and Shuttle Bus Service**

4. Research savings data for each policy according to part of program to be affected by savings.
   a. **Charm City Circulator and Hampden Neighborhood Shuttle**
      i. **Hampden Neighborhood Shuttle**[59]
         1. Riders per Day—250
         2. Operating Days per Year—260
         3. Average Trip Length in Miles—2
         4. One Way Fare—$1.00 ($0.50 for Seniors)
         5. Reduction in CO2e in 2020 in mmt—0.0001
      ii. Charm City Circulator[60]
         1. Average Daily Ridership—11,955
      iii. Passenger Trips—69,315,249

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[58] Civilian Labor Force, Employment & Unemployment by Place of Residence (LAUS) - Maryland - Division of Workforce Development and Adult Learning. Welcome to the Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 21 Oct. 2011. Web. 14 Nov. 2011. <http://www.dllr.state.md.us/lmi/laus/maryland.shtml>.

[59] O'Malley, Martin, Anthony Brown, and Beverly Swaim-Staley. Maryland Department of Transportation, "Maryland Climate Action Plan." Last modified 2012. Accessed October 2012. http://www.mdot.maryland.gov/Office of Planning and Capital Programming/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf.

[60] Baltimore City Department of Transportation, "Month of October Ridership Stats." Last modified 2012. http://www.charmcitycirculator.org/news/2012/nov/month-october-ridership-stats.

iv. Number of Buses—698
v. Bus Fare—1.06
vi. Miles Traveled Annually by all Buses—22,414,441
vii. Average Annual Passengers—2,633,760

b. Locally Operated Transit Systems

i. Passenger Trips—69,315,249
ii. Number of Buses—698
iii. Bus Fare—$1.06

c. Smart Card Implementation

i. Number of Boardings (Rail)—71,311
ii. Number of Boardings (Bus)—231,795
iii. Percentage Rail—75%
iv. Percentage Bus—60%
v. Average ATM fee—$2.40
vi. Average Fare—$1.60

d. Transit Oriented Development

i. Number of Properties—6
ii. Potential Savings per Person—$9,087
iii. Potential Parking—1,245.33

e. Maryland Commuter Tax Credit

i. Number of Firms—18
ii. Number of Employees—950
iii. Average Tax Credit per Employee—$52.50

f. Guaranteed Ride Home

i. Mean Cost Per Claim[61]—$36.95
ii. Cost of Cab[62]—$161.80
iii. Number of Commuters in Baltimore—8,650.71

g. College Pass

i. Cost of Monthly Pass—$64.00
ii. Cost to College Students—$39.00
iii. Number of College Students in Collegetown Network—120,000
iv. Reduction in CO2e—0.0029 mmt CO2e

h. Ride Share

i. Average Daily Miles VMT[63]—$28.97
ii. Cost of Gas—$3.61
iii. Avg. MPG—27 mpg
iv. Number of those employed in MD[64]—2,771,833

[61] Menczer, William B. Journal of Public Transportation. 4th ed. Vol. 10. Ser. 2007. Guaranteed Ride Home Programs. Federal Transportation Administration. Web. 14 Nov. 2011. <http://www.nctr.usf.edu/jpt/pdf/JPT%2010-4%20Menczer.pdf>.
[62] Taxi Fares in Major U.S. Cities. Schaller Consulting Home Page. Schaller Consulting, Jan. 2006. Web. 14 Nov. 2011. <http://www.schallerconsult.com/taxi/fares1.htm>.
[63] 2009 National Household Travel. National Household Travel Survey. U.S. Department of Transportation, 2009. Web. 14 Nov. 2011. <http://nhts.ornl.gov/2009/pub/stt.pdf>.

v. Reduction in CO2e—0.0207 mmt CO2e[65]

i. **Commuter Connections—Washington, D.C. Region**
   i. Average Daily Miles VMT[66]—$28.97
   ii. Cost of Gas—$3.61
   iii. Avg. MPG—27

j. **Baltimore Collegetown Network**
   i. Total Students—74,000
   ii. Number of Buses—698
   iii. Bus Fare—$1.06
   iv. Miles traveled annually by All Buses[67]—14
   v. Average Annual Passengers—74,000

k. **Hunt Valley Shuttle**
   i. Insurance Premium—$922
   ii. Travel Distance from York to Hunt Valley—37.1
   iii. Avg. MPG—27
   iv. Cost of Gas—$3.61
   v. Time—1
   vi. One Month Pass[68]—$136.00
   vii. Time—2
   viii. Total One Way Ridership[69]—17,333

l. **Kent Street Transit Plaza**
   i. Cost of Monthly Pass[70]—$64
   ii. Cost of Gas—$3.61
   iii. Length of Track—15.5 miles
   iv. Average Annual Ridership—8,650.71
   v. Average Cost of Gas—$3.61
   vi. Average MPG—27
   vii. Annual Congestion Cost—$713
   viii. Average Cost of Insurance[71]—$922

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[64] Civilian Labor Force, Employment & Unemployment by Place of Residence (LAUS) - Maryland - Division of Workforce Development and Adult Learning. Welcome to the Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 21 Oct. 2011. Web. 14 Nov. 2011. <http://www.dllr.state.md.us/lmi/laus/maryland.shtml>.

[65] O'Malley, Martin, Anthony Brown, and Beverly Swaim-Staley. Maryland Department of Transportation, "Maryland Climate Action Plan." Last modified 2012. Accessed October 2012. http://www.mdot.maryland.gov/Office of Planning and Capital Programming/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf.

[66] 2009 National Household Travel. National Household Travel Survey. U.S. Department of Transportation, 2009. Web. 14 Nov. 2011. <http://nhts.ornl.gov/2009/pub/stt.pdf>.

[67] Colleges - Miles and Minutes. 2011. Baltimore Collegetown Network. 14 Nov. 2011 <http://www.baltimorecollegetown.org/colleges/miles-and-minutes/>.

[68] RabbitEXPRESS – Fares and Accommodations. Rabbittransit - Welcome! York County Transportation Authority, 2011. Web. 14 Nov. 2011. <http://www.rabbittransit.org/express/pages/cashfarechart.html>.

[69] 2010 Annual Report. Rabbittransit-Welcome. Rabbittransit, 2011. Web. 14 Nov. 2011. <http://www.rabbittransit.org/docs/2010_Annual_Report.pdf>.

[70] Regular Fares | Maryland Transit Administration. Home | Maryland Transit Administration. Maryland Transit Administration, 14 Nov. 2011. Web. 14 Nov. 2011. <http://mta.maryland.gov/regular-fares>.

m. **University of Maryland College Park Carpool Program and Shuttle Bus Service**
    i. Number of Annual Riders[72]—2,967,164
    ii. Cost of Shuttle—$0.00
    iii. Parking Spots[73]—19,270
    iv. Number of Permits[74]—17,906
    v. Revenue from Permit Sales[75]—$8,030,897.00
    vi. Annual Citations[76]—72,546
    vii. Annual Revenue from Citations—$1,862,333.00
    viii. Total Enrollment—37,631
    ix. Total Employment—13,081
    x. Total Residing On Campus[77]—8,363
    xi. Commuter Student Permit Price—$217.00

5. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
    a. **Charm City Circulator and Hampden Neighborhood Shuttle**
        i. 65,000 [250 Daily Riders * 260 Operating Days]:=Total Rides Per Year
        ii. 651—Consumer Spending—All Categories—$48,750 [Total Rides per Year * $0.75 Fare (assume half of riders are seniors)]:=Total Fare Revenue Per Year for Hampden Shuttle from (applied from years 2010 to 2020)
        iii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Categories—$40,582.15 [0.001 mmt CO2e * 405,821,147.4 (conversion factor[78])]:=Fuel Savings from CO2e Reduction from Hampden Shuttle
        iv. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Categories—$7,579,812.60 [11,955 Daily Riders * 365 * (1/27 Avg. MPG) * $3.61 per Gallon of Gas = Dollars of Fuel Saved by Riders of Charm City Circulator
        v. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Categories—$276,131.58 [11,955 Daily Riders * 365 *2 minutes Idle Time per Trip (saved) * 0.03164 (conversion

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[71] Auto Insurance. Insurance Information Institute. U.S. Department of Labor, Bureau of Labor Statistics; National Association of Realtors, 2011. Web. 11 Nov. 2011. <http://www.iii.org/media/facts/statsbyissue/auto/>.
[72] Departmental Mission Statement. Department of Transportation. University of Maryland, 2011. Web. 14 Nov. 2011. <http://www.transportation.umd.edu/images/about/pdfs/ANNUAL%20REPORT%20FY%2011.pdf>.
[73] Ibid.
[74] Ibid.
[75] Ibid.
[76] Ibid.
[77] Residence Halls at a Glance. Department of Resident Life | University of Maryland, College Park. Department of Resident Life | University of Maryland, College Park, 2011. Web. 14 Nov. 2011. <http://www.resnet.umd.edu/hallsatglance/>.
[78] Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator." Last modified 2012. Accessed October 2012. http://www.epa.gov/cleanenergy/energy-resources/calculator.html.

factor[79])]:=Value of Fuel Saved from Avoided Idle Time by Charm City Circulator Users

vi. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Categories—$1,981,063.05 [11,955 Daily Riders * 365 * $0.454 Non-Fuel Driving Cost Per Mile (savings)]:=Total Non-Fuel Driving Cost Savings

b. Locally Operated Transit Systems

i. 99,306 [(69,315,249 Passenger Trips / 698 Number of Buses)]=Total Average per Bus

ii. 651—Consumer Spending—Intercity bus—$5,157,928.41 [(99,306 Total Average per Bus * $1.06 Bus Fare * 49)]=Total Yearly Fare Revenue from 2010 to 2020

c. Smart Card Implementation

i. 171,146.40 [((71,311 Number of Rail Boardings * 0.75) * ($1.60 Average Fare * 2))]=Total Annual Boards (Rail/Smart Card)

ii. 445,046.40 [((231,795 Number of Bus Boardings * 0.60) * ($1.60 Average Fare * 2))]=Total Annual Boards (Bus/Smart Card)

iii. $410,751.36 [((71,311 Number of Rail Boardings * 0.75) * ($1.60 Average Fare * 2) * $2.40 Average ATM fee)]=Total Annual Boards (Rail)

iv. $1,068,111.36 [((231,795 Number of Bus Boardings * 0.60) * ($1.60 Average Fare * 2) * $2.40 Average ATM fee)]=Total Annual Boards (Bus)

v. $239,604.96 [($410,751.36 Total Annual Boards (Rail) - $171,146.40 Total Annual Boards (Rail/Smart Card))]=Annual Savings for Rail

vi. $623,064.96 [($1,068,111.36 Total Annual Boards (Bus) - $445,046.40 Total Annual Boards (Bus/Smart Card))]=Annual Savings for Bus

vii. $862,669.92 [($239,604.96 Annual Savings for Rail + $623,064.96 Annual Savings for Bus)]=Total Annual Savings

viii. 673—Consumer Spending—Bank service charges, trust services, and safe deposit box rentals, 78—Consumption Reallocation—All Consumption Categories—
$862,669.92 [($239,604.96 Annual Savings for Rail + $623,064.96 Annual Savings for Bus)]=Total Annual Savings per Year from 2010 to 2020

d. Transit Oriented Development

i. $11,316,344.00 [($9,087 Potential Savings per Person * 1,245.33 Potential Parking)]=Total Potential Savings

ii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$11,316,344.00 [($9,087

[79] O'Malley, Martin, Anthony Brown, and Beverly Swaim-Staley. Maryland Department of Transportation, "Maryland Climate Action Plan." Last modified 2012. Accessed October 2012. http://www.mdot.maryland.gov/Office of Planning and Capital Programming/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf.

Potential Savings per Person * 1,245.33 Potential Parking)]=Total Potential Savings per Year from 2010 to 2020

e. Maryland Commuter Tax Credit

i. $598,500.00 [(950 Number of Employees * 52.5 Average Tax per Employee * 12)]=Total of tax credits

ii. 63—State Government Spending—$598,500.00 [(950 Number of Employees * 52.5 Average Tax per Employee * 12)]=Total Value of Tax Credits per Year for the years 2010 to 2020

f. Guaranteed Ride Home

i. $124.85 [(%161.80 Cost of Cab - $36.95 Mean Cost Per Claim)]=Savings

ii. $1,080,041.06 [(8650.71 Number of Commuters in Baltimore * $124.85 Savings)]=Savings to Commuters

iii. 653—Consumer Spending—Taxicabs, 78—Consumption Reallocation—All Consumption Categories—63—State Government Spending$1,080,041.06 [(8650.71 Number of Commuters in Baltimore * $124.85 Savings)]=Savings to Commuters per Year from 2010 to 2020

g. College Pass

i. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$1,176,881.33 [0.0029 mmt CO_2e * Conversion Factor[80]]= Fuel Savings to Consumers from Reduced Idling Time per Year from 2011 to 2020

ii. 63—State Government Spending—$36,000,000 [(120,000 Number of College Students in Collegetown Network * 12 * ($64.00-$39.00) Subsidized Cost of a Monthly Pass)]=Investment in College Pass per Year from 2010 to 2020

iii. 651—Consumer Spending—Intercity bus—$4,468,000.00 [(120,000 Number of College Students in Collegetown Network * $39.00 Cost of a College Students)]= Increase in Fare Revenue Associated With College Pass

iv. $7,680,000.00 [(120,000 Number of College Students in Collegetown Network * $64.00 Cost of a Monthly Pass)]=Value of Monthly Passes Before Subsidy

v. 651—Consumer Spending—Intercity—bus $4,468,000.00 [(120,000 Number of College Students in Collegetown Network * $39.00 Cost of a College Students)]=Value of Monthly Passes After Subsidy

vi. $3,000,000.00 [($7,680,000.00 - $4,468,000.00)]=Total Monthly Value of Subsidy

vii. 78—Consumption Reallocation—All Consumption Categories—$36,000,000 [($7,680,000.00 - $4,468,000.00)*12]=Yearly Value of Subsidy from 2011 to 2020

[80] Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator." Last modified 2012. Accessed October 2012. http://www.epa.gov/cleanenergy/energy-resources/calculator.html.

h. Ride Share

i. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$24,552,178.61 [0.0605 mmt CO2e * Conversion Factor] = Fuel Savings from CO2e Reduction in 2020
ii. 63—State Government Spending—$720,833.33 [$4,324,999.98 Total Cost of Implementation in Operations Phase]=Yearly Cost of Implementation from 2011 to 2016

i. Commuter Connections—Washington, D.C. Region

i. 1.07 [(28.97 Average Daily Miles VMT / 27 Avg. MPG)]=Gallons Used Daily
ii. $3.86 [(1.07 Gallons Used Daily * $3.61 Cost of Gas)]=Price to Travel Daily
iii. $77,205.85 [(20,000 Total Commuting to Work * $3.86 Price to Travel Daily)]=Total Cost to Those Commuting by Car
iv. $38,602.93 [($77,205.85 Total Cost to Those Commuting by Car / 2)]=Price of Gas per Car, if carpooling 2 to a car
v. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$38,602.93 [($77,205.85 Total Cost to Those Commuting by Car - $38,602.93 Price of Gas per Car, if carpooling 2 to a car)]=Savings per Year from 2010 to 2020

j. Baltimore Collegetown Network

i. 106 [(74,000 Total Students / 698 Number of Buses)]=Total Average per Bus
ii. $5,506.53 [(106 Total Average per Bus * $1.06 Bus Fare * 49)]=Total Average Bus Fare
iii. 4,140 [((14 Miles traveled annually by All Buses * 2) * 150)]=Average Miles Traveled by all Buses
iv. 153 [(4,140 Average Miles Traveled by all Buses / 27)]=Average Gallons Used
v. $553.26 [(153 Average Gallons Used * $3.61)]=Average Cost of Sedan
vi. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$40,941,240 [(74,000 Average Annual Passengers * 526 Average Cost of Sedan)]=Average Savings to College Students

k. Hunt Valley Shuttle

i. $2.75 [((37.1 Travel Distance from York to Hunt Valley * 2) / 27 Avg. MPG)]=Total Cost on Trip Up and Back
ii. $9.43 [($2.75 Total Cost on Trip Up and Back * $3.61 Cost of Gas)]=Total Cost on Trip
iii. $4,296.56 [(($9.43 Total Cost on Trip * (365 - 7)) + $922 Insurance Premium)]=Annual Cost to Travel by Car
iv. 7.25 [((2—1) * 7.25)]=Time Value
v. $4,227.50 [((136 * 12 months) + (7.25 Time Value * (365—7))]=Annual Cost to Travel by Bus

vi. $69.06 [($4,296.56 Annual Cost to Travel by Car - $4,227.50 Annual Cost to Travel by Bus)]=Savings
vii. 34,666 [(17,333 Total One Way Ridership * 2)]=Both Way Assumption
viii. 11,555.33 [(34,666 Both Way Assumption / 3)]=Three Routes
ix. 11,555.33 [(34,666 Both Way Assumption / 3)]=Avg. Rider for 83S Route
x. $798,023.30 [(11,555.33 Avg. Rider for 83S Route * $69.06 Savings)]=Total Savings
xi. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$829,911.87 [(11,555.33 Avg. Rider for 83S Route * $69.06 Savings)]=Total Savings

l. Kent Street Transit Plaza

i. $768 [($64 Cost of a Monthly Pass * 12)]=Cost of a Pass for a Year
i. 651—Consumer Spending—Intercity bus—$6,643,745.28 [($768 Cost of a Pass for a Year * 8,650.71 Riders per Year)]=Total Fare Spending per Year from 2010 to 2020
ii. 617.91 [(8,650.71 Average Annual Ridership / 14)]=Per Station
iii. 0.57 [(15.5 Length of Track / 27 Average MPG)]=Average Gallons Needed to Travel per Day
iv. $751.06 [((0.57 Average Gallons Needed to Travel per Day * $3.61 Average Cost of Gas) * 365)]=Average Cost of Gas a Year
v. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$464,087.79 [($751.06 * 617.91)]=Total Value of Fuel Savings per Year from 2010 to 2020
vi. 648—Consumer Spending—Auto insurance less claims paid, 78—Consumption Reallocation—All Consumption Categories—$569,713.02 [(617.91 Riders * $922 Average Cost of Insurance)]=Cost to Travel Annual from 2010 to 2020

m. University of Maryland College Park Carpool Program and Shuttle Bus Service

i. $448.50 [($8,030,897.00 Revenue from Permit Sales / 17,906 Number of Permits)]=Avg. Cost of Permit
ii. $25.67 [($1,862,333.00 Annual Revenue from Citations / 72,546 Annual Citations)]=Avg. Cost of Citation
iii. $474.17 [($448.50 Avg. Cost of Permit + $25.67 Avg. Cost of Citation)]=Avg. Cost to Drive to Campus
iv. 50,712 [(37,631 Total Enrollment + 13,081 Total Employment)]=Total Population
v. 30,907.96 [(((2,967,164 / 12 months) / 4 weeks) / 2 times a day)]=Total Riding Shuttle
vi. 19,804.04 [(50,712 Total Population - 30,907.96 Total Riding Shuttle)]=Total Not Riding Shuttle
vii. 29,268 [(8,363 Total Residing On Campus—37,631 Total Enrollment)]=Total Not On Campus
viii. 42,349 [(29,268 Total Not On Campus + 13,081 Total Employment)]=People Commuting

ix. 24,443 [(42,349 People Commuting—17,906 Total Permit Holders)]=Non Permit Holders
x. $5.42 [(132,455 / 24,443 Non Permit Holders)]=Total Meter Costs Per Non Holder
xi. $76.19 [($1,862,333 Annual Revenue from Citations / 24,443 Non Permit Holders)]=Citation Costs Per Non Holder
xii. $32.27 [($788,824 / 24,443 Non Permit Holders)]=Affiliate Costs for Non Permit
xiii. $113.88 [($5.42 Total Meter Costs Per Non Holder + $76.19 Citation Costs Per Non Holder + $32.27 Affiliate Costs for Non Permit)]=Total Possible Cost to Non Permit Holder
xiv. $6,351,156.00 [($217 Commuter Student Permit Price * 29,268 Total Not on Campus)]=Total Cost to Commute
xv. $3,175,578.00 [($6,351,156.00 Total Cost to Commute / 2)]=If Commuter Students Carpool, 2 to each car
xvi. 623—Consumer Spending—Gasoline and oil, 603—Consumer Spending—Other motor vehicles—$3,175,578.00 [($6,351,156.00 Total Cost to Commute - $3,175,578.00 If Commuter Students Carpool, 2 to each car)]=Savings
xvii. 623—Consumer Spending—Gasoline and oil—78—Consumption Reallocation—All Consumption Categories—$73,562.96 [42,349 Commuters * 0.5 (result of carpooling) * 13 Avg. Commute Miles * 2 Ways * (1/27 Avg. MPG) * $3.61]:= Value of Gasoline Savings to Commuters per Year from 2010 to 2020

6. Input savings by sector into REMI model and run impacts.
7. Export impacts and analyze.

3.2.6 Initiatives to Double Ridership by 2020

Investment Phase

1. Determine relevant REMI sectors for each program under the policy.
   a. **MARC East Baltimore Station**
      i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   b. **Expanded Transit (Purple Line, Corridor Cities Transitway, Red Line)**
      i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   c. **MARC Growth and Investment Plan**
      i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
2. Determine overall cost of policy implementation for each program under the policy.
   a. **MARC East Baltimore Station**
      i. $11,974,417 per year from 2015—2020
   b. **Expanded Transit (Purple Line, Corridor Cities Transitway, Red Line)**
      i. $290,900,000 per Year from 2011 - 2020

- **c. MARC Growth and Investment Plan**
    - i. $82,750,000 per year (2012-2020)

3. Input investment by sector into REMI model and run impacts.
4. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI sectors.
    - **a. MARC East Baltimore**
        - i. 652—Intercity Mass Transit
        - ii. 648—Consumer Spending—Auto insurance less claims paid
        - iii. 603—Consumer Spending—Other motor vehicles
        - iv. 78—Consumption Reallocation—All Consumption Categories
    - **b. Expanded Transit (Purple Line, Corridor Cities Transitway, Red Line)**
        - i. 652—Intercity Mass Transit
        - ii. 648—Consumer Spending—Auto insurance less claims paid
        - iii. 603—Consumer Spending—Other motor vehicles
        - iv. 78—Consumption Reallocation—All Consumption Categories
    - **c. MARC Growth and Investment Plan**
        - i. 652—Intercity Mass Transit
        - ii. 648—Consumer Spending—Auto insurance less claims paid
        - iii. 603—Consumer Spending—Other motor vehicles
        - iv. 78—Consumption Reallocation—All Consumption Categories
2. Determine part of program to be affected by savings (from strategy write-up).
    - **a. MARC East Baltimore Station**
    - **b. Expanded Transit (Purple Line, Corridor Cities Transitway, Red Line)**
    - c. **MARC Growth and Investment Plan**
3. Research savings data for each policy according to part of program to be affected by savings.
    - **a. MARC East Baltimore Station**
        - i. Number of Annual Passengers on Metro[81]—8,095,577
        - ii. Number of Stations[82]—40
        - iii. Average Cost of Gas—$3.61
        - iv. Average Annual Miles Traveled—774,575,600
        - v. Average Miles Per Gallon of Sedan—27
        - vi. Average Cost of Monthly MARC Pass—$349.00
    - **b. Expanded Transit (Purple Line, Corridor Cities Transitway, Red Line)**
        - i. Cost of Daily Pass[83]—$3.50
        - ii. Cost of gas—$3.61

[81] National Transit Information. National Transit Database. National Transit Database, 2011. Web. 14 Nov. 2011. <http://www.ntdprogram.gov/ntdprogram/cs?action=showRegionAgencies&region=3>.
[82] MARC Station Information | Maryland Transit Administration. Home | Maryland Transit Administration. Maryland Transit Administration, 14 Nov. 2011. Web. 14 Nov. 2011. <http://mta.maryland.gov/marc-station-information>.
[83] Regular Fares | Maryland Transit Administration. Home | Maryland Transit Administration. Maryland Transit Administration, 14 Nov. 2011. Web. 14 Nov. 2011. <http://mta.maryland.gov/regular-fares>.

iii. Length of Track—15.5
iv. Average Annual Ridership—8,650.71
v. Average cost of gas—$3.61
vi. Average MPG—27
vii. Annual Congestion Cost—713
viii. Average Cost of Insurance[84]—922
ix. Red Line Weekly Ridership in 2030—57,000
x. Purple Line Annual Net Boardings in 2030—16,500,000

c. **MARC Growth and Investment Plan**
   i. Number of Annual Passengers—8,095,577
   ii. Number of Stations—40
   iii. Added by 2035[85]—130,000
   iv. Current Seats[86]—27,000
   v. Miles Travel Annually—774,575,600
   vi. Cost of Gas—$3.61
   vii. Average Per MPG—27
   viii. Cost of Monthly Pass—$349.00

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **Expanded Transit (Purple Line, Corridor Cities Transitway, Red Line)**
      i. 652—Intercity Mass Transit– $25,467,681.50 [$22,376,891.33 Net Fare Revenue per Year for Red Line[87] from 2020—2025 + $3,090,790.17 Net Fare Revenue per Year for Purple Line[88] from 2020—2025]=Total Net Increase in Fare Revenue per Year 2020—2025
      ii. $3,090,790.17[(45,851.65 Rides per Week in 2020 * $3.61 Gas Price * 13 Average Miles per Vehicle Trip) / (1.34 Average Passengers per Trip * 27 Average Miles per Gallon for Sedan)]=Value of Fuel Saved by Purple Line Riders in 2020 (note: riders increase by 21,285 per year until 20205)
      iii. $4,143,935.03 [61,475 Riders per Week in 2020 * $3.61 Gas Price * 13 Average Miles per Vehicle Trip) / (1.34 Average Passengers per Trip * 27 Average Miles per Gallon for Sedan)]=Value of Fuel Saved by Red Line Riders in 2020
      iv. $29,744,122.36 [441,251 Riders per Week in 202011 * $3.61 Gas Price * 13 Average Miles per Vehicle Trip) / (1.34 Average Passengers per Trip *

[84] Auto Insurance. Insurance Information Institute. U.S. Department of Labor, Bureau of Labor Statistics; National Association of Realtors, 2011. Web. 11 Nov. 2011. <http://www.iii.org/media/facts/statsbyissue/auto/>.
[85] MARC Growth and Investment Plan. Maryland Transit Administration. Maryland Transit Administration, Sept. 2007. Web. 14 Nov. 2011. <http://mta.maryland.gov/sites/default/files/marcplanfull.pdf>.
[86] Ibid.
[87] Maryland Transit Administration, "Red Line Financial Plan Synopsis." Last modified 2012. Accessed October 2012.http://www.baltimoreredline.com/images/stories/redline_documents/preliminary_engineering/04_financial_plan/01_Financial_Plan_Synopsis.pdf.
[88] Maryland Transit Administration, "Purple Line Financial Plan." Last modified 2012. Accessed October 2012. http://dlslibrary.state.md.us/publications/JCR/2010/2010_61(PL).pdf.

27 Average Miles per Gallon for Sedan)]=Value of Fuel Saved by MARC Riders in 2020

v. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$36,978,847.56 [$3,090,790.17 Purple Line Fuel Savings + $4,143,935.03 Red Line Fuel Savings + $29,744,122.36 MARC Growth and Investment Plan]=Total Fuel Savings in 2020

vi. 648—Consumer Spending—Auto insurance less claims paid, 78—Consumption Reallocation—All Consumption Categories—$7,039,894.07 [(45,851.65 Rides per Week in 2020 * 13 Average Miles per Vehicle Trip * 52 Weeks * $0.23 Insurance Cost per Mile[89]) / (1.34 Average Passengers per Trip)=Value of Insurance Saved by Purple Line Riders in 2020 (note: riders increase by 21,285 per year until 2025)

vii. 648—Consumer Spending—Auto insurance less claims paid, 78—Consumption Reallocation—All Consumption Categories—$5,250,766.53 [(61,475 Rides per Week in 2020 * 13 Average Miles per Vehicle Trip * 52 Weeks * $0.23 Insurance Cost per Mile[90]) / (1.34 Average Passengers per Trip)=Value of Insurance Saved by Red Line Riders in 2020

viii. 648—Consumer Spending—Auto insurance less claims paid, 78—Consumption Reallocation—All Consumption Categories—$50,531,198.49 [(441,251 Rides per Week in 2011 * 13 Average Miles per Vehicle Trip * 52 Weeks * $0.23 Insurance Cost per Mile[91]) / (1.34 Average Passengers per Trip)=Value of Insurance Saved by MARC Riders in 2011

ix. 603—Consumer Spending—Other motor vehicles, 78—Consumption Reallocation—All Consumption Categories—$7,039,894.07 [(45,851.65 Rides per Week in 2020 * 13 Average Miles per Vehicle Trip * 52 Weeks * $0.23 Insurance Cost per Mile[92]) / (1.34 Average Passengers per Trip)=Value of Driving (Less Insurance and Fuel) Saved by Purple Line Riders in 2020 (note: riders increase by 21,285 per year until 2025)

x. 603—Consumer Spending—Other motor vehicles, 78—Consumption Reallocation—All Consumption Categories—$5,250,766.53 [(61,475 Rides per Week in 2020 * 13 Average Miles per Vehicle Trip * 52 Weeks * $0.23 Driving (Less Insurance and Fuel) Cost per Mile[93]) / (1.34 Average Passengers per Trip)=Value of Driving (Less Insurance and Fuel) Saved by Red Line Riders in 2020

xi. 603—Consumer Spending—Other motor vehicles, 78—Consumption Reallocation—All Consumption Categories—$50,531,198.49 [(441,251 Rides per Week in 2011 * 13 Average Miles per Vehicle Trip * 52 Weeks

[89] AAA Association Communication, "Your Driving Costs." Last modified 2012. Accessed October 2012. http://newsroom.aaa.com/wp-content/uploads/2012/04/YourDrivingCosts2012.pdf.
[90] Ibid.
[91] Ibid.
[92] Ibid.
[93] Ibid.

* $0.23 Driving (Less Insurance and Fuel) Cost per Mile[94]) / (1.34 Average Passengers per Trip)=Value of Driving (Less Insurance and Fuel) Saved by MARC Riders in 2011

5. Input savings by sector into REMI model and run impacts.
6. Export impacts and analyze.

3.2.7 Intercity Transportation Initiatives

Investment Phase

1. Determine relevant REMI sectors for each program under the policy.
    a. **MARC Station Parking Enhancements**
        i. 63—State Government Spending
        ii. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
    b. **Refurbishing MARC and Other Rail Vehicles**
        i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
    c. **Update on Maryland High Speed Rail**
        i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
2. Determine overall cost of policy implementation for each program under the policy.
    a. **MARC Station Parking Enhancements**
        i. 63—$4,385,158.50 in 2011
        ii. 68—$4,385,158.50 in 2011
        iii. 63—$4,530,541.50 per year 2012-2013
        iv. 68—$4,530,541.50 per year 2012-2013
        v. 63—$3,717,625 in 2014
        vi. 68—$3,717,625 in 2014
        vii. 63—$3,572,541.50 in 2014-2015
        viii. 68—$3,572,541.50 per year 2015-2016
    b. **Refurbishing MARC and Other Rail Vehicles**
        i. 63—$4,385,158.50 in 2011
        ii. 68—$4,385,158.50 in 2011
        iii. 63—$4,530,541.50 per year 2012-2013
        iv. 68—$4,530,541.50 per year 2012-2013
        v. 63—$3,717,625 in 2014
        vi. 68—$3,717,625 in 2014
        vii. 63—$3,572,541.50 in 2014-2015
        viii. 68—$3,572,541.50 per year 2015-2016
    c. **Update on Maryland High Speed Rail**
        i. No funding specified
3. Input investment by sector into REMI model and run impacts.
4. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI sectors.

[94] AAA Association Communication, "Your Driving Costs." Last modified 2012. Accessed October 2012. http://newsroom.aaa.com/wp-content/uploads/2012/04/YourDrivingCosts2012.pdf.

   a. **MARC Station Parking Enhancements**
      i. 652—Intercity Mass Transit
      ii. 623—Consumer Spending—Gasoline and oil
      iii. 648—Consumer Spending—Auto insurance less claims paid
      iv. 603—Consumer Spending—Other motor vehicles
   b. **Refurbishing MARC and Other Rail Vehicles**
      i. 652—Intercity Mass Transit
      ii. 623—Consumer Spending—Gasoline and oil
      iii. 648—Consumer Spending—Auto insurance less claims paid
      iv. 603—Consumer Spending—Other motor vehicles
   c. **Update on Maryland High Speed Rail**
      i. 652—Intercity Mass Transit

2. Determine part of program to be affected by savings (from strategy write-up).
   a. **MARC Station Parking Enhancements**
      i. Phase I—428 new parking spaces
      ii. Odenton station feasibility study—2,500 additional parking spaces
   b. **Refurbishing MARC and Other Rail Vehicles**
      i. 23 cars scheduled to be overhauled between FY 2005 and FY 2012
   c. **Update on Maryland High Speed Rail**
      i. $9.4 million allocation to MDOT for high-speed stimulus to complete environmental and engineering work to replace BWI Station as of Sept. 2010
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **MARC Station Parking Enhancements**
      i. Average cost of monthly MARC pass[95]—$349/month (Transit Link Card)
      ii. Average cost savings of using public transit[96]—$9,383/year for Baltimore City
      iii. Average cost of MARC station parking[97]—$6.39/day average (between 7 stations and not including outliers)
      iv. Note about Transit Link Card data use: A Monthly Transit Link pass is used in the calculations of all rail passes. Often users of the MARC system traveling in and around the metropolitan region of Maryland/Washington, D.C. will wish to visit areas within the city which are accessible through walking or easy-to-navigate light rail systems. Instead of purchasing separate fares for each point of travel, most individuals prefer having one card designated for travel within the region. The cost benefit ranges from easy parking to less time spent searching for dollars to pay for extra fare

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[95] MARC Train Service Order Form. CommuterDirect.com®. 2011. MARC. 14 Nov. 2011 <https://www.commuterpage.com/orderforms/transitorders_v3.cfm?sysid=12>.
[96] "Riding Public Transit Saves Individuals $9,242 Annually." APTA Homepage. 1 Dec. 2010. American Public Transportation Association (APTA). 14 Nov. 2011 <http://www.apta.com/mediacenter/pressreleases/2010/Pages/100112_Transit_Savings.aspx>.
[97] MARC Parking Details | Maryland Transit Administration. Home | Maryland Transit Administration. Nov. 2011. Maryland Transit Administration (MTA). 14 Nov. 2011 <http://mta.maryland.gov/marc-parking-details>.

cards or to add value to existing fare cards. The average cost of monthly fares for MARC has been calculated using the transit link pass over a span of stations from Aberdeen to Washington, D.C.

b. Refurbishing MARC and Other Rail Vehicles

i. Average cost of monthly MARC pass[98]—$349/month (Transit Link Card)
ii. Capacity of MARC train cars (single-level and bi-level)[99]—121 seats (average)
iii. Note about Transit Link Card data use: A Monthly Transit Link pass is used in the calculations of all rail passes. Often users of the MARC system traveling in and around the metropolitan region of Maryland/Washington, D.C. will wish to visit areas within the city which are accessible through walking or easy-to-navigate light rail systems. Instead of purchasing separate fares for each point of travel, most individuals prefer having one card designated for travel within the region. The cost benefit ranges from easy parking to less time spent searching for dollars to pay for extra fare cards or to add value to existing fare cards. The average cost of monthly fares for MARC has been calculated using the transit link pass over a span of stations from Aberdeen to Washington, D.C.

c. Update on Maryland High Speed Rail

i. Average cost of monthly MARC pass for BWI Rail Station between stations for Baltimore City and Washington, D.C[100].—$227/month (Transit Link Card)
ii. Number of parking spots at BWI Rail Station[101]—3,187 spots
iii. Cost of MARC station parking at BWI Rail Station[102]—$9/day
iv. Cost of BWI Garage (daily)[103]—$12/day
v. Note about Transit Link Card data use: A Monthly Transit Link pass is used in the calculations of all rail passes. Often users of the MARC system traveling in and around the metropolitan region of Maryland/Washington, D.C. will wish to visit areas within the city which are accessible through walking or easy-to-navigate light rail systems. Instead of purchasing separate fares for each point of travel, most individuals prefer having one card designated for travel within the region. The cost benefit ranges from easy parking to less time spent searching for dollars to pay for extra fare cards or to add value to existing fare cards. The average cost of fare for the

[98] MARC Train Service Order Form. CommuterDirect.com®. 2011. MARC. 14 Nov. 2011 <https://www.commuterpage.com/orderforms/transitorders_v3.cfm?sysid=12>.
[99] Dresser, Michael. "New cars may ease MARC crowding - Baltimore Sun." Featured Articles From The Baltimore Sun. 20 Aug. 2008. The Baltimore Sun. 14 Nov. 2011 <http://articles.baltimoresun.com/2008-08-20/news/0808190131_1_marc-new-cars-passenger-cars>.
[100] MARC Train Service Order Form. CommuterDirect.com®. 2011. MARC. 14 Nov. 2011 <https://www.commuterpage.com/orderforms/transitorders_v3.cfm?sysid=12>.
[101] MARC Parking Details | Maryland Transit Administration. Home | Maryland Transit Administration. Nov. 2011. Maryland Transit Administration (MTA). 14 Nov. 2011 <http://mta.maryland.gov/marc-parking-details>.
[102] Ibid.
[103] Parking. Baltimore Washington International Thurgood Marshall Airport. 11 Nov. 2011. < http://www.bwiairport.com/en/parking/information-rates/daily-garage>.

BWI Rail Station has been calculated under the assumption that most tourists will travel from BWI to Baltimore and BWI to Washington, D.C.

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **MARC Station Parking Enhancements**
      i. 652—Intercity Mass Transit—$12,262,464 [(428 new Phase I parking spots + 2,500 new Odenton parking spots (assume 1 vehicle parked per day) * $349/month (assume all buy monthly pass) * 12 months)]
      ii. 652–Intercity Mass Transit–$6,829,120.80 [((2,500 new Odenton parking spots + 428 Phase I parking spots)(assume 1 vehicle parked per day) * $6.39/day on average (assume all park at station garage) * 365 days)]=annual increase in revenue
      iii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$3,712,871.82 [(2,928 Passengers * 2 minutes idle per trip * 2 trips per Day * 365 trips per year * $0.032 conversion to $)]=Value of Fuel Saved per Year by Passengers
      iv. 648—Consumer Spending—Auto insurance less claims paid, 78—Consumption Reallocation—All Consumption Categories $6,307,585.44 [((2,928 passengers * 365 days * 2 trips * 13 miles)/1.34 average persons per vehicle trip) * $0.304 Insurance per Mile]=Value of Insurance Saved by Passengers per Year from 2015—2020
      v. 603—Consumer Spending—Other motor vehicles, 78—Consumption Reallocation—All Consumption Categories $6,307,585.44 [((2,928 passengers * 365 days * 2 trips * 13 miles)/1.34 average persons per vehicle trip) * $0.304 driving cost per mile less insurance less fuel]=Value of Driving Cost (less fuel less insurance) Saved by Passengers per Year from 2015—2020
   b. **Refurbishing MARC and Other Rail Vehicles**
      i. 652—Intercity Mass Transit—$11,655,204 [(23 cars refurbished (assume still in use in addition to newer cars) * 121 seats per car on average * $349/month (assume all buy monthly pass) * 12 months]=annual increase in revenue per year from 2010—2020
   c. **Update on Maryland High Speed Rail**
      i. 652—Intercity Mass Transit—$16,138,968 [(3,187 spots at BWI Rail Station (assume 1 vehicle parked per day) * $227/month (assume all buy monthly pass) * 12 months)] + [(3,187 spots at BWI Rail Station (assume 1 vehicle parked per day) * $9/day (assume all park at station) * 260 days)] = annual increase in revenue
      ii. 652—Intercity Mass Transit—$2,485,860 (3,187 spots at BWI Rail Station (assume 1 vehicle parked per day) *$3/day savings (comparing $12/day and $9/day parking fees) * 260 days = annual savings for riders)
5. Input savings by sector into REMI model and run impacts.
6. Export impacts and analyze.

3.2.8 Bike and Pedestrian Initiatives

Investment Phase

1. Determine relevant REMI sectors for each program under the policy.
   a. **Bicycle/Pedestrian Enhancements**
      i. 68—Government Spending Non-Pecuniary (Amenity)
   b. **Bike Racks on Buses, MARC, Subway, Light Rail**
      i. 68—Government Spending Non-Pecuniary (Amenity)
   c. **Construction of Bike Lanes and Bike Paths**
      i. 68—Government Spending Non-Pecuniary (Amenity)
   d. **East Coast Greenway**
      i. 68—Government Spending Non-Pecuniary (Amenity)
   e. **Bike Stations**
      i. 68—Government Spending Non-Pecuniary (Amenity)
   f. **Bike Rentals**
      i. 68—Government Spending Non-Pecuniary (Amenity)
   g. **Bike Racks**
      i. 68—Government Spending Non-Pecuniary (Amenity)
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Bicycle/Pedestrian Enhancements**
      ii. $19,168,800 per year 2012-2016
   h. **Bike Racks on Buses, MARC, Subway, Light Rail**
      i. *No funding specified*
   i. **Construction of Bike Lanes and Bike Paths**
      i. *No funding specified*
   j. **East Coast Greenway**
      i. *No funding specified*
   k. **Bike Stations**
      i. $32,081,600 in 2011
      ii. $26,787,930 per year 2012-2013
      iii. $24,743,270 in 2014
      iv. $23,201,600 in 2015
      v. $20,455,130 in 2016
      vi. $18,605,800 per year 2017-2020
   l. **Bike Rentals**
      i. $32,081,600 in 2011
      ii. $26,787,930 per year 2012-2013
      iii. $24,743,270 in 2014
      iv. $23,201,600 in 2015
      v. $20,455,130 in 2016
      vi. $18,605,800 per year 2017-2020
   m. **Bike Racks**
      i. $32,081,600 in 2011
      ii. $26,787,930 per year 2012-2013
      iii. $24,743,270 in 2014
      iv. $23,201,600 in 2015

- v. $20,455,130 in 2016
- vi. $18,605,800 per year 2017-2020

3. Input investment by sector into REMI model and run impacts.
4. Export impacts and analyze.

Operation Phase

2. Determine relevant REMI sectors.
   - **a. Bicycle/Pedestrian Enhancements**
     - i. 623—Consumer Spending—Gasoline and Oil
     - ii. 78—Consumption Reallocation—All Consumption Categories
   - **b. Bike Racks on Buses, MARC, Subway, Light Rail**
     - i. 623—Consumer Spending—Gasoline and Oil
     - ii. 78—Consumption Reallocation—All Consumption Categories
   - **c. Construction of Bike Lanes and Bike Paths**
     - i. 623—Consumer Spending—Gasoline and Oil
     - ii. 78—Consumption Reallocation—All Consumption Categories
   - **d. East Coast Greenway**
     - i. 623—Consumer Spending—Gasoline and Oil
     - ii. 78—Consumption Reallocation—All Consumption Categories
   - **e. Bike Stations**
     - i. 623—Consumer Spending—Gasoline and Oil
     - ii. 78—Consumption Reallocation—All Consumption Categories
   - **f. Bike Rentals**
     - i. 623—Consumer Spending—Gasoline and Oil
     - ii. 78—Consumption Reallocation—All Consumption Categories
   - **g. Bike Racks**
     - i. 623—Consumer Spending—Gasoline and Oil
     - ii. 78—Consumption Reallocation—All Consumption Categories
3. Determine part of program to be affected by savings (from strategy write-up)[104].
   - **a. Bicycle/Pedestrian Enhancements**
     - i. Total reduction achieved by 2020—57.14 metric tons of Co2
     - ii. Annual reduction over 10 years (2011—2020)—5.71 metric tons of Co2
   - **b. Bike Racks on Buses, MARC, Subway, Light Rail**
     - i. Total reduction achieved by 2020—57.14 metric tons of Co2
     - ii. Annual reduction over 10 years (2011—2020)—5.71 metric tons of Co2
   - **c. Construction of Bike Lanes and Bike Paths**
     - i. Total reduction achieved by 2020—57.14 metric tons of Co2
     - ii. Annual reduction over 10 years (2011—2020)—5.71 metric tons of Co2
   - **d. East Coast Greenway**
     - i. Total reduction achieved by 2020—57.14 metric tons of Co2

[104] O'Malley, Martin, Anthony Brown, and Beverly Swaim-Staley. Maryland Department of Transportation, "Maryland Climate Action Plan." Last modified 2012. Accessed October 2012. http://www.mdot.maryland.gov/Office of Planning and Capital Programming/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf.

   ii. Annual reduction over 10 years (2011—2020)—5.71 metric tons of Co2

   e. **Bike Stations**
      i. Total reduction achieved by 2020—57.14 metric tons of Co2
      ii. Annual reduction over 10 years (2011—2020)—5.71 metric tons of Co2

   f. **Bike Rentals**
      i. Total reduction achieved by 2020—57.14 metric tons of Co2
      ii. Annual reduction over 10 years (2011—2020)—5.71 metric tons of Co2

   g. **Bike Racks**
      i. Total reduction achieved by 2020—57.14 metric tons of Co2
      ii. Annual reduction over 10 years (2011—2020)—5.71 metric tons of Co2

4. Research savings data for each policy according to part of program to be affected by savings.
5. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).

   a. **Bicycle/Pedestrian Enhancements**
      i. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$16,232.85 [(400 metric tons CO2 * (1/1,000,000) * $405,821,147 Conversion[105] to $ Fuel)/10]=Value of Fuel Use Reductions in 2011 (note: Value of Fuel Use Reduction incrementally increases by $16,232.85 per year until $162,328 in 2020)

   b. **Bike Racks on Buses, MARC, Subway, Light Rail**
      i. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$16,232.85 [(400 metric tons CO2 * (1/1,000,000) * $405,821,147 Conversion to $ Fuel)/10]=Value of Fuel Use Reductions in 2011 (note: Value of Fuel Use Reduction incrementally increases by $16,232.85 per year until $162,328 in 2020)

   c. **Construction of Bike Lanes and Bike Paths**
      i. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$16,232.85 [(400 metric tons CO2 * (1/1,000,000) * $405,821,147 Conversion to $ Fuel)/10]=Value of Fuel Use Reductions in 2011 (note: Value of Fuel Use Reduction incrementally increases by $16,232.85 per year until $162,328 in 2020)

   d. **East Coast Greenway**
      i. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$16,232.85 [(400 metric tons CO2 * (1/1,000,000) * $405,821,147 Conversion to $ Fuel)/10]=Value of Fuel Use Reductions in 2011 (note: Value of Fuel Use

[105] All Conversions : Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator." Last modified 2012. Accessed October 2012. http://www.epa.gov/cleanenergy/energy-resources/calculator.html.

Reduction incrementally increases by $16,232.85 per year until $162,328 in 2020)

- **e. Bike Stations**
  - i. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$16,232.85 [(400 metric tons CO2 * (1/1,000,000) * $405,821,147 Conversion to $ Fuel)/10]=Value of Fuel Use Reductions in 2011 (note: Value of Fuel Use Reduction incrementally increases by $16,232.85 per year until $162,328 in 2020)
- **f. Bike Rentals**
  - i. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$16,232.85 [(400 metric tons CO2 * (1/1,000,000) * $405,821,147 Conversion to $ Fuel)/10]=Value of Fuel Use Reductions in 2011 (note: Value of Fuel Use Reduction incrementally increases by $16,232.85 per year until $162,328 in 2020)
- **g. Bike Racks**
  - i. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$16,232.85 [(400 metric tons CO2 * (1/1,000,000) * $405,821,147 Conversion to $ Fuel)/10]=Value of Fuel Use Reductions in 2011 (note: Value of Fuel Use Reduction incrementally increases by $16,232.85 per year until $162,328 in 2020)

6. Input savings by sector into REMI model and run impacts.
7. Export impacts and analyze.

3.2.9 Pricing Initiatives

Investment Phase

1. Determine relevant REMI sectors for each program under the policy.
   - **a. Electronic Toll Collection**
     - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   - **b. High Occupancy Toll Lanes**
     - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   - **c. VMT Fees**
     - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   - **d. Congestion Pricing and Managed Lanes**
     - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   - **e. Parking Impact Fees**
     - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
   - **f. Employer Commute Incentives**
     - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
2. Determine overall cost of policy implementation for each program under the policy.
   - **a. Electronic Toll Collection**
     - i. $15,004,210 per year 2011-2014

   b. **High Occupancy Toll Lanes**
      i. $15,004,210 per year 2011-2014
   c. **VMT Fees**
      i. $15,004,210 per year 2011-2014
   d. **Congestion Pricing and Managed Lanes**
      i. $15,004,210 per year 2011-2014
   e. **Parking Impact Fees**
      i. $15,004,210 per year 2011-2014
   f. **Employer Commute Incentives**
      i. $15,004,210 per year 2011-2014
3. Distribute inputs among identified REMI sectors.
4. Input investment by sector into REMI model and run impacts.
5. Export impacts and analyze.

Operation Phase

2. Determine relevant REMI sectors.
   a. **Electronic Toll Collection**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All Consumption Categories
   b. **High Occupancy Toll Lanes**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All Consumption Categories
   c. **VMT Fees**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All Consumption Categories
   d. **Congestion Pricing and Managed Lanes**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All Consumption Categories
   e. **Parking Impact Fees**
      i. 652—Intercity Mass Transit
   f. **Employer Commute Incentives**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All Consumption Categories
3. Determine part of program to be affected by savings (strategy write-up).
   a. **Electronic Toll Collection**
   b. **High Occupancy Toll Lanes**
   c. **VMT Fees**
   d. **Congestion Pricing and Managed Lanes**
   e. **Parking Impact Fees**
   f. **Employer Commute Incentives**
4. Research savings data for each policy according to part of program to be affected by savings.

a. **Electronic Toll Collection**
    i. Avg. Wait Time at Toll Booth Reduction[106]=2.5 minutes
    ii. Avg. Annual Commuters Passing Through Tolls [107]=153,800,000
    iii. Number of hours a year=8,765
    iv. Number of Tolls Booths in MD[108]=10
    v. Gas wasted in idle per year[109]=5,528,176.045
    vi. Assumed Price per Gallon of Gas=3.43
b. **High Occupancy Toll Lanes**
    i. Avg. Reduction in Time from HOT Lane[110]=2%
    ii. Current Congestion Time In MD (Total by Commuter Annually)[111]=34
    iii. Number of those employed in MD[112]=2,771,833
    iv. Assumed Price per Gallon of Gas =3.43
    v. Gas wasted in idle per minute Idle[113]=0.014377571
c. **VMT Fees**
    i. Net Annual Revenue Projections[114]=644.1 millions
d. **Congestion Pricing and Managed Lanes**
    i. Toll Lane Miles in MD[115]=3,140
    ii. Total that are congested[116]=30.40%
    iii. Gas wasted in idle per minute Idle[117]=0.014377571
    iv. Current Congestion Time In MD (Total by Commuter Annually)[118]=2,040 in min

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106 Saka, Anthony A., Dennis K. Agboh, Simon Ndiritu, and Richard A. Glassco. "An Estimation of Mobile Emissions Reduction." RITA | National Transportation Library. National Transportation Centre, Mar. 2000. Web. 14 Nov. 2011. <http://ntl.bts.gov/lib/16000/16800/16888/PB2000105915.pdf>.
107 MdTA Toll Facilities. MdTA Index. Maryland Transportation Authority, 2011. Web. 14 Nov. 2011. <http://www.mdta.maryland.gov/TollFacilities/facilities.html>.
108 Ibid.
109 ISDH: ISDH Home. IN.gov: Home. IN.gov. Web. 14 Nov. 2011. <http://www.in.gov/isdh/files/Idling_Brochure.>.
110 Baker, Michael, and Cambridge Systematics. "Maryland Climate Action Plan Draft 2012." Maryland Department of Transportation. Maryland Department of Transportation, 11 Apr. 2011. Web. 16 Nov. 2011. <http://www.mdot.maryland.gov/Planning/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf>.
111 Ibid.
112 Civilian Labor Force, Employment & Unemployment by Place of Residence (LAUS) - Maryland - Division of Workforce Development and Adult Learning. Welcome to the Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 21 Oct. 2011. Web. 14 Nov. 2011. <http://www.dllr.state.md.us/lmi/laus/maryland.shtml>.
113 ISDH: ISDH Home. IN.gov: Home. IN.gov. Web. 14 Nov. 2011. <http://www.in.gov/isdh/files/Idling_Brochure.>.
114 Baker, Michael, and Cambridge Systematics. "Maryland Climate Action Plan Draft 2012." Maryland Department of Transportation. Maryland Department of Transportation, 11 Apr. 2011. Web. 16 Nov. 2011. <http://www.mdot.maryland.gov/Planning/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf>.
115 Ibid.
116 Ibid.
117 ISDH: ISDH Home. IN.gov: Home. IN.gov. Web. 14 Nov. 2011. <http://www.in.gov/isdh/files/Idling_Brochure.>.

   v. Number of those that pass through a MD Toll Annually[119]= 207,530
   vi. Avg. Price of Gas=$3.61 (assumed)

e. **Parking Impact Fees**
   i. Daily Parking[120]=$0.75 average per hour
   ii. Assume 8 Hours=$6.00 (cost per day) (daily parking*8)
   iii. Number of those that work in the city of Baltimore[121]=1,289,169

f. **Employer Commute Incentives**
   i. Assume 15% of Employers in Metro Area provide Passes or something to employees[122]
   ii. Reduction in Annual VMT[123]=1,094,381
   iii. Avg. MPG=27 mpg
   iv. Avg. Assumed Price Per Gallon=$3.61 per gallon

5. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).

a. **Electronic Toll Collection**
   i. 384,500,000 [Avg. Annual Commuters Passing Through Tolls * Avg. Wait Time at Toll Booth Reduction]: = Total Number of Idle Minutes Saved per Year.
   ii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$121,165,780.71 [Total Number of Idle Minutes Saved per Year * 0.0316 (conversion factor)]: = $19,944,277.13

b. **High Occupancy Toll Lanes**
   i. Current Congestion Time in MD (Total by Commuter Annually Mins)=2,040 (Current Congestion Time In MD (Total by Commuter Annually)*60)

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118 Baker, Michael, and Cambridge Systematics. "Maryland Climate Action Plan Draft 2012." Maryland Department of Transportation. Maryland Department of Transportation, 11 Apr. 2011. Web. 16 Nov. 2011. <http://www.mdot.maryland.gov/Planning/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf>.

119 Civilian Labor Force, Employment & Unemployment by Place of Residence (LAUS) - Maryland - Division of Workforce Development and Adult Learning. Welcome to the Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 21 Oct. 2011. Web. 14 Nov. 2011. <http://www.dllr.state.md.us/lmi/laus/maryland.shtml>.

120 Documents – Resource Types – SFpark. SFpark. Municipal Transportation Agency, 2011. Web. 16 Nov. 2011. <http://sfpark.org/resource-type/documents/>

121 Civilian Labor Force, Employment & Unemployment by Place of Residence (LAUS) - Maryland - Division of Workforce Development and Adult Learning. Welcome to the Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 21 Oct. 2011. Web. 14 Nov. 2011. <http://www.dllr.state.md.us/lmi/laus/maryland.shtml>.

122 Baker, Michael, and Cambridge Systematics. "Maryland Climate Action Plan Draft 2012." Maryland Department of Transportation. Maryland Department of Transportation, 11 Apr. 2011. Web. 16 Nov. 2011. <http://www.mdot.maryland.gov/Planning/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf>.

123 Ibid.

ii. Total Yearly Congestion For those Passing Through MD tolls=5,654,539,320 (Current Congestion Time in MD (Total by Commuter Annually Mins)* Number of those employed in MD)
iii. If HOT Lanes Enforced, Avg. Annual Time Reduced=106,022,612.3 (Avg. Reduction in Time from HOT Lane*Current Congestion Time in MD [(Total by Commuter Annually Mins))*(Number of those employed in MD)]
iv. IF HOT Lanes enforced, new avg. annual congestion time=5,548,516,708 (Total Yearly Congestion For those Passing Through MD tolls-If HOT Lanes Enforced, Avg. Annual Time Reduced)
v. Amount Wasted on Time a Year (mins) =5,654,539,320 (Current Congestion Time in MD (Total by Commuter Annually Mins)* (Number of those employed in MD))
vi. Amount Wasted on Time a Year - WITH HOT LANES (mins)=5,548,516,708 [(Current Congestion Time in MD (Total by Commuter Annually Mins)- Current Congestion Time in MD (Total by Commuter Annually Mins)* Avg. Reduction in Time from HOT Lane))* (Number of those employed in MD)]
vii. Amount of Gas Wasted Without HOT Lanes=81,298,540.48 [(Amount Wasted on Time a Year (mins)* Gas wasted in idle per minute Idle)]
viii. Amount of Gas Wasted With HOT Lanes =79,774,192.85 [(Amount Wasted on Time a Year - WITH HOT LANES (mins)* (Gas wasted in idle per minute Idle)]
ix. Amount of Gas Wasted without HOT Lanes ($)=$278,853,993.86 [(Assumed Price per Gallon of Gas)*(Amount of Gas Wasted Without HOT Lanes)]
x. Amount of Gas Wasted with HOT Lanes ($)=$273,625,481.48 [(Assumed Price per Gallon of Gas)*(Amount of Gas Wasted With HOT Lanes)]
xi. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$5,499,465.17 [(Amount of Gas Wasted without HOT Lanes ($))—(Amount of Gas Wasted with HOT Lanes ($))]=Savings From HOT Lanes per year from 2010—2020

c. VMT Fees

i. 63—State Government Spending—$644,100,000 [(Annual Net Revenue Projection from MDOT MD Climate Action Plan 2012 Draft)]

d. Congestion Pricing and Managed Lanes

i. Total Gallons of Gas Wasted Annually =29.33024482 (Gas wasted in idle per minute Idle* Current Congestion Time In MD (Total by Commuter Annually))
ii. Avg. Cost to Consumer Due to Congestion=$100.60 (Total Gallons of Gas Wasted Annually*avg. price of gas)
iii. If Congestion is reduced by 30.4%
    1. Total Congestion Time Reduced Annually (in mins)=620.16 (Total that are congested* Current Congestion Time In MD (Total by Commuter Annually))

2. Total Minutes in Congestion Under Congestion Cost Policy=1419.84 (Current Congestion Time In MD (Total by Commuter Annually)—(Total Congestion Time Reduced Annually (in mins))
3. Avg. Gallons Used in New Congestion=20.41385039 (Gas wasted in idle per minute Idle* Total Minutes in Congestion Under Congestion Cost Policy)
4. Avg. Cost to Consumer under new Pricing=$70.02 (Avg. Price of Gas* Avg. Gallons Used in New Congestion)

iv. Savings to consumer=$30.58 (Avg. Cost to Consumer Due to Congestion- Avg. Cost to Consumer under new Pricing)
v. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$89,164,662.06 (Savings to consumer* Number of those employed in MD)=Total Avg. Annual Savings to All those on MD Roads 2010—2020

e. **Parking Impact Fees**
   i. Suppose they work in Baltimore but live outside City=30 weekly cost (assumer 8 hrs*5)
   ii. Annual Cost to Consumer to Park in Baltimore City=1560 (Suppose they work in Baltimore but live outside City*52)
   iii. 63—State Government Spending—$100,555,182.00 [(Number of those that work in the city of Baltimore*0.05)*(Annual Cost to Consumer to Park in Baltimore City)]=Total Possible Revenue Recouped from City if 5% commute to areas without parking lots

f. **Employer Commute Incentives**
   i. Avg. Gallons Saved Annually=40,532.62963 (Reduction in Annual VMT/Avg. MPG)
   ii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$139,026.92 (Avg. Gallons Saved Annually* Avg. Assumed Price Per Gallon)= Savings Annually 2010—2020

6. Input savings by sector into REMI model and run impacts.
7. Export impacts and analyze.

3.2.10 Transportation Technology Initiatives

Investment Phase

1. Determine relevant REMI sectors for each program under the policy.

a. **Traffic Flow Improvements**
   i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects

b. **Truck Stop Electrification**
   i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects

- **c. Timing of Highway Construction Schedules**
  - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
- **d. Electronic Toll Collection**
  - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
- **e. Traffic Signal Synchronization**
  - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
- **f. Variable Message Signs**
  - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
- **g. Telework Partnership with Employers**
  - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
- **h. Smart Card Implementation**
  - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
- **i. Light-Emitting Diode Traffic Signals**
  - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
- **j. Vehicle Technologies**
  - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
- **k. Transportation Fuels**
  - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects

2. Determine overall cost of policy implementation for each program under the policy.
   - **a. Traffic Flow Improvements**
     - *i. No funding specified*
   - **b. Truck Stop Electrification**
     - *i. No funding specified*
   - **c. Timing of Highway Construction Schedules**
     - i. *No funding specified*
   - **d. Electronic Toll Collection**
     - *i. No funding specified*
   - **e. Traffic Signal Synchronization**
     - *i. No funding specified*
   - **f. Variable Message Signs**
     - i. $250,000 per year 2011-2014
   - **g. Telework Partnership with Employers**
     - *i. No funding specified*
   - **h. Smart Card Implementation**
     - *i. No funding specified*

- **i. Light-Emitting Diode Traffic Signals**
  - i. $3,744,000 in 2012
- **j. Vehicle Technologies**
  - *i. No funding specified*
- **k. Transportation Fuels**
  - *i. No funding specified*

3. Input investment by sector into REMI model and run impacts.
4. Export impacts and analyze.

Operation Phase

7. Determine relevant REMI sectors.
   - **a. Traffic Flow Improvements**
     - i. 623—Consumer Spending—Gasoline and oil
     - ii. 78—Consumption Reallocation—All consumption categories
   - **b. Truck Stop Electrification**
     - i. 623—Consumer Spending—Gasoline and oil
     - ii. 78—Consumption Reallocation—All consumption categories
   - **c. Timing of Highway Construction Schedules**
     - i. 623—Consumer Spending—Gasoline and oil
     - ii. 78—Consumption Reallocation—All consumption categories
   - **d. Electronic Toll Collection**
     - i. 623—Consumer Spending—Gasoline and oil
     - ii. 78—Consumption Reallocation—All consumption categories
   - **e. Traffic Signal Synchronization**
     - i. 623—Consumer Spending—Gasoline and oil
     - ii. 78—Consumption Reallocation—All consumption categories
   - **f. Variable Message Signs**
     - i. 623—Consumer Spending—Gasoline and oil
     - ii. 78—Consumption Reallocation—All consumption categories
   - **g. Telework Partnership with Employers**
     - i. 623—Consumer Spending—Gasoline and oil
     - ii. 78—Consumption Reallocation—All consumption categories
   - **h. Smart Card Implementation**
     - i. 673—Consumer Spending—Bank service charges, trust services, and safe deposit box rentals
     - ii. 78—Consumption Reallocation—All consumption categories
   - **i. Light-Emitting Diode Traffic Signals**
     - i. X6409—Exogenous Final Demand—Electric power generation, transmission, and distribution
     - ii. 63—State Government Spending
   - **j. Vehicle Technologies**
     - i. 648—Consumer Spending—Auto insurance less claims paid
     - ii. 78—Consumption Reallocation—All consumption categories
   - **k. Transportation Fuels**
     - i. 623—Consumer Spending—Gasoline and oil

ii. 78—Consumption Reallocation—All consumption categories

8. Determine part of program to be affected by savings (from strategy write-up).
   a. **Traffic Flow Improvements**
      i. Annual Reduction in Diesel Fuel=2,520,000 gallons (assume 40% of vehicles traveling are trucks) (6,300,000*0.4)
      ii. Annual Reduction in Fuel=3,780,000 (assumer 60% of vehicles traveling are cars) (6,300,000*0.6)
   b. **Truck Stop Electrification**
      i. 23 cars scheduled to be overhauled between FY 2005 and FY 2012
   c. **Timing of Highway Construction Schedules**
   d. **Electronic Toll Collection**
   e. **Traffic Signal Synchronization**
   f. **Variable Message Signs**
   g. **Telework Partnership with Employers**
      i. Total Employers=35
      ii. Savings for 50 people working from home=$789,810
   h. **Smart Card Implementation**
   i. **Light-Emitting Diode Traffic Signals**
      i. 39,000 traffic signals in Baltimore City (From write-up)
   j. **Vehicle Technologies**
   k. **Transportation Fuels**
9. Research savings data for each policy according to part of program to be affected by savings.
   a. **Traffic Flow Improvements**
      i. Cost of Diesel Fuel[124]= $3.89 per gallon
      ii. Assumed Price of Gas= $3.61 per gallon
   b. **Truck Stop Electrification**
      i. Number of Parking Spaces at Station[125]=63
      ii. Avg. Fuel Saved per hour of Operation[126]=0.8 (gallons of fuel saved an hour)
      iii. Rest Period of 8 Hours (sleep)=8
      iv. Cost of Diesel Fuel[127]=$3.89 per gallon
      v. Hours in a Day=24
   c. **Timing of Highway Construction Schedules**
      i. Example of overnight(non-peak) lane closure for I-95/I-495 near Branch Ave (Capitol Beltway)

[124] Lowest Diesel Fuel Prices in the Last 24 Hours. Maryland Gas Prices - Find Cheap Gas Prices in Maryland. 2011. Web. 14 Nov. 2011. <http://www.marylandgasprices.com/index.aspx?fuel=D>.
[125] Maryland Moves. Baltimore Metropolitan Council. Baltimore Metropolitan Council for the Regional Transportation Board May 2006. Web. 16 Nov. 2011. <http://www.baltometro.org/eNews/MM-5-06.pdf>.
[126] Truck Stop Electrification. California Energy Commission. California Energy Commission, June 2006. Web. 16 Nov. 2011. <http://www.energy.ca.gov/2006publications/CEC-600-2006-001/CEC-600-2006-001-FS.PDF>.
[127] Lowest Diesel Fuel Prices in the Last 24 Hours. Maryland Gas Prices - Find Cheap Gas Prices in Maryland. 2011. Web. 14 Nov. 2011. <http://www.marylandgasprices.com/index.aspx?fuel=D>.

ii. Average Delay from Construction=55.5mins (Example of I-95 in Howard County from SHA Work Zone Analysis Guide: Appendix C)
iii. On Peak Assume 50%=83.25 minutes
iv. Gas wasted in idle per minute Idle[128]=0.014377571
v. Assumed Price of Gas=$3.61 per gallon
vi. Avg. Cars Overnight=8,812 (Example of I-95 in Howard County from SHA Work Zone Analysis Guide: Appendix C)
vii. Cost of Diesel Fuel[129]=$3.89 per gallon

d. Electronic Toll Collection

i. Avg. Wait Time at Toll Booth Reduction[130]=2.5 minutes
ii. Avg. Annual Commuters Passing Through Tolls[131]=153,800,000
iii. Number of Tolls Booths in MD[132]=10
iv. Gas wasted in idle[133]=5,528,176 gallons
v. Number of hours a year=8,765
vi. Assumed Price per Gallon of Gas=$3.61 per gallon

e. Traffic Signal Synchronization

i. Min delay in time[134]=13%
ii. Gas wasted in idle per minute Idle[135]=0.014377571
iii. Current Congestion Time In MD (Total by Commuter Annually)[136]=2,040 in minutes
iv. Number of Registered Vehicles=3,382,451 (provided by MDE courtesy of MVA)

f. Variable Message Signs

i. Avg. Reduction with VMS=17%
ii. Gas wasted in idle per minute Idle[137]=0.014377571

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[128] ISDH: ISDH Home. IN.gov: Home. IN.gov. Web. 14 Nov. 2011. <http://www.in.gov/isdh/files/Idling_Brochure.>.

[129] Lowest Diesel Fuel Prices in the Last 24 Hours. Maryland Gas Prices - Find Cheap Gas Prices in Maryland. 2011. Web. 14 Nov. 2011. <http://www.marylandgasprices.com/index.aspx?fuel=D>.

[130] Saka, Anthony A., Dennis K. Agboh, Simon Ndiritu, and Richard A. Glassco. "An Estimation of Mobile Emissions Reduction." RITA | National Transportation Library. National Transportation Centre, Mar. 2000. Web. 14 Nov. 2011. <http://ntl.bts.gov/lib/16000/16800/16888/PB2000105915.pdf>.

[131] MdTA Toll Facilities. MdTA Index. Maryland Transportation Authority, 2011. Web. 14 Nov. 2011. <http://www.mdta.maryland.gov/TollFacilities/facilities.html>.

[132] MdTA Toll Facilities. MdTA Index. Maryland Transportation Authority, 2011. Web. 14 Nov. 2011. <http://www.mdta.maryland.gov/TollFacilities/facilities.html>.

[133] ISDH: ISDH Home. IN.gov: Home. IN.gov. Web. 14 Nov. 2011. <http://www.in.gov/isdh/files/Idling_Brochure.>.

[134] "RITA | ITS | Benefits: The Texas Traffic Light Synchronization program reduced delays by 24.6 percent by updating traffic signal control equipment and optimizing signal timing." RITA | ITS | Welcome to the Costs Database. 10 Aug. 2005. U.S. Department of Transportation (USDOT). 11 Nov. 2011 <http://www.itscosts.its.dot.gov/its/benecost.nsf/ID/D0DCC197DC7382BE852573D8006F7EDA?OpenDocument>.

[135] ISDH: ISDH Home. IN.gov: Home. IN.gov. Web. 14 Nov. 2011. <http://www.in.gov/isdh/files/Idling_Brochure.>.

[136] Baker, Michael, and Cambridge Systematics. "Maryland Climate Action Plan Draft 2012." Maryland Department of Transportation. Maryland Department of Transportation, 11 Apr. 2011. Web. 16 Nov. 2011. <http://www.mdot.maryland.gov/Planning/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf>.

iii. Number of Registered Vehicles=3,382,451 (provided by MDE courtesy of MVA)
iv. Current Congestion Time In MD (Total by Commuter Annually)[138]=2,040 in minutes

g. **Telework Partnership with Employers**

h. **Smart Card Implementation**
   i. Number of Boardings (Rail)—71,311
   ii. Number of Boardings (Bus)—231,795
   iii. Percentage Rail—75%
   iv. Percentage Bus—60%
   v. Average ATM fee—$2.40
   vi. Average Fare—$1.60

i. **Light-Emitting Diode Traffic Signals**
   i. 20,500 Traffic Signals replaced with LED Traffic Signals
   ii. $276,000—Savings a year in energy costs from switch
   iii. $154,000—Savings in labor and maintenance
   iv. $430,000—Total Yearly Savings
   v. Total Yearly Savings/Number of Traffic Signals=$20.98 per signal in savings

j. **Vehicle Technologies**
   i. Goal in 2016=35mpg
   ii. Current Average miles per gallon=27 mpg
   iii. Difference=8 mpg
   iv. Annual growth in mpg to reach goal=2 mpg
   v. Average Annual Miles Driven By Population[139]=13,041
   vi. New Vehicle Registrations in MD=2,700 (courtesy of MVA)

k. **Transportation Fuels**
   i. Annual increase in renewable fuels[140]=8,750,000
   ii. Reduction that can come about from Biofuels[141]=0.29

10. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).

a. **Traffic Flow Improvements**
   i. $9,802,800 [2,520,000 gallons of diesel * $3.89 price per gallon]=Value of diesel saved

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[137] ISDH: ISDH Home. IN.gov: Home. IN.gov. Web. 14 Nov. 2011. <http://www.in.gov/isdh/files/Idling_Brochure.>.

[138] Baker, Michael, and Cambridge Systematics. "Maryland Climate Action Plan Draft 2012." Maryland Department of Transportation. Maryland Department of Transportation, 11 Apr. 2011. Web. 16 Nov. 2011. <http://www.mdot.maryland.gov/Planning/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf>.

[139] "State & Urbanized Area Statistics - Our Nation's Highways - 2000." Home | Federal Highway Administration. 4 Apr. 2011. Federal Highway Administration (FHWA). 11 Nov. 2011 <http://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm>.

[140] Task Force on Renewable Alternative Fuels. State of Maryland. 31 Dec. 2007. Web. 14 Nov. 2011. < http://www.mda.state.md.us/pdf/altfuelsreport.pdf>.

[141] Ibid.

ii. $13,637,295 [3,780,000 gallons of gasoline * $3.61 price per gallon]=value of gasoline saved

iii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$23,440,095 [$9,802,800 + $13,637,295]=Total value of fuel saved per year from 2010—2020

b. Truck Stop Electrification

i. Gallons Saved Per Rest Period =6.4 (Avg. Fuel Saved per hour of Operation*Rest Period of 8 Hours (sleep))

ii. Savings of Fuel Per Truck Rest =$26.19 (Gallons Saved Per Rest Period*Price of Diesel Fuel)

iii. Assume one truck every 8 hours=3 trucks a day (hours in a day/8)

iv. Total Fuel Saved a Day =$78.56 saved daily (Savings of Fuel Per Truck Rest*Assume one truck every 8 hours)

v. Annual Fuel Saved=$28,673.85 (Total Fuel Saved a Day*365)

vi. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$1,806,452.28 [(Annual Fuel Saved*Number of Parking Spaces at Station)]= Total Annual Savings from Truck Stop Electrification Stopping in MD

c. Timing of Highway Construction Schedules

i. Avg. Gas Wasted Idle Peak Hours=1.196932785 (On Peak Assume 50%*Gas wasted in idle per minute Idle)

ii. Avg. Gas Wasted Idle Non-Peak Hours =0.79795519 (Average Delay from Construction*Gas wasted in idle per minute Idle)

iii. Cost of Peak Hours=4.318234255 (Avg. Gas Wasted Idle Peak Hours*Assumed Price of Gas)

iv. Cost of Off Peak Hours =2.878822837 (Avg. Gas Wasted Idle Non-Peak Hours*Assumed Price of Gas)

v. Savings to Night time Construction=1.439411418 (Cost of Peak Hours-Cost of Off Peak Hours)

vi. Assume 40% Trucks=3524.8 (Avg. Cars Overnight*0.4)

vii. Assume 60% Cars=5287.2 (Avg. Cars Overnight*0.6)

viii. Total Cost to Truck on Peak=4,218.94868 gallons fuel wasted (Assume 40% Trucks*Avg. Gas Wasted Idle Peak Hours)

ix. Cost to Truck on Peak= $17,262.21 (Total Cost to Truck on Peak*Cost of Diesel Fuel)

x. Total Cost to Trucks Off-Peak=2,812.632453 gallons fuel (Assume 40% Trucks*Avg. Gas Wasted Idle Non-Peak Hours)

xi. Cost to Truck Off-Peak =$11,508.14 (Total Cost to Trucks Off-Peak*Cost of Diesel Fuel)

xii. Savings to Trucks if Construction Night =$5,754.07 (Cost to Truck on Peak - Cost to Truck Off-Peak)

xiii. Total Cost to Cars On Peak=6,328.42302 (Assume 60% Cars*Avg. Gas Wasted Idle Peak Hours)

xiv. Assumed Price of Gas =3.61

xv. Cost to Cars on Peak =$22,831.37 (Total Cost to Cars On Peak*Assumed Price of Gas)
xvi. Total Cost to Cars Off Peak=2,812.632453 (Assume 40% Trucks*Avg. Gas Wasted Idle Non-Peak Hours)
xvii. Assumed Price of Gas=3.61
xviii. Cost to Cars Off Peak =$10,147.28 (Total Cost to Cars Off Peak* Assumed Price of Gas)
xix. Savings to Cars =$12,684.09 (Cost to Cars on Peak - Cost to Cars Off Peak)
xx. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$18,438.16 [$12,684.09 savings to cars + $5,754.07]=Total fuel savings per year from 2010 to 2020

d. Electronic Toll Collection

i. Number of Mins a year=525,900 (Number of hours a year*60)
ii. Amount of Time Saved in a Year on Avg. =384,500,000 mins (Avg. Wait Time at Toll Booth Reduction* Avg. Annual Commuters Passing Through Tolls)
iii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$19,944,277.13 [(Gas wasted in idle* Assumed Price per Gallon of Gas)]=Total Saved From Electronic Tolls

e. Traffic Signal Synchronization

i. Reduction in time=265.2 [(Current Congestion Time In MD (Total by Commuter Annually))* (Min delay in time)]
ii. Savings in Fuel for Typical Consumer=3.812931826 (Gas wasted in idle per minute Idle*reduction in time)
iii. Savings in Dollar Amounts=13.7561048 (Savings in Fuel for Typical Consumer*3.61)
iv. iii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$46,529,350.46 [(Number of Registered Vehicles* Savings in Dollar Amounts)== Annual Savings to All Registered Vehicles in MD

f. Variable Message Signs

i. Assume Only 25% of vehicles registered see sign =845,612.75 (Number of Registered Vehicles*0.25)
ii. VMS Sign Reduction=346.8 [(Current Congestion Time In MD (Total by Commuter Annually)*(Avg. Reduction with VMS)]
iii. New Minutes Traveled =1693.2 [(Current Congestion Time In MD (Total by Commuter Annually)—(VMS Sign Reduction)]
iv. Total Gallons of Gas Wasted=24.3441032 (New Minutes Traveled* Gas wasted in idle per minute Idle)
v. Cost to Drivers =87.82743832 (Total Gallons of Gas Wasted*3.61)
vi. Total Savings to MD Drivers=74,181,492.61 (Cost to Drivers* Assume Only 25% of vehicles registered see sign)

vii. Assume half are trucks =$37,090,746.31 (Total Savings to MD Drivers/2)
viii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$37,090,746.31 = Total fuel savings to households

g. Telework Partnership with Employers

i. 26,071.43 Car Trips Avoided Per Year = (50 * (365-104.2857 Weekend Days) * 2)
ii. 12,552.91 Gallons of Fuel Saved Per Year = (26,071.43 * 13 Average Miles Per Trip * (1/27 Average MPG))
iii. $45,287.76 Value of Gas Saved = (# Gallons Saved * Assumed Price of Gas)
iv. $1,649.83 Value of Gas Saved From Idling = (Car Trips Avoided * 2 min Average Idling Per Trip * 0.031 (conversion factor))
v. viii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$46,937.59 [$45,287.76 + $1,649.83]=Total value of fuel saved
vi. 603—Consumer Spending—Other motor vehicles, 78—Consumption Reallocation—All Consumption Categories—$11,836.43 [(26,071.43 * 13 Average Miles Per Trip * 0.454 (non-fuel Driving Cost Per Mile))= Value of Non-Fuel Driving Cost Saved

h. Smart Card Implementation

i. $171,146.40 [((71,311 Number of Rail Boardings * 0.75) * ($1.60 Average Fare * 2))]=Total Annual Boards (Rail/Smart Card)
ii. $445,046.40 [((231,795 Number of Bus Boardings * 0.60) * ($1.60 Average Fare * 2))]=Total Annual Boards (Bus/Smart Card)
iii. $410,751.36 [((71,311 Number of Rail Boardings * 0.75) * ($1.60 Average Fare * 2) * $2.40 Average ATM fee)]=Total Annual Boards (Rail)
iv. $1,068,111.36 [((231,795 Number of Bus Boardings * 0.60) * ($1.60 Average Fare * 2) * $2.40 Average ATM fee)]=Total Annual Boards (Bus)
v. $239,604.96 [($410,751.36 Total Annual Boards (Rail) - $171,146.40 Total Annual Boards (Rail/Smart Card))]=Annual Savings for Rail
vi. $623,064.96 [($1,068,111.36 Total Annual Boards (Bus) - $445,046.40 Total Annual Boards (Bus/Smart Card))]=Annual Savings for Bus
vii. $862,669.92 [($239,604.96 Annual Savings for Rail + $623,064.96 Annual Savings for Bus)]=Total Annual Savings
viii. 673—Consumer Spending—Bank Service charges, trust services, and safe deposit box rentals, 78—Consumption Reallocation—All Consumption Categories—$862,669.92 [($239,604.96 Annual Savings for Rail + $623,064.96 Annual Savings for Bus)]=Total Annual Savings

i. Light-Emitting Diode Traffic Signals

i. 63—State Government Spending, X6409—Exogenous Final Demand—Electric power generation, transmission, and distribution—$818,220

[(39,000 Number of Traffic Signals to be Replaced * $20.98 per Signal Savings)]=Average Estimated Savings Annually for 39,000 Signals Replaced from 2010—2020

j. **Vehicle Technologies**
   i. Current Gas Wasted by a driver =483 (Average Annual Miles Driven By Population/current avg)
   ii. Current Cost=$1,742.54 (Current Gas Wasted by a driver* 3.61)
   iii. If move 2 mpg next year=449.6896552 (Average Annual Miles Driven By Population/29)
   iv. Gallons Saved =33.31034483 (Current Gas Wasted by a driver-If move 2 mpg next year)
   v. Cost next year =$120.18 (Gallons Saved*3.61)
   vi. Savings=$120.18
   vii. Transport by Truck=$162,236.78 (savings/2)
   viii. Households=$162,236.78
   ix. 603—Consumer Spending—Other motor vehicles, 78—Consumption Reallocation—All Consumption Categories—$324,486.00 [(New Vehicle Registrations in MD*savings)]=Savings

k. **Transportation Fuels**
   i. 77,962,500 [(8,750,000 Average Proposed Reduction in Regular Fuel * 8.91)] = Average Annual Reduction in Fuel Converted to Kilograms
   ii. 77,962.50 [(77,962,500 CO2 emissions from Regular Fuel in kilograms / 1000)] = Conversion to CO2 in metric tons
   iii. 22,609.125 [(0.29 Reduction that can come about from Biofuels * 77,962.50 Conversion to CO2 in metric tons)] = Average Annual Reduction from Biofuels in CO2 metric tons
   iv. 55,353.375 [(77,962.50 GHG Conversion to CO2 in metric tons—22,609.13 Reduction to account for Biofuels)] = Average Reductions from Strategy not a part of biofuels
   v. 55,353,375 [(55,353.375 Average Reduction from Strategy not a part of biofuels * 1,000)] = Average Reduction from Strategy not a part of biofuels in kilograms
   vi. 6,212,500 (55,353,375 Average Reduction from Strategy not a part of biofuels in kg / 8.91)] = Average Reduction from Strategy not a part of biofuels converted to gallons of gas
   vii. $30,012,500 [(8,750,000 Annual increase in renewable fuels * $3.61 Average Cost of a Gallon of Gas)] = Average Annual Cost if no Reduction Occurs
   viii. $21,308,875 (6,212,500 Reductions in Current Fuels not associated with biofuels * $3.61 average gallon of gas)] = Average Annual Savings from Conversion of Renewable Fuels not associated with biofuels
   ix. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$9,154,665.63 ($30,012,500 Cost if no reduction occurred in regular gas - $21,308,875 Savings from

reduction in gas)*1.052 adjust price of fuel] = Average Annual Savings Associated with Reduction

11. Input savings by sector into REMI model and run impacts.
12. Export impacts and analyze.

3.2.11 Electric Vehicles Initiatives

Investment Phase

1. Determine relevant REMI sectors for each program under the policy.
    - a. **Vehicle-to-Grid (V2G)**
        - i. 68—Government Spending including Non-Pecuniary (Amenity)
    - b. **Electric Vehicles**
        - i. 68—Government Spending including Non-Pecuniary (Amenity)
    - c. **Maryland Electric Vehicles Initiatives**
        - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
    - d. **Maryland Transit Administration Support for Howard County Bus Project**
        - i. 68—Government Spending including Non-Pecuniary (Amenity)
    - e. **Clean and Efficient Strategies**
        - i. 68—Government Spending including Non-Pecuniary (Amenity)
    - f. **Baltimore City Electric Vehicles Infrastructure**
        - i. 68—Government Spending including Non-Pecuniary (Amenity) Aspects
2. Determine overall cost of policy implementation for each program under the policy.
    - a. **Vehicle-to-Grid (V2G)**
        - *i. No Investment Costs Specified*
    - b. **Electric Vehicles**
        - i. $409,344 per year (2010-2020)
    - c. **Maryland Electric Vehicles Initiatives**
        - i. $511,680 per year (2010-2020)
    - d. **Maryland Transit Administration Support for Howard County Bus Project**
        - i. $28,814 per year (2010-2020)
    - e. **Clean and Efficient Strategies**
        - *i. No Investment Costs Specified*
    - f. **Baltimore City Electric Vehicles Infrastructure**
        - *i. No Investment Costs Specified*
3. Input investment by sector into REMI model and run impacts.
4. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI sectors.
    - a. **Vehicle-to-Grid (V2G)**
        - i. X6409—Exogenous Final Demand—Electric power generation, transmission, and distribution
    - b. **Electric Vehicles**
        - i. 623—Consumer Spending—Gasoline and oil

      ii. 78—Consumption Reallocation—All consumption categories
   c. **Maryland Electric Vehicles Initiatives**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All consumption categories
   d. **Maryland Transit Administration Support for Howard County Bus Project**
      i. 63—State Government Spending
   e. **Clean and Efficient Strategies**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All consumption categories
   f. **Baltimore City Electric Vehicles Infrastructure**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All consumption categories
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Vehicle-to-Grid (V2G)**
      i. $30 per megawatt in Maryland’s regulated energy market
   b. **Electric Vehicles**
      i. Currently 10,874 cars are registered in the state of Maryland as Hybrids
      ii. 65 new recharging stations to be installed
      iii. Proposed 20% tax credit for charging station infrastructure
   c. **Maryland Electric Vehicles Initiatives**
      i. Currently 10,874 cars are registered in the state of Maryland as Hybrids
      ii. 65 new recharging stations to be installed
   d. **Maryland Transit Administration Support for Howard County Bus Project**
      i. Replace 3 diesel buses with new Electric Buses
      ii. Add 2 quick charge stations
   e. **Clean and Efficient Strategies**
      i. Two (2) quick charge stations to be installed for Baltimore Fleet
   f. **Baltimore City Electric Vehicles Infrastructure**
      i. Plans to install 8 new charge stations in Baltimore City garages
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Vehicle-to-Grid (V2G)**
      i. Maryland Electricity cost (in KWh)[142]—$0.133 per kW/h
      ii. Average kilowatt introduced into grid by electric vehicle[143]—6 kilowatts
      iii. Annual New Vehicle Registration in Maryland (2010)[144]—186,759 (total for cars and light trucks)

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[142] "Average Energy Prices in the Washington-Baltimore Area." U.S. Bureau of Labor Statistics. 27 Sept. 2011. 11 Nov. 2011 <http://www.bls.gov/ro3/apwb.htm#wb_energy_table1>.
[143] Motavalli, Jim. "In a Blackout, Nissan, Mitsubishi and Toyota E.V.'s Could Function as Generators - NYTimes.com." Automobiles - Wheels Blog - NYTimes.com 1 Sept. 2011. 22 Nov. 2011 <http://wheels.blogs.nytimes.com/2011/09/01/in-a-blackout-nissan-mitsubishi-and-toyota-e-v-s-could-function-as-generators/>.
[144] "Maryland Auto Outlook." Www.mdauto.org. 9 Aug. 2011. Maryland Automobile Dealers Association. 11 Nov. 2011 <http://www.mdauto.org/admin/publications/AutoOutlookQuarter22011.pdf>.

iv. Energy consumed per capita in the state of Maryland[145]—1,429 trillion Btu
v. Annual Energy Generation for the state of Maryland[146]—248 trillion Btu
vi. Note: External research was conducted to construct an average price for Electric Vehicles in the US. RESI constructed this average price across the top 5 reported prices for new 2012 models of Electric Vehicles. Ford's Focus EV has yet to report an official price for their 2012 model and thus was not included in the average. Instead the Honda Fit EV was included in the top five and used to create the average price of Electric Vehicles.

b. Electric Vehicles

i. Average Cost for One Recharge Station[147]—$7,872.00 annual maintenance
ii. Maryland Electricity cost (in KWh)[148]—$0.133 per kW/h
iii. Average fuel price per gallon (regular unleaded)[149]—$3.61 per gallon
iv. Average Annual Miles Driven By Population[150]—13,041 miles
v. Annual New Vehicle Registration in Maryland (2010)[151]—186,759 (total for cars and light trucks)
vi. Average Cost per Mile for Electric Vehicles—$0.02 per mile
vii. Average mile per kilowatt-hour—95.88 miles/KWh
viii. Average Cost to MD driver annually (in gasoline)—$1,764.99
ix. Average Battery Size charge time—5.1 hours
x. Note: External research was conducted to construct an average price for Electric Vehicles in the US. RESI constructed this average price across the top 5 reported prices for new 2012 models of Electric Vehicles. Ford's Focus EV has yet to report an official price for their 2012 model and thus was not included in the average. Instead the Honda Fit EV was included in the top five and used to create the average price of Electric Vehicles.

c. Maryland Electric Vehicles Initiatives

i. Average Cost for One Recharge Station[152]—$7,872.00 annual maintenance

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[145] Data - Prices. Maryland. Nov. 2011. U.S. Energy Information Administration (EIA). 14 Nov. 2011 <http://www.eia.gov/state/state-energy-profiles-data.cfm?sid=MD#Prices>.
[146] Ibid.
[147] "Electric Vehicle Charging Stations." 2010. EVsRoll.com. 14 Nov. 2011 <http://www.evsroll.com/Electric_Vehicle_Charging_Stations.html>.
[148] "Average Energy Prices in the Washington-Baltimore Area." U.S. Bureau of Labor Statistics. 27 Sept. 2011. 11 Nov. 2011 <http://www.bls.gov/ro3/apwb.htm#wb_energy_table1>.
[149] Daily Fuel Gauge Report--national, state and local average prices for gasoline, diesel and E-85. 11 Nov. 2011. Oil Price Information Service (OPIS). 11 Nov. 2011 <http://fuelgaugereport.aaa.com/?redirectto=http://fuelgaugereport.opisnet.com/index.asp
[150] "State & Urbanized Area Statistics - Our Nation's Highways - 2000." Home | Federal Highway Administration. 4 Apr. 2011. Federal Highway Administration (FHWA). 11 Nov. 2011 <http://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm>.
[151] "Maryland Auto Outlook." Www.mdauto.org. 9 Aug. 2011. Maryland Automobile Dealers Association. 11 Nov. 2011 <http://www.mdauto.org/admin/publications/AutoOutlookQuarter22011.pdf>.
[152] "Electric Vehicle Charging Stations." 2010. EVsRoll.com. 14 Nov. 2011 <http://www.evsroll.com/Electric_Vehicle_Charging_Stations.html>.

ii. Maryland Electricity cost (in KWh)[153]—$0.133 per kW/h
iii. Average fuel price per gallon (regular unleaded)[154]—$3.61 per gallon
iv. Average Annual Miles Driven By Population[155]—13,041 miles
v. Annual New Vehicle Registration in Maryland (2010)[156]—186,759 (total for cars and light trucks)
vi. Average Cost per Mile for Electric Vehicles—$0.02 per mile
vii. Average mile per kilowatt-hour—95.88 miles/KWh
viii. Average Cost to MD driver annually (in gasoline)—$1,764.99
ix. Average Battery Size charge time—5.1 hours
x. Note: External research was conducted to construct an average price for Electric Vehicles in the US. RESI constructed this average price across the top 5 reported prices for new 2012 models of Electric Vehicles. Ford's Focus EV has yet to report an official price for their 2012 model and thus was not included in the average. Instead the Honda Fit EV was included in the top five and used to create the average price of Electric Vehicles.

d. Maryland Transit Administration Support for Howard County Bus Project

i. Maryland Electricity cost (in KWh)[157]—$0.133 per kW/h
ii. Total Miles of Routes 1 and 2 (Annual)[158]—779,928 annual miles
iii. Average Cost of Diesel Fuel[159]—$3.76 per gallon
iv. Average Miles per gallon of Hybrid Bus[160]— 5.4 miles per gallon
v. Average miles per gallon of transit buses[161]—6.4 miles per gallon
vi. Average Cost for One Recharge Station[162]—$7,872.00 annual maintenance
vii. Note –RESI will take into consideration that Hybrid Transit Buses have a diesel hybrid. Partial energy is derived from the ion-battery cells and from

[153] "Average Energy Prices in the Washington-Baltimore Area." U.S. Bureau of Labor Statistics. 27 Sept. 2011. 11 Nov. 2011 <http://www.bls.gov/ro3/apwb.htm#wb_energy_table1>.
[154] Daily Fuel Gauge Report--national, state and local average prices for gasoline, diesel and E-85. 11 Nov. 2011. Oil Price Information Service (OPIS). 11 Nov. 2011 <http://fuelgaugereport.aaa.com/?redirectto=http://fuelgaugereport.opisnet.com/index.asp
[155] "State & Urbanized Area Statistics - Our Nation's Highways - 2000." Home | Federal Highway Administration. 4 Apr. 2011. Federal Highway Administration (FHWA). 11 Nov. 2011 <http://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm>.
[156] "Maryland Auto Outlook." Www.mdauto.org. 9 Aug. 2011. Maryland Automobile Dealers Association. 11 Nov. 2011 <http://www.mdauto.org/admin/publications/AutoOutlookQuarter22011.pdf>.
[157] "Average Energy Prices in the Washington-Baltimore Area." U.S. Bureau of Labor Statistics. 27 Sept. 2011. 11 Nov. 2011 <http://www.bls.gov/ro3/apwb.htm#wb_energy_table1>.
[158] KFH Group, Inc. "Harford County Transportation Development Plan." Harford County. June 2007. Office of Planning, Maryland Transit Administration (MTA). 14 Nov. 2011 <http://www.harfordcountymd.gov/services/community/doc/985.pdf>.
[159] Ibid.
[160] Allison Hybrid H 40 EP | H 50 EP. Allisontransmission.com. 2011. Allison Transmission. 14 Nov. 2011 <http://www.allisontransmission.com/servlet/DownloadFile?Dir=publications/pubs&FileToGet=SA5983EN.pdf>
[161] RITA | BTS | Table 4-15: Bus Fuel Consumption and Travel. RITA | Bureau of Transportation Statistics (BTS). Bureau of Transportation, 26 Apr. 2010. Web. 14 Nov. 2011. <http://www.bts.gov/publications/national_transportation_statistics/html/table_04_15.html>.
[162] "Electric Vehicle Charging Stations." 2010. EVsRoll.com. 14 Nov. 2011 <http://www.evsroll.com/Electric_Vehicle_Charging_Stations.html>.

the diesel counterpart. RESI assumes that this energy distribution is equal for all intents and purposes.

e. Clean and Efficient Strategies

i. Average Cost for One Recharge Station[163]—$7,872.00 annual maintenance
ii. Maryland Electricity cost (in KWh)[164]—$0.133 per kW/h
iii. Average fuel price per gallon (regular unleaded)[165]—$3.61 per gallon
iv. Average number of vehicles in downtown fleet[166]—5,800 vehicles
v. Percentage of downtown fleet that are fuel efficient[167]—35%
vi. Average Annual Miles Driven By Population[168]—13,041 miles
vii. Average Cost per Mile for Electric Vehicles—$0.02 per mile
viii. Average mile per kilowatt-hour—95.88 miles/KWh
ix. Average Cost to MD driver annually (in gasoline)—$1,764.99
x. Average Battery Size charge time—5.1 hours
xi. Note: External research was conducted to construct an average price for Electric Vehicles in the US. RESI constructed this average price across the top 5 reported prices for new 2012 models of Electric Vehicles. Ford's Focus EV has yet to report an official price for their 2012 model and thus was not included in the average. Instead the Honda Fit EV was included in the top five and used to create the average price of Electric Vehicles.

f. Baltimore City Electric Vehicles Infrastructure

i. Average Cost for One Recharge Station[169]—$7,872.00 annual maintenance
ii. Maryland Electricity cost (in KWh)[170]—$0.133 per kW/h
iii. Average fuel price per gallon (regular unleaded)[171]—$3.61 per gallon

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[163] "Electric Vehicle Charging Stations." 2010. EVsRoll.com. 14 Nov. 2011 <http://www.evsroll.com/Electric_Vehicle_Charging_Stations.html>.
[164] "Average Energy Prices in the Washington-Baltimore Area." U.S. Bureau of Labor Statistics. 27 Sept. 2011. 11 Nov. 2011 <http://www.bls.gov/ro3/apwb.htm#wb_energy_table1>.
[165] Daily Fuel Gauge Report--national, state and local average prices for gasoline, diesel and E-85. 11 Nov. 2011. Oil Price Information Service (OPIS). 11 Nov. 2011 <http://fuelgaugereport.aaa.com/?redirectto=http://fuelgaugereport.opisnet.com/index.asp>.
[166] "Baltimore Ready to Install 9 Electric Vehicle Charging Stations." General Services / Press Releases. 2010. City of Baltimore, Maryland - Official Website. 14 Nov. 2011 <http://baltimorecity.gov/Government/AgenciesDepartments/GeneralServices/PressReleases/tabid/1028/articleType/ArticleView/articleId/1143/Baltimore-Ready-to-Install-9-Electric-Vehicle-Charging-Stations.aspx>.
[167] Ibid.
[168] "State & Urbanized Area Statistics - Our Nation's Highways - 2000." Home | Federal Highway Administration. 4 Apr. 2011. Federal Highway Administration (FHWA). 11 Nov. 2011 <http://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm>.
[169] "Electric Vehicle Charging Stations." 2010. EVsRoll.com. 14 Nov. 2011 <http://www.evsroll.com/Electric_Vehicle_Charging_Stations.html>.
[170] "Average Energy Prices in the Washington-Baltimore Area." U.S. Bureau of Labor Statistics. 27 Sept. 2011. 11 Nov. 2011 <http://www.bls.gov/ro3/apwb.htm#wb_energy_table1>.
[171] Daily Fuel Gauge Report--national, state and local average prices for gasoline, diesel and E-85. 11 Nov. 2011. Oil Price Information Service (OPIS). 11 Nov. 2011 <http://fuelgaugereport.aaa.com/?redirectto=http://fuelgaugereport.opisnet.com/index.asp>.

iv. Average Annual Miles Driven By Population[172]—13,041 miles
v. Annual New Vehicle Registration in Maryland (2010)[173]—186,759 (total for cars and light trucks)
vi. Average Cost per Mile for Electric Vehicles—$0.02 per mile
vii. Average mile per kilowatt-hour—95.88 miles/KWh
viii. Average Cost to MD driver annually (in gasoline)—$1,764.99
ix. Average Battery Size charge time—5.1 hours
x. Note: External research was conducted to construct an average price for Electric Vehicles in the US. RESI constructed this average price across the top 5 reported prices for new 2012 models of Electric Vehicles. Ford's Focus EV has yet to report an official price for their 2012 model and thus was not included in the average. Instead the Honda Fit EV was included in the top five and used to create the average price of Electric Vehicles.

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).

a. **Vehicle-to-Grid (V2G)**

i. 600 [(10,874 hybrids registered in the state of Maryland / 186,759 new vehicle registrations (light vehicles) annually in Maryland)] * [(186,759 new vehicle registrations (light vehicles) annually in Maryland)]=average possible purchases of electric vehicles in the state of Maryland
ii. 1,314,872 [(6 kilowatts produced by an electric vehicle * 600 average possible purchase of electric vehicles * 365 days a year)]=average possible kilowatts introduced into grid by electric vehicles
iii. 418,798,559,276 [(1,469 trillion BTUs * 0.000293071 kilowatt hours for 1 BTU)]=average consumption of kilowatts in Maryland annually
iv. $55,700,208,383.72 [($0.133 average cost per kilowatt hour * 418,798,559 average consumption of kilowatt hours in Maryland annually)]=average annual cost of consumption of kilowatt hours in Maryland
v. 418,797,244,404 [(418,798,559 average consumption of kilowatts in Maryland - 1,314,872 contribution of kilowatts from electric vehicles annually)]=annual consumption of kilowatt hours less contribution from EVs
vi. $55,700,033,505.75 [(417,483,687 annual consumption of kilowatt hours less contribution from EVs * $0.133 average cost per kilowatt hour)]=average cost of kilowatt consumption annually in Maryland less the kilowatt contribution of EVs
vii. $174,877.97 [($55,700,208.38 annual consumption costs of kilowatts in Maryland - $55,525,330.41 annual consumption costs of kilowatts in Maryland less the EV contribution)]=annual savings from EVs in V2G

[172] "State & Urbanized Area Statistics - Our Nation's Highways - 2000." Home | Federal Highway Administration. 4 Apr. 2011. Federal Highway Administration (FHWA). 11 Nov. 2011 <http://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm>.
[173] "Maryland Auto Outlook." Www.mdauto.org. 9 Aug. 2011. Maryland Automobile Dealers Association. 11 Nov. 2011 <http://www.mdauto.org/admin/publications/AutoOutlookQuarter22011.pdf>.

viii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$39,446.16 [(1,314,872 contribution of kilowatts from electric vehicles annually / 1000 kilowatts per one megawatt)] * [($30.00 per megawatt hour)]=average annual savings to electric companies

b. Electric Vehicles

i. 600 [(10,874 hybrids registered in the state of Maryland / 186,759 new vehicle registrations (light vehicles) annually in Maryland)] * [(186,759 new vehicle registrations (light vehicles) annually in Maryland)]=average possible purchases of electric vehicles in The State of Maryland

ii. $1.80 [(5.1 average battery charge time * $0.133 per KW/h average price per kilowatt-hour in Maryland])=average cost to fill a tank to electric vehicle consumer

iii. $0.02 [($1.80 average cost to fill tank of EV / 95.88 average miles per tank)]=average cost per mile of electric vehicle

iv. $244.28 [($0.02 average cost per mile of EV * 13,041 miles driven annually by Maryland residents)]=average annual cost to drive an EV in Maryland

v. $1,617.44 [($1,861.72 cost to drive annually with gasoline powered vehicles - $244.28 cost to drive an EV annually in MD)]=annual savings to those that purchase EV

vi. $970,460.82 [($1,617.44 annual savings to EV owners * 600 average annual possible purchase of EVs in Maryland)]=average annual savings to EV car owners in Maryland

vii. $409,344.00 [($7,872.00 average cost of maintenance for one recharge station annually * 65 charge stations in Maryland—20% tax credit)]=annual cost to maintain new charge stations

viii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$561,116.82 [($970,460.82 average annual fuel savings to EV car owners - $409,344.00 annual maintenance fees of 65 new recharge stations)]=average annual savings to Maryland EV owners net convenience fees of recharge stations

c. Maryland Electric Vehicles Initiatives

i. 600 [(10,874 hybrids registered in the state of Maryland / 186,759 new vehicle registrations (light vehicles) annually in Maryland)] * [(186,759 new vehicle registrations (light vehicles) annually in Maryland)]=average possible purchases of electric vehicles in the state of Maryland

ii. $1.80 [(5.1 average battery charge time * $0.133 per KW/h average price per kilowatt-hour in Maryland])=average cost to fill a tank to electric vehicle consumer

iii. $0.02 [($1.80 average cost to fill tank of EV / 95.88 average miles per KW/h)]=average cost per mile of electric vehicle

iv. $244.28 [($0.02 average cost per mile of EV * 13,041 miles driven annually by Maryland residents)]=average annual cost to drive an EV in Maryland

v. $1,617.44 [($1,861.72 cost to drive annually with gasoline powered vehicles - $244.28 cost to drive an EV annually in MD)]=annual savings to those that purchase EV
vi. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$970,464 [($1,617.44 annual savings to EV owners * 600 average annual possible purchase of EVs in Maryland)]=average annual savings to EV car owners in Maryland
vii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$511,680.00 [($7,872.00 average cost of maintenance for one recharge station annually * 65 charge stations in Maryland)]=annual cost to maintain new charge stations

d. Maryland Transit Administration Support for Howard County Bus Project

i. $474,554.14 [(779,928 average annual miles of Routes 1 and 2 / 6.4 average miles per gallon of transit buses)] * [($3.89 per gallon of diesel fuel)]=average cost annually of one diesel bus for Routes 1 and 2
ii. $1,423,662.41 [($474,554.14 average annual cost of one diesel bus for Routes 1 and 2 * 3 buses to be replaced)]=average cost annually of three diesel bus for Routes 1 and 2
iii. $9,604.67 [(779,928 average annual miles of Routes 1 and 2 / 5.4 average miles per gallon of transit bus * .50 energy distribution)] * [($0.133 Maryland energy cost per kilowatt hour)]=average annual cost of new hybrid bus for Routes 1 and 2 (Electricity)
iv. $281,217.36 [(779,928 average annual miles of Routes 1 and 2 / 5.4 average miles per gallon of transit bus * .50 energy distribution)] * [($3.89 per gallon of diesel fuel)]=average annual cost of new hybrid bus for Routes 1 and 2 (Diesel)
v. $888,210.09 [(($9,604.67 average cost in electric + $281,217.36 average cost in diesel fuel for Routes 1 and 2 for a single bus) * 3 new buses)] + [($7,872.00 average cost of maintenance for one recharge station annually *2)]=average annual costs of 3 new hybrid bus and 2 recharge stations
vi. 623—State Government Spending—$580,010.33 [($1,423,662.41 average annual cost for three diesel buses on Routes 1 and 2 - $888,210.09 annual costs for 3 new hybrid buses and 2 recharge stations for Routes 1 and 2)]=Overall Average Annual Savings from replacing three diesel buses and adding two recharge stations

e. Clean and Efficient Strategies

i. 2,030 [(5,8000 total vehicles registered with the downtown fleet * 35% are fuel efficient vehicles)]=average possible purchases of electric vehicles for downtown fleet
ii. $1.80 [(5.1 average battery charge time * $0.133 per KW/h average price per kilowatt-hour in Maryland])=average cost to fill a tank to electric vehicle
iii. $0.02 [($1.80 average cost to fill tank of EV / 95.88 average miles per KW/h)]=average cost per mile of electric vehicle

iv. $244.28 [($0.02 average cost per mile of EV * 13,041 miles driven annually by Maryland residents)]=average annual cost to drive an EV in Maryland
v. $1,617.44 [($1,861.72 cost to drive annually with gasoline powered vehicles - $244.28 cost to drive an EV annually in MD)]=annual savings attributed to purchase of an Electric Vehicles
vi. $3,283,392.44 [($1,617.44 annual savings to EV owners * 2,030 possible purchase of EVs for downtown fleet)]=average annual savings in gas for EV fleet
vii. $15,744.00 [($7,872.00 average cost of maintenance for one recharge station annually * 2 charge stations in Maryland)]=annual cost to maintain new charge stations
viii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$3,071,327.40 [($3,087,071.40 average annual fuel savings to EV cars - $15,744.00 annual maintenance fees of 2 new recharge stations)]=average annual savings to Downtown Fleet

f. Baltimore City Electric Vehicles Infrastructure

i. 600 [(10,874 hybrids registered in the state of Maryland / 186,759 new vehicle registrations (light vehicles) annually in Maryland)] * [(186,759 new vehicle registrations (light vehicles) annually in Maryland)]=average possible purchases of electric vehicles in the state of Maryland
ii. $1.80 [(5.1 average battery charge time * $0.133 per KW/h average price per kilowatt-hour in Maryland])=average cost to fill a tank to electric vehicle consumer
iii. $0.02 [($1.80 average cost to fill tank of EV / 95.88 average miles per KW/h)]=average cost per mile of electric vehicle
iv. $244.28 [($0.02 average cost per mile of EV * 13,041 miles driven annually by Maryland residents)]=average annual cost to drive an EV in Maryland
v. $1,617.44 [($1,861.72 cost to drive annually with gasoline powered vehicles - $244.28 cost to drive an EV annually in MD)]=annual savings to those that purchase EV
vi. viii. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$970,460.82 [($1,617.44 annual savings to EV owners * 600 average annual possible purchase of EVs in Maryland)]=average annual savings to EV car owners in Maryland
vii. 623—Consumer Spending—Other motor vehicles, 78—Consumption Reallocation—All Consumption Categories—$62,976.00 [($7,872.00 average cost of maintenance for one recharge station annually * 8 charge stations in Maryland)]=annual cost to maintain new charge stations

5. Input savings by sector into REMI model and run impacts.
6. Export impacts and analyze.

3.2.12 Low-Emitting Vehicles Initiatives

Investment Phase

1. Determine relevant REMI sectors for each program under the policy.
   a. **Howard Transit Paratransit Fleet Replacement Vehicles**
      i. 63—State Government Spending
   b. **Clean and Efficient Strategies**
      i. 63—State Government Spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Howard Transit Paratransit Fleet Replacement Vehicles**
      i. 2010: $1,600,000
      ii. 2011—2020: $400,000 per year
   b. **Clean and Efficient Strategies**
      i. *No Investment Costs Specified*
3. Input investment by sector into REMI model and run impacts.
4. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI sectors.
   a. **Howard Transit Paratransit Fleet Replacement Vehicles**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All consumption categories
   b. **Clean and Efficient Strategies**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All consumption categories
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Howard Transit Paratransit Fleet Replacement Vehicles**
      i. Number of Sedans=4
      ii. Number of Buses=1
   b. **Clean and Efficient Strategies**
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Howard Transit Paratransit Fleet Replacement Vehicles -** We have calculated the savings in dollars for Howard County Transportation
      i. Average Savings for EV=$1,520
      ii. Vehicles Miles for ADA=1,545
      iii. Cost of Diesel Fuel=3.76
      iv. Average Miles per gallon of Diesel Sedan=25.5 mpg
      v. Average cost of EV per miles=$0.02
      vi. Average MPG of Hybrid Buses=5.4 mpg
      vii. Average MPG of Diesel Buses = 6.1 mpg
      viii. Cost for Diesel Bus to Travel ADA Route Annually - $907.54

- **b. Clean and Efficient Strategies**
  - **i. Clean and Efficient Strategies (all reductions)**[174]
    1. Baltimore City 18.9 tons
    2. Howard County 4.98 tons
    3. JHU 1.992 tons
    4. Anne Arundel Schools 15.22 tons
  - ii. Avg. price per gallon of fuel =3.43

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   - **a. Howard Transit Paratransit Fleet Replacement Vehicles**
     - i. Average Annual Savings =$ 235.65 (Average Cost of Diesel Sedan (Gas) - Average cost of EV for ADA route)
     - ii. Average Annual Savings from 3 sedans=$706.95 (Average Annual Savings*3)
     - iii. Average Miles per gallon of Bus=6.4
     - iv. Average Cost of Diesel Bus=938.92 [(Vehicles Miles for ADA/Average Miles per gallon of Bus)* (Cost of Diesel Fuel)]
     - v. Average MPG of Hybrid Buses=5.4
     - vi. Average Gallons of Fuel Needed =286.0648148 (Vehicles Miles for ADA/Average MPG of Hybrid Buses)
     - vii. Average Cost of Hybrid Buses for Electricity=$19.02
     - viii. Average Cost of Hybrid Buses for Diesel =$556.39 [(Cost of Diesel Fuel*Average Gallons of Fuel Needed)/2]
     - ix. Average Overall Annual Cost of Hybrid Bus=$575.42 (Average Cost of Hybrid Buses for Electricity + Average Cost of Hybrid Buses for Diesel)
     - x. Average Annual Savings from Hybrid Bus=$350.72 (Average Cost of Diesel Bus - Average Overall Annual Cost of Hybrid Bus)
     - xi. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$1,057.67 [(Average Annual Savings from Hybrid Bus+ Average Annual Savings from 3 sedans)]= Total Savings Annually from Policy
   - **b. Clean and Efficient Strategies**
     - i. Total reduction of CO_2=0.0039 mmt
     - ii. $1,600,000 [0.0039 * 405,821,147.4 conversion]=Total value of reduction
5. Input savings by sector into REMI model and run impacts.
6. Export impacts and analyze.

3.2.13 Evaluating the GHG Emissions Impacts from Major Projects and Plans

This policy was omitted from the analysis.

[174] "U.S. EPA Sensitive Population Grant for the City of Baltimore and the City of Annapolis (Fire Trucks and Ambulances)." Maryland Department of the Environment (MDE). 14 Nov. 2011 <http://www.mde.state.md.us/programs/Air/MobileSources/DieselVehicleInformation/DieselRetrofitProjects/Pages/balto_annapcity_retrofit.aspx>.

3.2.14 Airport Initiatives

Investment Phase

No investment costs were specified by the agency for this policy.

Operation Phase

1. Determine relevant REMI sectors.
   a. **Compressed Natural Gas Buses**
      i. 63—State Government Spending
   b. **Air Emissions Reductions**
      i. 63—State Government Spending
   c. **BWI Energy Audit**
      i. 63—State Government Spending
   d. **BWI Utility Master Plan**
      i. 63—State Government Spending
   e. **BWI Energy Efficiency**
      i. 63—State Government Spending
   f. **Enhanced Access to BWI by Other Travel Modes**
      i. 63—State Government Spending
   g. **BWI's Periodic Air Quality Assessments**
      i. 63—State Government Spending
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Compressed Natural Gas Buses**
   b. **Air Emissions Reductions**
   c. **BWI Energy Audit**
   d. **BWI Utility Master Plan**
   e. **BWI Energy Efficiency**
   f. **Enhanced Access to BWI by Other Travel Modes**
   g. **BWI's Periodic Air Quality Assessments**
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Compressed Natural Gas Buses**
      i. Average Cost of Fuel—$3.61 per gallon
   b. **Air Emissions Reductions**
      i. Average Cost of Fuel—$3.61 per gallon
   c. **BWI Energy Audit**
      i. Average Cost of Fuel—$3.61 per gallon
   d. **BWI Utility Master Plan**
      i. Average Cost of Fuel—$3.61 per gallon
   e. **BWI Energy Efficiency**
      i. Average Cost of Fuel—$3.61 per gallon
   f. **Enhanced Access to BWI by Other Travel Modes**
      i. Average Cost of Fuel—$3.61 per gallon
   g. **BWI's Periodic Air Quality Assessments**
      i. Average Cost of Fuel—$3.61 per gallon

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
    a. **Compressed Natural Gas Buses**
        i. 63—State Government Spending—$2,509,315.04 [.006 mmt CO2e * $405,821,147.4 conversion]=Value of fuel saved at BWI per year from 2012—2020
    b. **Air Emissions Reductions**
        i. 63—State Government Spending—$2,509,315.04 [.006 mmt CO2e * $405,821,147.4 conversion]=Value of fuel saved at BWI per year from 2012—2020
    c. **BWI Energy Audit**
        i. 63—State Government Spending—$2,509,315.04 [.006 mmt CO2e * $405,821,147.4 conversion]=Value of fuel saved at BWI per year from 2012—2020
    d. **BWI Utility Master Plan**
        i. 63—State Government Spending—$2,509,315.04 [.006 mmt CO2e * $405,821,147.4 conversion]=Value of fuel saved at BWI per year from 2012—2020
    e. **BWI Energy Efficiency**
        i. 63—State Government Spending—$2,509,315.04 [.006 mmt CO2e * $405,821,147.4 conversion]=Value of fuel saved at BWI per year from 2012—2020
    f. **Enhanced Access to BWI by Other Travel Modes**
        i. 63—State Government Spending—$2,509,315.04 [.006 mmt CO2e * $405,821,147.4 conversion]=Value of fuel saved at BWI per year from 2012—2020
    g. **BWI's Periodic Air Quality Assessments**
        i. 63—State Government Spending—$2,509,315.04 [.006 mmt CO2e * $405,821,147.4 conversion]=Value of fuel saved at BWI per year from 2012—2020
5. Input savings by sector into REMI model and run impacts.
6. Export impacts and analyze.

3.2.15 Port Initiatives

Investment Phase

1. Determine relevant REMI sectors for each program under the policy.
    a. **Port of Baltimore Initiatives**
        i. 63—State Government Spending
2. Determine overall cost of policy implementation for each program under the policy.
    a. **Port of Baltimore Initiatives**
        i. 2010: $14,400
3. Input investment by sector into REMI model and run impacts.
4. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI sectors.
    a. **Port of Baltimore Initiatives**
        i. 63—State Government Spending
2. Determine part of program to be affected by savings (from 6.2.11 write-up).
    a. **Port of Baltimore Initiatives**
        i. Retrofit tire gantry cranes with Diesel Oxidation Catalysts
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Port of Baltimore Initiatives**
        i. Total Tire Gantry Cranes to be Retrofitted[175]—12 tire gantry cranes
        ii. Average cost of Diesel Oxidation Catalysts Retrofit[176]—$1,200.00 per retrofitted vehicle
        iii. Reductions resulting from DOC retrofit[177]—20% air particles
        iv. Fees associated with Title V Permit for emissions [178]—$52.23 per ton + $200 base fee
        v. Useful Life of a Rubber Tire Gantry[179]—19 years per RTG
        vi. Emissions from Rubber Tire Gantry (average annually)[180]—875 tons of pollutants per RTG
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
    a. **Port of Baltimore Initiatives**
        i. $757.89 [(12 tire gantry cranes * $1,200.00 per retrofitted vehicle)] / [(19 number of useful years)]=annual cost incurred per retrofit of RTGs
        ii. $548,615.00 [(875 tons of pollutants from RTGs on average a year * $52.23 per ton)] + {($200.00 base fee of Title V permit)] * [(12 cranes in operation at Seagirt)]=annual average cost of permit from RTGs
        iii. 8,400 [(875 tons of pollutants from RTGs on average a year * 20% reduction in RTG pollution due to retrofit * 12 cranes)]=average reduction in tons of air pollutants from DOC retrofit

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175 Port of Baltimore. 2009. Ports America - Home. PortsAmerica.com 11 Nov. 2011 <http://www.portsamerica.com/baltimore-maryland.html>.

176 "U.S. EPA Sensitive Population Grant for the City of Baltimore and the City of Annapolis (Fire Trucks and Ambulances)." Maryland Department of the Environment (MDE). 14 Nov. 2011 <http://www.mde.state.md.us/programs/Air/MobileSources/DieselVehicleInformation/DieselRetrofitProjects/Pages/balto_annapcity_retrofit.aspx>.

177 Green Port of Baltimore. Air Quality. Maryland Department of Transportation; Port Administration. 11 Nov. 2011 <http://mpa.maryland.gov/content/air-quality.php>.

178 MARC Parking Details | Maryland Transit Administration. Home | Maryland Transit Administration. Nov. 2011. Maryland Transit Administration (MTA). 14 Nov. 2011 <http://mta.maryland.gov/marc-parking-details>.

179 Starcrest Consulting Group, LLC. "Rubber Tired Gantry (RTG) Crane Load Factor Study." Nov. 2009. Port of Los Angeles; Port of Long Beach. 14 Nov. 2011 <http://www.polb.com/civica/filebank/blobdload.asp?BlobID=6915>.

180 New Hybrid Crane to Reduce the Carbon Footprint. About MAERSK. 31 March 2011. MAERSK. 11 Nov. 2011. <http://www.maersk.com/AboutMaersk/News/Pages/20110331-154630.aspx>.

iv. $439,489.89 [((8,400 tons on average of air pollutants from RTG retrofitted * $52.23 per ton of pollutant) + $200.00 base fee of permit)]=average annual cost of permit after retrofitting of twelve cranes
v. $440,247.79 [($438,732.00 average cost of new permit after retrofit + ($63.16 per crane for cost of retrofit annually))]=average annual cost of reduction in emissions
vi. 63—State Government Spending—$108,367.21 [($548,615.00 before retrofit permit costs - $440,247.79 average annual costs (permit and depreciating costs of retrofit))]=annual savings to industry

5. Input savings by sector into REMI model and run impacts.
6. Export impacts and analyze.

3.2.16 Freight and Freight Rail Strategies

Investment Phase

5. Determine relevant REMI sectors for each program under the policy.
    a. **Freight and Freight Rail Strategies**
        i. 63—State Government Spending
6. Determine overall cost of policy implementation for each program under the policy.
    b. **Freight and Freight Rail Strategies**
        i. 2010: $14,400
7. Input investment by sector into REMI model and run impacts.
8. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI sectors.
    a. **Auxiliary Power Units for Existing Locomotives**
        i. 63—State Government Spending
        ii. 623—Consumer Spending—Gasoline and oil
        iii. 78—Consumption Reallocation—All Consumption Categories
2. Determine part of program to be affected by savings (from 6.2.3 write-up).
    a. **Auxiliary Power Units for Existing Locomotives**
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Auxiliary Power Units for Existing Locomotives**
        i. Marginal Savings per Year[181]=$1,339
        ii. Number of Locomotives with CSX[182]=20
    b. **Technology Advances for Non-highway Vehicles**
        i. Avg. Contribution in 2006 of CO2 Emissions from US[183]=55,400,000 tons

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[181] Truck and Locomotive Idling Solutions. South East Diesel Collaborative, 25 June 2008. Web. 14 Nov. 2011. <http://www.southeastdiesel.org/Presentations%20for%203rd%20Annual%20Meeting/Day%202/Idle%20Reduct%20Tech-%20anthony%20erb.pdf>.

[182] Fuel Efficiency. CSX Corporation. Web. 11 Nov. 2011. < http://www.csx.com/index.cfm/about-csx/projects-and-partnerships/fuel-efficiency/>.

[183] Pathways to Reduced Transportation CO2 in the Year 2050. Cornell University. 11 Nov. 2011 <http://www.cee.cornell.edu/academics/graduate/loader.cfm?csModule=security/getfile&PageID=84226>.

ii. Avg. Rail Miles in the US[184]=140,000
iii. Avg. Rail Miles in Maryland[185]=759
iv. Avg. Potential Fuel Reduction of Elect Loco[186]=0.625
v. Average Reduction of Emissions from Program—30%
vi. Avg. Cost of a gallon of gas in MD=$3.61 per gallon

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **Auxiliary Power Units for Existing Locomotives**
      i. 63—State Government Spending—$26,780 [($1,339 Marginal Savings per Year * 20 Number of Locomotives with CSX)]=Average Annual Savings Associated with this program
5. Input savings by sector into REMI model and run impacts.
6. Export impacts and analyze.

3.2.17 Federal Renewable Fuel Standard

Investment Phase

No investment costs were specified by the agency for this policy.

Operation Phase

1. Determine relevant REMI sectors.
   a. **Federal Renewable Fuel Standard**
      i. 623—Consumer Spending—Gasoline and oil
      ii. 78—Consumption Reallocation—All Consumption Categories
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Federal Renewable Fuel Standard**
      i. Reduction=240,000 metric tons (.24*1,000,000)
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Federal Renewable Fuel Standard**
      i. Cost of Avg. Gallon of Gas=$3.61 per gallon
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **Federal Renewable Fuel Standard**
      i. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$12,147,306.40 [(0.24 mmt CO2e * 405,821,147.4)/8]=Total value of fuel saved per year from 2013—2020
5. Input savings by sector into REMI model and run impacts.

[184] Rail Track Mileage and Number of Class I Rail Carriers, United States, 1830-2008. The Geography of Transport Systems. Web. 14 Nov. 2011.
< http://people.hofstra.edu/geotrans/eng/ch3en/conc3en/usrail18402003.html>.
[185] Freight Railroads in Maryland. Association of American Railroads. 2009. Web. 11 Nov. 2011.
< http://www.aar.org/Railroads-States/Maryland-2009.pdf>.
[186] Pathways to Reduced Transportation CO2 in the Year 2050. Cornell University. 11 Nov. 2011
<http://www.cee.cornell.edu/academics/graduate/loader.cfm?csModule=security/getfile&PageID=84226>.

6. Export impacts and analyze.

3.2.18 CAFE Standards: Model Years 2008-2011

Investment Phase

No investment costs were specified by the agency for this policy.

Operation Phase

1. Determine relevant REMI sectors.
    a. **CAFE Standards: Model Years 2008-2011**
        i. 623—Consumer Spending—Gasoline and oil
        ii. 78—Consumption Reallocation—All Consumption Categories
2. Determine part of program to be affected by savings (from 6.2.6 write-up).
    a. **CAFE Standards: Model Years 2008-2011**
        i. Raise MPG standards for all new light vehicles to 27.5 mpg by 2011
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **CAFE Standards: Model Years 2008-2011**
        i. By 2011 New MPG[187]=27.3 mpg
        ii. Average Annual Miles Driven By Population[188]=13,041
        iii. Avg. Price of Gas=$3.61
        iv. Previous Ruling on CAFE Standards[189]=22.5 mpg
        v. Average Annual Miles Driven By Population[190]=13,041
        vi. New Vehicle Registrations in MD=2,700 courtesy of MVA
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
    a. **CAFE Standards: Model Years 2008-2011**
        i. Annual Gallons of Gas Used=477.6923077 (By 2011 New MPG/ Average Annual Miles Driven By Population)
        ii. Average Cost to MD Driver Under new CAFE=$1,723.39 (Annual Gallons of Gas Used* Avg. Price of Gas)
        iii. Annual Gallons of Gas Used Under old CAFE=579.6 (Average Annual Miles Driven By Population/ Previous Ruling on CAFE Standards)
        iv. Average price of gas today=3.61
        v. Cost to Drivers today under old CAFE=$2,091.05 (Annual Gallons of Gas Used Under old CAFE*average price of gas)
        vi. 623—Consumer Spending—Gasoline and oil, 78—Consumption Reallocation—All Consumption Categories—$5,645,840.13 (Cost to

187 "Average Fuel Economy Standards for Light Trucks." Department of Transportation. 14 Nov. 2011 <http://www.nhtsa.gov/DOT/NHTSA/Rulemaking/Rules/Associated%20Files/2006FinalRule.pdf>
188 "State & Urbanized Area Statistics - Our Nation's Highways - 2000." Home | Federal Highway Administration. 4 Apr. 2011. Federal Highway Administration (FHWA). 11 Nov. 2011 <http://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm>.
189 "Average Fuel Economy Standards for Light Trucks." Department of Transportation. 14 Nov. 2011 <http://www.nhtsa.gov/DOT/NHTSA/Rulemaking/Rules/Associated%20Files/2006FinalRule.pdf>
190 Ibid.

Drivers today under old CAFE* New Vehicle Registrations in MD)= Annual Savings from New CAFE Standards

5. Input savings by sector into REMI model and run impacts.
6. Export impacts and analyze.

3.2.19 Promoting Hybrid and Electric Vehicles

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
    a. **Promoting Hybrid and Electric Vehicles**
        i. 63—State Government Spending
2. Determine overall cost of policy implementation for each program under the policy.
    a. **Promoting Hybrid and Electric Vehicles**
        i. $110,000 annually (provided by MEA)
3. Distribute inputs among identified REMI PI+ sectors.
    a. **Promoting Hybrid and Electric Vehicles**
        i. 100% spent by government on administrative costs and oversight
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors.
    a. **Promoting Hybrid and Electric Vehicles**
        i. 641—Consumer spending (gas)
        ii. 78—Consumption Reallocation
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **Promoting Hybrid and Electric Vehicles**
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Promoting Hybrid and Electric Vehicles**
        i. Total Hybrids registered in Maryland=10,874 (MDOT provided)
        ii. Average Annual Savings to Drive an EV (from 3.2.11)=$1,520.73
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
    a. **Electric Vehicle Infrastructure Program**
        i. 641—$16,536,361.76 [(10,874 Total Hybrids Registered in Maryland * $1,520.73 Average Annual Savings to Drive an EV)]=Average Savings to all Hybrid Owners in Maryland
        ii. 78—$16,536,361.76 [(reallocation of savings across all other consumption categories)]
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.2.20 Pay-as-You-Drive (PAYD) Insurance

Investment Phase

No investment costs were specified by the agency for this policy.

Operation Phase

1. Determine relevant REMI PI+ sectors.
   a. **Voluntary Efforts to Promote Pay as Your Drive Insurance**
      i. 648—Consumer spending (auto insurance)
      ii. 78—Consumption reallocation (across all categories)
2. Determine part of program to be affected by savings (strategy write-up).
   a. **Voluntary Efforts to Promote Pay as Your Drive Insurance**
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Voluntary Efforts to Promote Pay as Your Drive Insurance**
      i. MD Population age 18 and older[191]—4,481,657
      ii. Baltimore City Population age 18 and older[192]—485,828
      iii. Progressive 2011 market share—5.72% (data provided by MIA)
      iv. Total employed and living in Baltimore City[193]–101,968
      v. Average annual premium to Baltimore City residents for car insurance—$4,074
      vi. Average savings from PAYD—10% (Progressive's website)
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **Voluntary Efforts to Promote Pay as Your Drive Insurance**
      i. 10.8% [(485,828 Baltimore City population age 18 or older / 4,481,657 MD population age 18 or older)]=percentage of potential insurance holders in Baltimore City
      ii. 256,351 [(485,828 MD population age 18 or older * 5.72% market share of Progressive members in MD)]=Potential number of Progressive customers in Maryland
      iii. 27,789 [(256,351 potential number of Progressive customers in Maryland * 10.8% percentage of potential insurance holder in Baltimore City)]=Number of potential progressive clients residing in Baltimore City
      iv. 0.6% [(27,789 number of potential progressive clients residing in Baltimore City / 4,481,657 MD population age 18 or older)]=percentage of those that are insured by progressive in Maryland residing in Baltimore City
      v. 632 [(101,968 total employed and living in Baltimore City * 0.6% percentage of those that are insured by Progressive in Maryland residing

191 United States Census Bureau, "ACS Demographic and Housing Estimates: 2010 American Community Survey 1-Year Estimates," *American FactFinder*, (Maryland and Baltimore City, Maryland), accessed October 17, 2012.
192 Ibid.
193 United States Census Bureau's Center for Economic Studies, "OnTheMap," *Longitudinal Employer-Household Dynamics*, accessed October 17, 2012.

in Baltimore City)]=Number of potential Progressive members in Baltimore City that may take advantage of PAYD

vi. $407 [($4,074 average annual premium paid by Baltimore City residents for car insurance * 10% discount on average for PAYD consumers through Progressive)]=Annual premium savings to consumers using PAYD

vii. $257,577 [(632 number of potential Progressive members in Baltimore City that may take advantage of PAYD * $407 average annual premium savings to consumers using PAYD)]=Average annual savings from PAYD to Maryland residents

viii. 648—$257,577 savings to Maryland residents from PAYD

ix. 78—$257,577 reallocation of savings across other consumption categories

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

C.3 Agriculture and Forestry

3.3.1 Managing Forests to Capture Carbon

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
    a. **Managing Forests to Capture Carbon**
        i. X6403—Exogenous Final Demand (Support activities for agriculture and forestry)
2. Determine overall cost of policy implementation for each program under the policy.
    a. **Managing Forests to Capture Carbon**
        i. $3,700,000 per year (2010-2020) (costs provided by DNR)
3. Distribute inputs among identified REMI PI+ sectors.
    a. **Managing Forests to Capture Carbon**
        i. 100% paid by government for forestry projects between 2010-2020
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **Managing Forests to Capture Carbon**
        i. X5401—Forestry; fishing, hunting, trapping, Sales
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **Managing Forests to Capture Carbon**
        i. Contribution to GDP per Acre=$478
        ii. Number of acres to be planted=30,000
        iii. Acres planted thus far=12,618
        iv. Total acres left=17,382 (number of acres planted- acres planted thus far)
3. Research savings data for each policy according to part of program to be affected by savings.

   a. **Managing Forests to Capture Carbon**
      i. Annual acres of trees planted per year=2,173
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2012-2020).
   a. **Managing Forests to Capture Carbon**
      i. $8,308,596—[($478 Contribution to GDP per Acre * 17,382 Number of Acres to Planted)] = Average Annual Contribution to GDP for Acres Left to Plant
      ii. X5401—$1,038,575 [($8,308,596 Average Annual Contribution to GDP for Acres Left to Plant / 8 years left until 2020)] = Average Annual Contribution to GDP over remainder of project
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.3.2 Creating Ecosystem Markets to Encourage GHG Emissions Reductions

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **Wetland Markets**
      i. 63—State Govt. Spending
   b. **Stream and Waterway Markets**
      i. 63—State Govt. Spending
   c. **Forest Markets**
      i. 63—State Govt. Spending
   d. **Critical Area Markets**
      i. 63—State Govt. Spending
   e. **Species and Habitat Markets**
      i. 63—State Govt. Spending
   f. **Nutrient Markets**
      i. 63—State Govt. Spending
   g. **Carbon Markets: RGGI and Maryland CO2 Budget Trading Program Offsets**
      i. 63—State Govt. Spending
   h. **Carbon Markets: GGRA of 2009—Offsets and Early Reductions**
      i. 63—State Govt. Spending
   i. **Carbon Markets: GGRA of 2009—Nutrient Trading with Carbon Co-benefits**
      i. 63—State Govt. Spending
   j. **Biomass Markets**
      i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy. [194]

[194] DNR has stated that the program would potentially cost $50,000 annually. RESI has analyzed this program from 2010-2020 at that cost to the government.

a. **Wetland Markets**
    i. $5,000 (provided by DNR)
b. **Stream and Waterway Markets**
    i. $5,000 (provided by DNR)
c. **Forest Markets**
    i. $5,000 (provided by DNR)
d. **Critical Area Markets**
    i. $5,000 (provided by DNR)
e. **Species and Habitat Markets**
    i. $5,000 (provided by DNR)
f. **Nutrient Markets**
    i. $5,000 (provided by DNR)
g. **Carbon Markets: RGGI and Maryland CO2 Budget Trading Program Offsets**
    i. $5,000 (provided by DNR)
h. **Carbon Markets: GGRA of 2009—Offsets and Early Reductions**
    i. $5,000 (provided by DNR)
i. **Carbon Markets: GGRA of 2009—Nutrient Trading with Carbon Co-benefits**
    i. $5,000 (provided by DNR)
j. **Biomass Markets**
    i. $5,000 (provided by DNR)

3. Distribute inputs among identified REMI PI+ sectors.
    a. **Wetland Markets**
        i. 100% paid by government to cover administrative costs
    b. **Stream and Waterway Markets**
        i. 100% paid by government to cover administrative costs
    c. **Forest Markets**
        i. 100% paid by government to cover administrative costs
    d. **Critical Area Markets**
        i. 100% paid by government to cover administrative costs
    e. **Species and Habitat Markets**
        i. 100% paid by government to cover administrative costs
    f. **Nutrient Markets**
        i. 100% paid by government to cover administrative costs
    g. **Carbon Markets: RGGI and Maryland CO2 Budget Trading Program Offsets**
        i. 100% paid by government to cover administrative costs
    h. **Carbon Markets: GGRA of 2009—Offsets and Early Reductions**
        i. 100% paid by government to cover administrative costs
    i. **Carbon Markets: GGRA of 2009—Nutrient Trading with Carbon Co-benefits**
        i. 100% paid by government to cover administrative costs
    j. **Biomass Markets**
        i. 100% paid by government to cover administrative costs

4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    - **a. Wetland Markets**
        - i. 63—State Government Spending
        - ii. X7802—Production costs, Logging
        - iii. X7801—Production costs, Forestry; fishing, hunting, trapping
    - **b. Stream and Waterway Markets**
        - i. 63—State Government Spending
        - ii. X7802—Production costs, Logging
        - iii. X7801—Production costs, Forestry; fishing, hunting, trapping
    - **c. Forest Markets**
        - i. 63—State Government Spending
        - ii. X7802—Production costs, Logging
        - iii. X7801—Production costs, Forestry; fishing, hunting, trapping
    - **d. Critical Area Markets**
        - i. 63—State Government Spending
        - ii. X7802—Production costs, Logging
        - iii. X7801—Production costs, Forestry; fishing, hunting, trapping
    - **e. Species and Habitat Markets**
        - i. 63—State Government Spending
        - ii. X7802—Production costs, Logging
        - iii. X7801—Production costs, Forestry; fishing, hunting, trapping
    - **f. Nutrient Markets**
        - i. 63—State Government Spending
        - ii. X7802—Production costs, Logging
        - iii. X7801—Production costs, Forestry; fishing, hunting, trapping
        - iv. 80—Electricity (Industrial Sector) Fuel Costs, All Industrial sectors
    - **g. Carbon Markets: RGGI and Maryland CO2 Budget Trading Program Offsets**
        - i. 63—State Government Spending
        - ii. X7802—Production costs, Logging
        - iii. X7801—Production costs, Forestry; fishing, hunting, trapping
    - **h. Carbon Markets: GGRA of 2009—Offsets and Early Reductions**
        - i. 80—Electricity (Industrial Sector) Fuel Costs, All Industrial sectors
    - **i. Carbon Markets: GGRA of 2009—Nutrient Trading with Carbon Co-benefits**
        - i. 80—Electricity (Industrial Sector) Fuel Costs, All Industrial sectors
    - **j. Biomass Markets**
        - i. 63—State Government Spending
        - ii. X7802—Production costs, Logging
        - iii. X7801—Production costs, Forestry; fishing, hunting, trapping
2. Determine part of program to be affected by savings (from strategy write-up).

- **a. Wetland Markets**
  - i. Acres of Wetlands=45
- **b. Stream and Waterway Markets**
- **c. Forest Markets**
  - i. Contribution to GDP per 1 acre of Forest Land—$478
- **d. Critical Area Markets**
  - i. Contribution to GDP per 1 acre of Forest Land—$478
- **e. Species and Habitat Markets**
- **f. Nutrient Markets**
- **g. Carbon Markets: RGGI and Maryland CO2 Budget Trading Program Offsets**
  - i. Total allowances yearly by the state of Maryland for GHG—37,503,983 metric tons
  - ii. Number of years of auctions—4 years
- **h. Carbon Markets: GGRA of 2009—Offsets and Early Reductions**
- **i. Carbon Markets: GGRA of 2009—Nutrient Trading with Carbon Co-benefits**
- **j. Biomass Markets**

3. Research savings data for each policy according to part of program to be affected by savings.
   - **a. Wetland Markets**
     - i. Average Value of Wetland (1 acre)=$175,000
   - **b. Stream and Waterway Markets**
     - i. Current Miles of Waterway=15,000
     - ii. Benefit to Healthy Waterway=$568,000,000 (spent by fishers on equipment to fish in MD in 2008)
     - iii. Percentage of Streams Unhealthy=46%
   - **c. Forest Markets**
     - i. Average Acreage Lost a year[195]=7,000
   - **d. Critical Area Markets**
     - i. Total Critical Area Acres in MD=680,000 acres
     - ii. Cost of Buffer=$2 per feet
     - iii. Intensely Developed Land=0.05
   - **e. Species and Habitat Markets**
     - i. Cost per acre of habitat area[196]=$5,750 per acre
     - ii. Species of Wildlife[197]=167
     - iii. Plants[198]=447
     - iv. Total Habitat Creatures/Plants=614
     - v. Assuming each species needs 45 acres=27,630 acres needed

[195] Ecosystem Services Working Group Final Report. Maryland Department of Natural Resources. Maryland Department of Natural Resources, Oct. 2011. Web. 14 Nov. 2011. <http://www.dnr.state.md.us/dnrnews/pdfs/ESWGFinalReportOct2011.pdf>.
[196] Ibid.
[197] Ibid.
[198] Ibid.

- f. **Nutrient Markets**
  - i. Total Potential Realization[199]=$45,000,000.00
- g. **Carbon Markets: RGGI and Maryland CO2 Budget Trading Program Offsets**
  - i. Total Proceeds to Date [200]=$169,600,423.80
  - ii. Number of Years=4
- h. **Carbon Markets: GGRA of 2009—Offsets and Early Reductions**
  - i. ERA Awardees 2009-2011[201]
  - ii. AES Warriors Run=$75,169
  - iii. Mirant Chalk Point=$142,534
  - iv. Sum of Awarded CO2=$217,703
  - v. Auction Price at Time of Award=2.19
- i. **Carbon Markets: GGRA of 2009—Nutrient Trading with Carbon Co-benefits**
  - **i. Assumption-**We will stack the benefits together and package
  - ii. 50% CO2 Credits=$21,200,052.98 (50% reduced revenue)
  - iii. 50% Potential Nutrient Credit[202]=$22,500,000.00 (50% reduced revenue)
- j. **Biomass Markets**
  - i. Annual Savings from 2015-2020=$21,413,700.00 (from DNR)

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   - a. **Wetland Markets**
     - i. $7,875,000 [(45 acres of Wetlands to be restored * $175,000 value of an acre of wetland)]=Average Savings from Restoration of 45 Acres of Wetlands
     - ii. 63—$984,375 [($7,875,000 / 8 years)]=average revenue paid to government by private firms
     - iii. X7802—$474,188 average annual costs
     - iv. X7801—$474,188 average annual costs
   - b. **Stream and Waterway Markets**
     - i. $261,280,000 [($568,000,000 Annual Benefit attributed to Healthy Waterways * 46% Waterways unhealthy)]=Current Loss of Savings, But Potential Realization of Savings if these Waterways are Brought from unhealthy to healthy

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[199] Jones, CY, Evan Branosky, Mindy Selman, and Michelle Perez. "How Nutrient Trading Could Help Restore the Chesapeake Bay." World Resource Institute. World Resource Institute, Feb. 2010. Web. 14 Nov. 2011. <http://pdf.wri.org/working_papers/how_nutrient_trading_could_help_restore_the_chesapeake_bay.pdf>.
[200] MD Proceeds by Auction. Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Welcome. Regional Greenhouse Gas Initiative CO2 Budget Trading Program, 2011. Web. 14 Nov. 2011. <http://rggi.org/docs/MD_Proceeds_by_Auction.pdf>.
[201] Early Reduction CO2 Allowance Awards. Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program. Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program, 18 Dec. 2009. Web. 16 Nov. 2011. <http://www.rggi.org/docs/md_proceeds_by_auction.pdf>.
[202] Jones, CY, Evan Branosky, Mindy Selman, and Michelle Perez. "How Nutrient Trading Could Help Restore the Chesapeake Bay." World Resource Institute. World Resource Institute, Feb. 2010. Web. 14 Nov. 2011. <http://pdf.wri.org/working_papers/how_nutrient_trading_could_help_restore_the_chesapeake_bay.pdf>.

ii. 63—$32,660,000 [($261,280,000 / 8 years)]=average annual revenue paid to government by private firms
iii. X7802—$16,330,000 average annual costs
iv. X7801—$16,330,000 average annual costs

c. **Forest Markets**

i. $3,346,000 [(7,000 acres of Forest Land Lost Annually * $478 Contribution to GDP of one acre of Forest Area)]=Average Annual Savings of restoration of Forest Areas
ii. 63—$418,250 [($3,346,000 / 8 years)]=average annual revenue paid to government by private firms
iii. X7802—$209,125 average annual costs
iv. X7801—$209,125 average annual costs

d. **Critical Area Markets**

i. 34,000 acres [(680,000 acres of Critical Area in MD * 5% Intensely Developed Land)]=Total Acres of Intensely Developed Land in acres
ii. 8,851.38 square feet [(square root(34,000 acres of Intensely Developed Land * 43,560 sq feet per acre) * 23% of which may be buffer area)]=Sq. Feet of Critical Areas that are Buffer Zone
iii. $17,702.77 [(8,851.38 sq feet of buffer area * $2.00 per sq feet)]=Average Savings to Buffer Area
iv. $15,392,269.20 [($478 Total Contribution to GDP from Forest Acres * 32,201.4 Acres of Woods)]=Average Annual Savings from Rest of Critical Area
v. $15,409,971.97 [($17,702.77 Average Savings to Buffer Area + $15,392,269.20 Average Annual Savings from Rest of Critical Area)]=Average Annual Savings From Whole Critical Area
vi. 63—$1,926,246.50 [($15,392,269.20 / 8 years)]=average annual revenue paid to government by private firms
vii. X7802—$963,123.25 average annual costs
viii. X7801—$963,123.25 average annual costs

e. **Species and Habitat Markets**

i. 2,763 [(27,630 acres available *10% sold a year)]=Average Annual Acres Sold a Year
ii. $15,887,250 [(2,763 acres * $5,750 Value of Habitat Area)]=Average Revenue from Sale of Habitat Area
iii. 63—$1,985,906.25 [($15,887,250 / 8 years)]=average annual revenue paid to government by private firms
iv. X7802—$992,953.13 average annual costs
v. X7801—$992,953.13 average annual costs

f. **Nutrient Markets**

i. $45,000,000 [(Potential Realization from DNR website)]
ii. 63—$5,625,000 [($45,000,000 / 8 years)]=average annual revenue paid to government by private firms
iii. X7802—$2,812,500 average annual costs
iv. X7801—$2,812,500 average annual costs

g. **Carbon Markets: RGGI and Maryland CO2 Budget Trading Program Offsets**
    i. $42,400,105.95 [($169,600,423.80 Total Proceeds to Date / 4 Years of Auctions to Date)]=Average Revenue from RGGI Auctions
    ii. 63—$5,300,013.25 [($42,400,105.95 / 8 years)]=average annual funds paid over next 8 years
    iii. X7802—$2,650,006.63 average annual costs
    iv. X7801—$2,650,006.63 average annual costs

h. **Carbon Markets: GGRA of 2009—Offsets and Early Reductions**
    i. 217,703 ERAs [(75,169 AES Warriors Run ERA + 142,534 Mirant Chalk Point ERA)]=Sum of ERAs Awarded thus Far
    ii. $476,769.57 [(217,703 Sum of ERAs Awarded thus Far * $2.19 Auction Prices at Time Of Award)]=Average Savings to Awardees
    iii. 80—$59,596.25 [($476,769.57 average savings to awardees / 8 years)]=average annual savings

i. **Carbon Markets: GGRA of 2009—Nutrient Trading with Carbon Co-benefits**
    i. $43,700,052.98 [($21,200,052.98 Potential Profits from CO2 Credit Sales + $22,500,000 Potential Profit from Nutrient Credit Sales)]=Total Potential Revenue from the Bundle
    ii. 80—$5,462,506.63 [($43,700,052.98 / 8 years)]=average annual savings

j. **Biomass Markets**
    i. $4,282,740.00 [(From DNR)]
    ii. 63—$535,342.50 [($4,282,740 / 8 years)]=average annual revenue from Biomass Markets
    iii. X7802—$267,671.25 costs to production
    iv. X7802—$267,671.25 costs to production

5. Input savings by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.3.3 Increasing Urban Trees to Capture Carbon

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
    a. **Increasing Urban Trees to Capture Carbon**
        i. X6412—Exogenous Final Demand (Construction)
        ii. X6526—Exogenous Final Demand (Architectural, engineering, and related services)
        iii. X6403—Exogenous Final Demand (Support activities for agriculture and forestry)
2. Determine overall cost of policy implementation for each program under the policy.
    a. **Increasing Urban Trees to Capture Carbon**
        i. $1,200,000 total from 2010-2020 (provided by DNR)
3. Distribute inputs among identified REMI PI+ sectors.
    a. **Increasing Urban Trees to Capture Carbon**
        i. 100% from government to plant tree and for administrative costs

4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Increasing Urban Trees to Capture Carbon**
      i. 640—Consumer spending (electricity)
      ii. 78—Reallocation of savings (across all consumption categories)
      iii. 82—Electricity (Commercial Sector) Fuel Costs, All Commercial sectors
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Increasing Urban Trees to Capture Carbon**
      i. Number of Trees to be planted=12,500,000
      ii. Trees planted thus far=5,114,478
      iii. Remaining Trees to Plant=6,535,522
      iv. Number of years Left=8
      v. Average Planting of Trees per year=933,646
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Increasing Urban Trees to Capture Carbon**
      i. Average savings in energy per tree[203]=$20.00
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
   a. **Increasing Urban Trees to Capture Carbon**
      i. $250,000,000 per year—[($20.00 energy savings per tree * 12,500,000 trees planted after full implementation)] = total savings after full implementation in 2020
      ii. $22,727,272.73 savings annually [($250,000,000 total savings after full implementation in 2020 / 11 years of the program)]=average annual savings during operation phase
      iii. $11,363,636.50 [($22,727,272.73 average annual savings / 2 sectors)]=average annual savings per sector
      iv. 640—$11,363,636.50 average annual savings to consumers
      v. 78—$11,363,636.50 reallocation of savings across all other consumption categories
      vi. 82—$11,363,636.50 average annual savings to the commercial sector
5. Input savings by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.3.4 Creating and Protecting Wetlands and Waterway Borders to Capture Carbon

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.

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[203] David J. Nowak, Susan M. Stein, Paula B. Randler, Eric J. Greenfield, Sara J. Comas, Mary A. Carr, and Ralph J. Alig, "Sustaining America's Urban Trees and Forest," *General Technical Report NRS-62* (June 2010), Newton Square, Pennsylvania: United States Department of Agriculture.

   a. **Creating and Protecting Wetlands and Waterway Borders to Capture Carbon**
      i. X6532—Exogenous Final Demand (Other professional, technical, and scientific services)
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Creating and Protecting Wetlands and Waterway Borders to Capture Carbon**
      i. $17,187,817 (total from 2010-2020) (provided by DNR)
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Creating and Protecting Wetlands and Waterway Borders to Capture Carbon**
      i. 100% spent by state to use for administrative costs and restoration costs
4. Input sales by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Creating and Protecting Wetlands and Waterway Borders to Capture Carbon**
      i. TOUR1—Tourism spending (amount)
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Creating and Protecting Wetlands and Waterway Borders to Capture Carbon**
      i. Acres to be restored—1,142
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Creating and Protecting Wetlands and Waterway Borders to Capture Carbon**
      i. Total visitors to State Parks in 2010[204]—10,000,000
      ii. Out-of-state visitors—29%
      iii. In-state visitors—71%
      iv. In-state pass cost—$75.00
      v. Out-of-state pass—$100.00
      vi. In-state visitors—7,100,000
      vii. Out-of-state visitors—2,900,000
      viii. Number of acres in state parks—137,000
      ix. Average secondary spending by state park visitors in 2010—$594.33
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).

[204] Rebecca Dougherty (March 2011), "2010 Maryland State Parks Economic Impact and Visitor Study," Department of Business and Economic Development, accessed October 17, 2012.

a. **Creating and Protecting Wetlands and Waterway Borders to Capture Carbon**
   i. $532,500,000 [($75.00 in-state park pass * 7,100,000 in-state visitors in 2010)] = Total cost of tourism to state parks by in-state visitors in 2010
   ii. $290,000,000 [($100.00 out-of-state park pass * 2,900,000 out-of-state visitors in 2010)] = Total cost of tourism to state parks by out-of-state visitors in 2010
   iii. $822,500,000 [($532,500,000 potential park pass revenues from in-state residents in 2010 + $290,000,000 potential park pass revenues from out-of-state residents in 2010)] = total potential revenues received in 2010 from state park visitors
   iv. $6,003.65 [($822,500,000 total potential park revenues received in 2010 from state park visitors / 137,000 acres in state parks)]=average spending per acre by visitors to state park annually
   v. $5,943,300,000 [($594.33 additional tourism spending by visitors in 2010 * 10,000,000 visitors in 2010 to state parks)]=total additional spending by visitors in 2010
   vi. $5,943,300,000 [($594.33 additional tourism spending by visitors in 2010 * 10,000,000 visitors in 2010 to state parks)]=total additional spending by visitors in 2010
   vii. $43,831.75 [($5,943,300,000 total additional spending by visitors in 2010 / 137,000 number of acres)]=average additional spending by acre by visitors
   viii. $49,385.40 [($43,831.75 average additional spending by acre by visitors in 2010 + $6,003.65 average spending per acre by visitors to state park annually)]=average total spending by visitors annually
   ix. $56,397,670 [($49,385.40 average total spending by visitors annually per acre * 1,142 acres to be restored)]=total additional revenue between 2010-2020
   x. $5,127,061 [($56,397,670 total additional revenue between 2010-2020 / 11 years over program life)]=average annual additional tourism spending from restored acres
   xi. TOUR1—$5,127,061 average annual spending by visitors visiting restored acres of wetlands

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.3.5 Geological Opportunities to Store Carbon

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **Geological Opportunities to Store Carbon**
      i. X932—Employment, Other professional, scientific, and technical services
2. Determine overall cost of policy implementation for each program under the policy.

   a. **Geological Opportunities to Store Carbon**
      i. 4 $66,701 total from 2010-2020 (provided by DNR)
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Geological Opportunities to Store Carbon**
      i. 100% spending by state government through hiring of professionals
4. Input costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Geological Opportunities to Store Carbon**
      i. 80—Electricity (Industrial sectors) Fuel Cost, All Industrial Sectors
      ii. 84—Natural Gas (Industrial sectors) Fuel Cost, All Industrial Sectors
      iii. 88—Residual (Industrial sectors) Fuel Cost, All Industrial Sectors
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Geological Opportunities to Store Carbon**
      i. Target Waste Gate Formation 4.4 gigatonnes
      ii. Target Needmore Shale 0.01 gigatonnes
      iii. Target Oriskany Sandstone 0.981 gigatonnes
      iv. Target Medina Sandstone 3.382 gigatonnes
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Geological Opportunities to Store Carbon**
      i. Tonnes to Gallon Conversion=317.76
      ii. Number of Gallons in a barrel=42
      iii. Cost per Barrel [205]=101

Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).

   b. **Geological Opportunities to Store Carbon**
      i. 8.773 gigatonnes (4.4 gigatonnes of waste gate formation + 0.01 gigatonnes of Needmore Shale + 0.981 gigatonnes + 3.382 gigatonnes of Medina Sandstone) = Total Target Gigatonnes
      ii. 8,773,000,000 tonnes (8.773 total target in gigatonnes * 10^9) = conversion from gigatonnes to tonnes
      iii. 27,608,925.19 gallons of fuel (8,773,000,000 total target tonnes / 317.75 gallons associated with a tonne) = target reduction in gallons of fuel
      iv. 657,355.36 barrels of oil (27,608,925.19 target reduction in gallons of fuel / 42 gallons to a barrel) = Average Reduction Target in Number of Barrels conserved
      v. $66,392,891.54 [(657,355.36 average reduction target in number of barrels conserved * $101 per barrel)] = average savings from reduction techniques associated with strategy by 2020

[205] "Petroleum and other Liquids." U.S. Energy Information Agency. EIA. Gov Web. 16 Nov 2011 < http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RCLC1&f=D>

vi. $6,035,717 [($66,392,891.54 average savings from reduction techniques associated with strategy by 2020 / 11 years)]=average annual savings from 2010-2020
vii. 80—$2,011,906 average annual reduction in fuel costs
viii. 84—$2,011,906 average annual reduction in fuel costs
ix. 88—$2,011,906 average annual reduction in fuel costs
4. Input savings/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

3.3.6 Planting Forests in Maryland

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
   a. **Planting Forests in Maryland**
      i. X3203—Industry sales, Support activities for agriculture
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Planting Forests in Maryland**
      i. $7,651,200 (provided by DNR)
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Planting Forests in Maryland**
      i. 100% spent by towards activities for agriculture increasing sales of forestry growth
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Planting Forests in Maryland**
      i. 640—Consumer spending (electricity)
      ii. 78—Consumption reallocation (across all other consumption categories)
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Planting Forests in Maryland**
      i. Number of trees planted by 2020=43,030
      ii. Average energy savings per tree=$20.00 (see urban trees)
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Planting Forests in Maryland**
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
   a. **Planting Forests in Maryland**
      i. $860,600 [(43,030 total trees to be planted by 2020 * $20.00 energy saving per tree)]=Total savings by 2020 in energy costs
      ii. $78,236.36 [($860,000 total savings by 2020 from newly planted trees / 11 years of program)]=average annual energy savings attributed to program
      iii. 640—$78,236.36 average annual energy savings
      iv. 78—$78,236.36 savings reallocation across other consumption categories

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.3.7 Expanded Use of Forests and Feedstocks for Energy Production

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
    a. **Expanded Use of Forests and Feedstocks for Energy Production**
        i. EQP13—Producer's Durable Equipment Investment (Electrical transmission, distribution, and industrial apparatus)
2. Determine overall cost of policy implementation for each program under the policy.
    a. **Expanded Use of Forests and Feedstocks for Energy Production**
        i. $100,000,000 total costs from 2010-2020 (provided by DNR)
3. Distribute inputs among identified REMI PI+ sectors.
    a. **Expanded Use of Forests and Feedstocks for Energy Production**
        i. 100% spent by government toward program startup and costs
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **Expanded Use of Forests and Feedstocks for Energy Production**
        i. X7809—Production costs, Electric power generation, transmission, and distribution
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **Expanded Use of Forests and Feedstocks for Energy Production**
        i. Annual Savings Per Year from Write up - $1,019,700
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Expanded Use of Forests and Feedstocks for Energy Production**
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
    a. **Expanded Use of Forests and Feedstocks for Energy Production**
        i. X7809— $1,019,700.00 (applicable savings from strategy write-up)
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.3.8 Conservation of Agricultural Land for GHG Benefits

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
    a. **Conservation of Agricultural Land for GHG Benefits**
        i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.

   a. **Conservation of Agricultural Land for GHG Benefits**
      i. $46,693,142 (projected costs based on current implementation costs to date provided by MDA)
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Conservation of Agricultural Land for GHG Benefits**
      i. 100% spent by government towards agricultural land conservation
4. Input sales by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Conservation of Agricultural Land for GHG Benefits**
      i. 104—Farm output, Total
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Conservation of Agricultural Land for GHG Benefits**
      i. Total Acres to Be Conserved by 2020—1,062,000 (provided by MDA)
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Conservation of Agricultural Land for GHG Benefits**
      i. Value of Real Estate for Farmland per acre[206]—$1,131 per ace
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
   a. **Conservation of Agricultural Land for GHG Benefits**
      i. $109,192,909 [(($1,131 Value of Real Estate for Farmland per acre * 1,062,000 Total Acres to Be Conserved by 2020)) / 11 years)]=Total Annually Additional Farm Output that Can be Achieved through Conservation
      ii. 104—$491,040,000.00
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.3.9 Buy Local for GHG Benefits

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **Buy Local for GHG Benefits**
      i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Buy Local for GHG Benefits**
      i. $12,346,424 (provided by MDA)
3. Distribute inputs among identified REMI PI+ sectors.

[206] "Cost of Net Farmland Change," *Maryland Smart, Green & Growing*, accessed October 17, 2012.

- a. **Buy Local for GHG Benefits**
  - i. 100% spent by government towards the promotion and building of local farmer's markets in the Maryland region

4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   - a. **Buy Local for GHG Benefits**
     - i. 104—Farm output, Total
     - ii. 63—State Govt. Spending
2. Determine part of program to be affected by savings (from strategy write-up).
   - a. **Buy Local for GHG Benefits**
3. Research savings data for each policy according to part of program to be affected by savings.
   - a. **Buy Local for GHG Benefits**
     - i. Average cost of Farmer's Market Association[207]—$37.50
     - ii. Total Farmer's Markets Active in Maryland[208]—43
     - iii. Number of Vendors on Average at Each Market[209]—12
     - iv. Average Customers Visiting a Farmer's Market Weekly[210]—387
     - v. Number of Months Farmer's Markets are Active[211]—6.1
     - vi. Average Number of Weeks[212]—24.4
     - vii. Average Sales per Customer Trip[213]—$17.30
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
   - a. **Buy Local for GHG Benefits**
     - i. $19,350 [($37.50 price for license to sell at Farmer's Market * 12 vendors per market * 43 markets in Maryland)]=Average annual increased revenue to state from Farmer's Market licenses
     - ii. 63—$19,350 spending by government back into state from Farmer's Market licenses
     - iii. $6,695.10 [($17.30 average sales per customer trip to Farmer's Market * 387 average customers per week)]=average weekly purchases made at Farmer's Markets by customers at a single market

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[207] Aaron Adalja, James C. Hanson, and Amy G. Crone, "Assessing the Need for a Statewide Farmers' Market Association in Maryland," *Fact Sheet 934,* (2011), University of Maryland Extension and Maryland Department of Agriculture.
[208] Ibid.
[209] Ibid.
[210] "Maryland Farmers' Market," *The Official Site of the Maryland Office of Tourism,* accessed October 17, 2012.
[211] Ibid.
[212] Ibid.
[213] Geoffrey S. Becker, "Farmers' Markets: The USDA Role," *CRS Report for Congress RS21652,* (Updated January 3, 2006), Congressional Research Service and the Library of Congress.

iv. $163,360.44 [($6,695.10 average weekly purchases made at a Farmer's Market by customers * 24.4 weeks the markets are in operation)]=total sales at a single market over the period of operation
v. $7,024,498.92 [($163,360.44 total sales at a single market over the period of operation * 43 markets in Maryland)]=total sales from all Maryland Farmer's Markets in a year
vi. 104—$7,024,498.92

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.3.10 Nutrient Trading for GHG Benefits

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **Nutrient Trading for GHG Benefits**
      i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Nutrient Trading for GHG Benefits**
      i. $3,770,500 (provided by MDA, total investment needed)
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Nutrient Trading for GHG Benefits**
      i. 100% spent by government for administrative and startup costs to establish nutrient trading markets in Maryland
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Nutrient Trading for GHG Benefits**
      i. 63—State Govt. Spending
      ii. 99—Investment spending, Non-residential
      iii. 106—Farm Value Added, with no effect on sales or employment
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Nutrient Trading for GHG Benefits**
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Nutrient Trading for GHG Benefits**
      i. Total Potential Realization[214]—$45,000,000.00
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).

[214] Jones, CY, Evan Branosky, Mindy Selman, and Michelle Perez. "How Nutrient Trading Could Help Restore the Chesapeake Bay." World Resource Institute. World Resource Institute, Feb. 2010. Web. 14 Nov. 2011. <http://pdf.wri.org/working_papers/how_nutrient_trading_could_help_restore_the_chesapeake_bay.pdf>.

   a. **Nutrient Trading for GHG Benefits**
      i. $4,090,909.09 [($45,000,000.00 total potential revenue realization between 2010-2020 / 11 years)]=Average annual revenue realization
      ii. 63—$2,045,454.55 if half credits are purchased by state
      iii. 99—$2,045,454.55 if half credits are purchased by private investment
      iv. 106—$4,090,909.09 additional value to farms (not from sales of output or employment)
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

C.4 Recycling

3.4.1 Recycling and Source Reduction

Investment Phase

No investment costs were specified by the agency for this policy.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Recycling and Source Reduction**
      i. X7939—Production costs, Waste management and remediation services
      ii. 63—State Govt. Spending
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Recycling and Source Reduction**
      i. Average Landfill capacity is 1,000 pounds per cubic year (0.5 tons)
      ii. Total Recycled Annually (from MDE website) [215]—6,866,424 tons
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Recycling and Source Reduction**
      i. Average Percentage of Recycled Waste in Maryland[216]—43.88% annual average
      ii. Cubic Yard to GHG—3.3 cubic yards per GHG emission
      iii. Total Cubic Yards Saved—3,433,212 cubic yards in landfills
      iv. Base Cost - $200 for license + $52.23 per ton
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **Recycling and Source Reduction**
      i. 1,040,367 metric tons [(3,433,212 cubic yards of landfill saved from recycling / 3.3 cubic yards per GHG emissions)]=Average Total Reduction in GHG emissions from recycling by 2020
      ii. $54,338,582.65 [(1,040,367 metric tons reduced that can be sold * $52.23 carbon permit per ton)]=Average total savings associated with landfill offset

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[215] County Recyclables by Commodity in Tons for Calendar Year 2008. Marylend Department of the Environment (MDE). 2008. Web. 11 Nov. 2011. <www.mde.maryland.gov/assets/document/recycling_chart.pdf>.
[216] Ibid.

iii. $27,169,291.33 [(split by Government and Private sector)]
iv. $2,716,929.13 [($27,169,291.33 average total savings per sector / 10 years)]
v. 63—$2,716,929.13 total offset government can spend on other projects
vi. X7939—$2,716,929.13 total reduction in costs to landfills

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

C.5 Buildings

3.5.1 Building and Trade Codes in Maryland

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **Building and Trade Codes in Maryland**
      i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Building and Trade Codes in Maryland**
      i. $700,000 annually spent on program[217]
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Building and Trade Codes in Maryland**
      i. 100% spent by government for trainings
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase[218]

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Building and Trade Codes in Maryland**
      i. X933—Industry Employment, Management of companies and enterprises
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Building and Trade Codes in Maryland**
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Building and Trade Codes in Maryland**
      i. Number of additional individuals able to be trained through program—614 average annually[219]
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **Building and Trade Codes in Maryland**
      i. X933—614 new individuals annually able to be trained

[217] "Housing and Community Development," Maryland Department of Housing and Community Development (2011), accessed October 17, 2012.
[218] Impacts from this policy in the operation phase are adjusted and reduced to 3 percent. Marginally, there is a 3 percent additional costs to projects involving LEED certification and codes, therefore RESI uses this estimate from EIA to estimate the potential marginal increase from Green Building projects.
[219] Office of Energy Performance and Conservation, "StateStat Template," *StateStat Maryland* (September 18, 2012), Maryland Department of General Services, accessed October 17, 2012.

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Adjustment of 3 percent to account for jobs directly related to meeting LEED certification or Green Standards.[220]
7. Export impacts and analyze.

3.5.2 BeSMART

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
    a. **BeSMART**
        i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
    a. **BeSMART**
        i. Data provided by StateStat for the BeSMART program funding, courtesy of DHCD.[221]
            1. 2010—$0
            2. 2011—$3,454,843
            3. 2012—$1,450,226
3. Adjustment of costs to marginally corresponding with the 3 percent that is directly accountable to meeting LEED certification.[222]
4. Distribute inputs among identified REMI PI+ sectors.
    a. **BeSMART**
        i. 100% provided by government under Federal funds to assist in residential refurbishing.
5. Input costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

[220] "Estimating Renewable Energy Costs" *United States Energy Information Administration,* accessed May 21, 2013.
[221] Office of Energy Performance and Conservation, "StateStat Template," *StateStat Maryland* (September 18, 2012), Maryland Department of General Services, accessed October 17, 2012.
[222] "Estimating Renewable Energy Costs" *United States Energy Information Administration,* accessed May 21, 2013.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **BeSMART**
      i. 82—Electricity (Commercial Sector) Fuel Costs, All Commercial Sectors
      ii. 640—Consumer Spending (Electricity)
      iii. 78—Consumption Reallocation
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **BeSMART**
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **BeSMART**
      i. Average energy savings supported by the BeSMART program—15-30%
      ii. Average monthly consumption of energy by Maryland consumers (kwh)[223]—1,030
      iii. Average price per kwh in Maryland[224]—$0.1331
      iv. Average monthly cost to Maryland residents for energy[225]—$137.17
      v. Number of participants in program (residential)[226]—8
      vi. Number of participants in program (commercial)[227]—19
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **BeSMART**
      i. 22.5% [((0.15+0.30)/2)]=Average reduction after BeSMART completion
      ii. 231.75 kwh [(1,030 average monthly consumption before BeSMART * 22.5% average reduction after BeSMART completion)]=Average monthly reduction in energy consumption
      iii. $30.85 [(231.75 reduction of monthly consumption after BeSMART program * $0.1331 per kwh average cost)]=Average monthly savings to those in the BeSMART program
      iv. $246.77 [($30.85 average monthly savings * 8 residential participants in the program)]=Average monthly savings to residential participants in program
      v. $586.07 [($30.85 average monthly savings * 19 business participants in the program)]=Average monthly savings to the commercial sector participants in the program
      vi. $2,961.21 [($246.77 average monthly savings to residential participants in program * 12 months)]=average annual savings to residential sector
      vii. $7,032.87 [($586.07 average monthly savings to commercial sector participants * 12 months)]=average annual savings to commercial sector

[223] "Frequently Asked Questions: How Much Electricity Does an American Home Use?" *United States Energy Information Administration,* accessed October 17, 2012.
[224] Ibid.
[225] Ibid.
[226] Office of Energy Performance and Conservation, "StateStat Template," *StateStat Maryland* (September 18, 2012), Maryland Department of General Services, accessed October 17, 2012.
[227] Ibid.

viii. 82—$7,032.87 annual savings to commercial sector from 2013-2020
ix. 640—$2,961.21 annual savings to residential sector from 2013-2020
x. 78—$2,961.21 [(Reallocation of savings to other consumption categories)]

5. Input savings by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.5.3 Weatherization and Energy Efficiency for Low-Income Houses

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **Weatherization and Energy Efficiency for Low-Income Houses**
      i. 63—State govt. spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Weatherization and Energy Efficiency for Low-Income Houses** [228]
      i. Annual allocations for program:
         1. 2010—$649,200
         2. 2011—$741,377
         3. 2012—$698,417
         4. 2013—$700,000
         5. 2014—$700,000
         6. 2015—$700,000
         7. 2016—$700,000
         8. 2017—$700,000
         9. 2018—$700,000
         10. 2019—$700,000
         11. 2020—$700,000
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Weatherization and Energy Efficiency for Low-Income Houses**
      i. 100% from government spending for grants towards programs for energy efficiency in affordable housing
4. Input costs by sector into REMI PI+ model and run impacts.
5. Adjustment of 3 percent to capture those green jobs that area directly linked to these building/construction costs to meet green initiatives.[229]
6. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Weatherization and Energy Efficiency for Low-Income Houses**
      i. 640—Consumer Spending (electricity)

[228] "Housing and Community Development," Maryland Department of Housing and Community Development (2011), accessed October 17, 2012.
[229] "Estimating Renewable Energy Costs" *United States Energy Information Administration,* accessed May 21, 2013.

ii. 642—Consumer Spending (fuel and oil)
iii. 78—Consumption Reallocation

2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Weatherization and Energy Efficiency for Low-Income Houses**
      i. Number of units completed[230]
         1. 2012—2,167
         2. 2013—2,166
         3. 2014—2,166
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Weatherization and Energy Efficiency for Low-Income Houses**
      i. Average Savings[231]=$437 a year per unit
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
   a. **Weatherization and Energy Efficiency for Low-Income Houses**
      i. $946,979 [($437 Average Annual Savings per Unit * 2,167 number of units completed in 2012)]=Total savings in 2012
      ii. $946,542 [($437 Average annual savings per unit * 2,166 number of units completed in 2013)]=Total savings in 2013
      iii. $946,542 [($437 average annual savings per unit * 2,166 number of units completed in 2014)]=Total savings in 2014
      iv. $473,490 [($946,979 total savings in 2012 / 2 sectors to represent electricity and heating)]=Average savings across electricity and heating for retrofitted units
      v. $473,270 [($946,542 total savings in 2013 / 2 sectors to represent electricity and heating)]=Average savings across electricity and heating for retrofitted units
      vi. $473,270 [($946,542 total savings in 2014 / 2 sectors to represent electricity and heating)]=Average savings across electricity and heating for retrofitted units
      vii. 640—$473,490 savings in 2012
      viii. 642—$473,490 savings in 2012
      ix. 78 — $946,979 reallocation of savings in 2012 across other consumption categories
      x. 640—$473,270 savings in 2013
      xi. 642—$473,270 savings in 2013
      xii. 78—$946,542 reallocation of savings in 2013 across other consumption categories
      xiii. 640—$473,270 savings in 2014
      xiv. 642—$473,270 savings in 2014

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[230] Office of Energy Performance and Conservation, "StateStat Template," *StateStat Maryland* (September 18, 2012), Maryland Department of General Services, accessed October 17, 2012.

[231] Weatherization and Intergovernmental Program: Weatherization Assistance Program. EERE: EERE Server Maintenance. U.S. Department of Energy, 25 Apr. 2011. Web. 11 Nov. 2011. <http://www1.eere.energy.gov/wip/wap.html>.

xv. 78—$946,542 reallocation of savings in 2014 across other consumption categories

2. Input savings/costs by sector into REMI PI+ model and run impacts.
3. Export impacts and analyze.

C.6 Land Use

3.6.1 Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency

Investment Phase

No investment costs were specified for this policy.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **Maryland Sustainable Growth Commission**
        i. X5412—Industry Sales, Construction
    b. **PlanMaryland**
        i. No additional benefits or costs were specified.
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **Maryland Sustainable Growth Communities**
    b. **Plan Maryland**
        i. No additional benefits or costs were specified.
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Maryland Sustainable Growth Commission**[232]
        i. Tax Credit Given to Projects in 2010[233]= $3,820,000
        ii. Tax Credit Given to 10 Projects in 2011[234] = $11,180,000
    b. **Plan Maryland**
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2011).
    a. **Maryland Sustainable Growth Commission**
        i. X5412—$3,820,000 (2010)
        ii. X5412— $11,180,000 (2011)
    b. **Plan Maryland**
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

[232] Please note that $3.8 million and $11.1 million are allocated to *Industry Sales, Construction* under 3.6.1 and also appear under 3.6.3 as investment phase *State Govt. Spending*, though are not double-counted in estimating economic impacts. This is done to capture construction-specific impacts of the SCTC program.
[233] Maryland Department of Planning Staff, "Maryland Smart Growth Sub-Cabinet Report on State Spending Inside and Outside of the Priority Funding Areas for Fiscal Years 2006-2009 and 2009 Annual Report," *Maryland Smart, Green & Growing* (December 2009), Maryland Department of Planning.
[234] Ibid.

3.6.2 Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations

Investment Phase

No investment costs were specified by the agency for this policy.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations**
        i. 641—Consumer spending (gas)
        ii. 78—Consumption reallocation (across all other consumption categories)
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations**
        i. Reduction by 2020- Assume that there is a 1.875% reduction annually (by 2020 we will have a 15% reduction in CO2 from this sector)
        ii. Number of Registered Vehicles=3,382,451 (provided by MDE courtesy of MVA)
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations**
        i. Conversion from Metric tons into Gallons of Gas
            1. Change to kg=0.01875
        ii. Average Annual Miles Driven By Population[235]=13,041
        iii. Avg. MPG for a 4-door sedan=27
        iv. Transfer from Gallons to KG[236]=1,455,647,935
        v. Transfer to Metric Tons of Co2=1,455,647.935 (annual metric tons from driving in MD)
        vi. Avg. Cost of Gas Per Gallon in MD=3.43
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
    a. **Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations**
        i. Assume 10% Are State Owned Fleet=338,245.1 (number of registered vehicles*0.1)
        ii. Total Miles Traveled in MD=4,411,054,349 (average annual miles driven by population*Assume 10% Are State Owned Fleet)
        iii. Number of Gallons used =163,372,383.3 (total miles traveled in MD*avg. MPG for a 4-door sedan)

[235] State and Urbanized Area Statistics. U.S. Department of Transportation, 4 April. 2011. Web. 11 Nov. 2011. < http://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm>.

[236] "How We Calculate Your Carbon Footprint." Carbon offsets for your carbon footprint & fighting global warming. 2011. CarbonFund.org. 14 Nov. 2011 <http://www.carbonfund.org/site/pages/carbon_calculators/category/Assumptions#Transportation>.

iv. Reduction=27,293.39879 (Change to kg*Transfer to Metric Tons of Co2)
v. New Metric Tons of Co2 Consumed=1,428,355 (Transfer to Metric Tons of Co2-reduction)
vi. Convert to kg =1,428,354,536 (New Metric Tons of Co2 Consumed*1,000)
vii. Convert to Gallons=160,309,151.1 (convert to kg/8.91)
viii. Previous Cost to Travel Annually=560,367,274.7 (Number of Gallons used*Avg. Cost of Gas Per Gallon in MD)
ix. New Cost to Travel Annually =549,860,388.3 (Convert to Gallons*Avg. Cost of Gas Per Gallon in MD)
x. 641—$10,506,886.40 (Previous Cost to Travel Annually-New Cost to Travel Annually)
xi. 78—$10,506,886.40 [(reallocation of savings across all other consumption categories)]

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.6.3 Land Use Planning for GHG Benefits

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **Funding Mechanisms for Smart Growth**
      i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Funding Mechanisms for Smart Growth**
      i. $5,599,638—spending in 2010 on SCTC tax credit (provided by MDP)
      ii. $12,879,736—spending in 2011 on SCTC tax credit (provided by MDP)
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Funding Mechanisms for Smart Growth**
      i. 100% spent by government on SCTC tax credit
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Funding Mechanisms for Smart Growth**
      i. X3612—Firm Employment, Construction
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Funding Mechanisms for Smart Growth**
      i. Average Jobs Created per $1 million investment[237]—72.5

[237] Cronyn, Joseph and Evans Paull. *Heritage Tax Credits: Maryland's Own Stimulus to Renovate Buildings for Productive Use and Create Jobs, an $8.53 Return on Every State Dollar Invested*. The Abell Foundation 22.1(March 2009) p. 1-8.

3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Funding Mechanisms for Smart Growth**
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).

a. **Funding Mechanisms for Smart Growth**
    i. 406.0 jobs [($5,599,638 tax credit in 2010 / $1,000,000) * 72.5 jobs created per $1 million in tax credit)]=average jobs created in 2010
    ii. 933.8 jobs [($12,879,736 tax credit in 2011 / $1,000,000) * 72.5 jobs created per $1 million in tax credit)]=average jobs created in 2011
    iii. 669.9 jobs [(406.0 + 993.8)/2 years)]=average annual jobs if average tax credit continues through 2020
    iv. X3612—669.9 jobs annually
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.6.4 GHG Benefits from Priority Funding Areas and Other Growth Boundaries

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
    a. **GHG Benefits from Priority Funding Areas and Other Growth Boundaries**
        i. 63—Govt. State Spending
2. Determine overall cost of policy implementation for each program under the policy.
    a. **GHG Benefits from Priority Funding Areas and Other Growth Boundaries**
        i. $779,000,000 annually investment on Chesapeake Bay TMDL from 2010-2017[238]
3. Distribute inputs among identified REMI PI+ sectors.
    a. **GHG Benefits from Priority Funding Areas and Other Growth Boundaries**
        i. 100% spent by government on storm water drainage updates
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **GHG Benefits from Priority Funding Areas and Other Growth Boundaries**
        i. X3211—Industry Sales, Water, sewage, and other systems
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **GHG Benefits from Priority Funding Areas and Other Growth Boundaries**
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **GHG Benefits from Priority Funding Areas and Other Growth Boundaries**
        i. Costs from 2017-2020 for Maintenance[239]—$81,116,728
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
    a. **GHG Benefits from Priority Funding Areas and Other Growth Boundaries**
        i. X3211—$81,116,728 annually from 2017-2020
5. Input savings/costs by sector into REMI PI+ model and run impacts.

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[238] "Chesapeake Bay TMDL," United States Environmental Protection Agency, accessed October 17, 2012.
[239] "The Chesapeake Bay TMDL, Maryland's Watershed Implementation Plan and Maryland's 2012-2013 Milestone Goals," Maryland Department of the Environment, accessed October 17, 2012.

6. Export impacts and analyze.

C.7 Innovative Initiatives

3.7.1 Leadership-by-Example—Local Government

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
    - **b. Leadership-by-Example—Local Government**
        - i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
    - **c. Leadership-by-Example—Local Government**
        - ii. $62,060,217 (total allocation towards program from 2010-2020, provided by MDE)
3. Distribute inputs among identified REMI PI+ sectors.
    - **d. Leadership-by-Example—Local Government**
        - iii. 100% spent by government on implementation of program
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    - **a. Leadership-by-Example—Local Government**
        - i. 65—Local government spending
        - ii. X3209—Industry sales, Electrical power generation, transmission, and distribution
2. Determine part of program to be affected by savings (from strategy write-up).
    - **a. Leadership-by-Example—Local Government**
3. Research savings data for each policy according to part of program to be affected by savings.
    - **a. Leadership-by-Example—Local Government**
        - i. Avg. Number of Sq. Feet Needed per Employee[240]—387
        - ii. Energy Consumption per Sq. Feet[241]—68.61
        - iii. Avg. Cost per kwh[242]—0.11
        - iv. Number of Local Government Employees[243]—241,869

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[240] Employment and Payrolls - Industry Series - Maryland 2009 - Employment and Payrolls - Division of Workforce Development and Adult Learning. Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 1 June 2011. Web. 11 Nov. 2011. <http://www.dllr.state.md.us/lmi/emppay/md2010ep.shtml>.

[241] Building Energy Data Book. Buildings Energy Data Book. U.S. Energy Information Administration, Mar. 2011. Web. 11 Nov. 2011. <http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx>.

[242]A Look at Office Buildings - How Many Employees Are There. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration (EIA), 3 Jan. 2001. Web. 14 Nov. 2011. <http://www.eia.gov/emeu/consumptionbriefs/cbecs/pbawebsite/office/office_howmanyempl.htm>.

[243] Employment and Payrolls - Industry Series - Maryland 2009 - Employment and Payrolls - Division of Workforce Development and Adult Learning. Maryland Department of Labor, Licensing and Regulation. Maryland Department

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2020-2025).
   a. **Leadership-by-Example—Local Government**
      i. 93,603,303 [(387 Avg. Number of Sq. Feet Needed per Employee * 241,869 Local Government Employees)]=Avg. Sq Feet of Local Government Buildings
      ii. 6,422,122,618.83 [(68.61 Units of Energy Consumed per Sq. Feet * 93603303 Avg. Sq Feet of Local Government Buildings)]=Avg. Energy Consumption in Local Govt. Buildings in kilowatts
      iii. $706,433,488.07 [(6,422,122,618.83 Avg. Energy Consumption in Local Govt. Buildings * 0.11 Cost in kWh)]=Avg. Cost of Energy Consumption in Local Govt.
      iv. 834,875,940.45 [(6,422,122,618.83 Avg. Energy Consumption in Local Govt. Buildings * 0.13)]=If Target is 13% for savings in kilowatts
      v. 5,587,246,678.38 [(6,422,122,618.83 Avg. Energy Consumption in Local Govt. Buildings - 834,875,940.45 If Target is 13% for savings)]=New Energy Consumption in kilowatts
      vi. $614,597,134.62 [(5,587,246,678.38 New Energy Consumption * 0.11 Cost in khw)]=New Costs in kwh
      vii. $91,836,353.45 [($706,433,488.07 Avg. Cost of Energy Consumption in Local Govt. - $614,597,134.62 New Costs)]=New Savings
      viii. X3209—$91,836,353.45 annual reduction in sales for energy
      ix. 65—$91,836,353.45 annual reallocation of spending by local government
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.7.2 Leadership-by-Example—Federal Government

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **Leadership-by-Example—Federal Government**
      i. 94—Federal Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Leadership-by-Example—Federal Government**
      i. $40,049,749 (provided by MDE, budget for 2010-2020)
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Leadership-by-Example—Federal Government**
      ii. 100% spent by government on Lead-by-Example initiatives
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

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of Labor, Licensing and Regulation, 1 June 2011. Web. 11 Nov. 2011. <http://www.dllr.state.md.us/lmi/emppay/md2010ep.shtml>.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **Leadership-by-Example—Federal Government**
        i. X6409—Exogenous final demand, Electric power generation, distribution, and transmission
        ii. 94—Federal Govt. Spending
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **Leadership-by-Example—Federal Government**
        i. Energy Saved—13.00%
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Leadership-by-Example—Federal Government**
        i. Avg. Number of Sq. Feet Needed per Employee[244]—387
        ii. Energy Consumption per Sq. Feet[245]—68.61
        iii. Avg. Cost per kwh[246]—0.11
        iv. Federal Employees in MD[247]—139,927
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2020-2025).
    a. **Leadership-by-Example—Federal Government**
        i. $587,156.93 [((68.61 units of energy consumed per sq. feet * 75000 sq. feet) * 0.11 per kwh)]=Avg. Cost per 75,000 Sq. Feet
        ii. $76,330.40 [($587,156.93 Avg. Cost per 75,000 Sq. Feet * 13.00% Energy Saved)]=Reduction
        iii. $510,826.53 [($587,156.93 Avg. Cost per 75,000 Sq. Feet - $76,330.40 Reduction)]=Avg. Annual Savings
        iv. 54,151,749 [(139,927 Federal Employees in MD * 387 Sq. Feet per employee)]=Estimated Number of Sq. Feet
        v. 3,715,521,464.23 [(54,151,749 Estimated Number of Sq. Feet * 68.61 units of energy consumed per sq. feet)]=Avg. Used in Federal Building per Sq. Feet
        vi. $423,940,999.07 [(3,715,521,464.23 Avg. Used in Federal Building per Sq. Feet * 0.11 Avg. Cost per kwh)]=Avg. Cost per khw

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[244] Employment and Payrolls - Industry Series - Maryland 2009 - Employment and Payrolls - Division of Workforce Development and Adult Learning. Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 1 June 2011. Web. 11 Nov. 2011. <http://www.dllr.state.md.us/lmi/emppay/md2010ep.shtml>.

[245] Building Energy Data Book. Buildings Energy Data Book. U.S. Energy Information Administration, Mar. 2011. Web. 11 Nov. 2011. <http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx>.

[246] A Look at Office Buildings - How Many Employees Are There. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration (EIA), 3 Jan. 2001. Web. 14 Nov. 2011. <http://www.eia.gov/emeu/consumptionbriefs/cbecs/pbawebsite/office/office_howmanyempl.htm>.

[247] Employment and Payrolls - Industry Series - Maryland 2009 - Employment and Payrolls - Division of Workforce Development and Adult Learning. Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 1 June 2011. Web. 11 Nov. 2011. <http://www.dllr.state.md.us/lmi/emppay/md2010ep.shtml>.

vii. 483,017,790.40 [(3,715,521,464.23 Avg. Used in Federal Building per Sq. Feet * 13.00% Energy Saved)]=Avg. Savings
viii. 3,232,503,674 [(3,715,521,464.23 Avg. Used in Federal Building per Sq. Feet - 483,017,790.40 Avg. Savings)]=New Amount Used
ix. $368,828,669.19 [(3,232,503,674 New Amount Used * 0.11 Avg. Cost per kwh)]=Total Cost of New Amount
x. $55,112,329.88 [($423,940,999.07 Avg. Cost per khw - $368,828,669.19 Total Cost of New Amount)]=Avg. Annual Savings
xi. X6409—$55,112,329.88 reduction in energy demand from federal government installations in Maryland
xii. 94—$55,112,329.88 reallocation of spending by federal government from reduced energy costs

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.7.3 Leadership-by-Example—Maryland Colleges and Universities

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
   a. **Leadership-by-Example—Maryland Colleges and Universities**
      i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **Leadership-by-Example—Maryland Colleges and Universities**
      i. $38,686,850 (provided by MDE, budget from 2010-2020)
3. Distribute inputs among identified REMI PI+ sectors.
   a. **Leadership-by-Example—Maryland Colleges and Universities**
      i. 100% spent by government on Lead-by-Example initiatives
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
   a. **Leadership-by-Example—Maryland Colleges and Universities**
      i. X3209—Industry sales, Electric power generation, transmission, and distribution
      ii. 63—State Govt. Spending
2. Determine part of program to be affected by savings (from strategy write-up).
   a. **Leadership-by-Example—Maryland Colleges and Universities**
      i. Number of MD Public Universities—64,222
3. Research savings data for each policy according to part of program to be affected by savings.
   a. **Leadership -by-Example—Maryland Colleges and Universities**
      i. Avg. Number of Sq. Feet Needed per Employee[248]—387

[248] Employment and Payrolls - Industry Series - Maryland 2009 - Employment and Payrolls - Division of Workforce Development and Adult Learning. Maryland Department of Labor, Licensing and Regulation. Maryland Department

   ii. Energy Consumption per Sq. Feet[249]—68.61
   iii. Avg. Cost per kwh[250]—0.11

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2020-2025).
   a. **Leadership-by-Example—Maryland Colleges and Universities**
      i. 24,853,914 [(64,222 MD Public Universities * 387 Sq. Feet Needed per Employee)]=Avg. Sq feet in Universities
      ii. 1,705,227,040 [(24,853,914 Avg. Sq. Feet in Universities * 68.61 Units of Energy Consumed per Sq. Feet)]=Avg. Electricity Used in Universities
      iii. $187,574,974.35 [(1,705,227,040 Avg. Electricity Used in Universities * $0.11 Cost in khw)]=Avg. Cost
      iv. 0.215 [((0.1 + 0.33) / 2)]=Avg. Reduction Target by 2020 from Universities
      v. 0.026875 [(0.215 Avg. Reduction Target by 2020 from Universities / 8)]=Target Reduction Annually
      vi. 45,827,976.69 [(1,705,227,040 Avg. Electricity Used in Universities * 0.026875 Target Reduction Annually)]=Savings Annually
      vii. 1,659,399,063 [(1,705,227,040 Avg. Electricity Used in Universities - 45,827,976.69 Savings Annually)]=Avg. Annual Savings
      viii. $182,533,896.91 [(1,659,399,063 Avg. Annual Savings * $0.11 Cost in khw)]=Avg. Cost After Reduction
      ix. $5,041,077.44 [($187,574,974.35 Avg. Cost - $182,533,896.91 Avg. Cost After Reduction)]=Avg. Annual Savings
      x. X3209—$5,041,077.44 annual reduction in energy sales to energy sector
      xi. 64—$5,041,077.44 government reallocation of funds from energy savings
5. Input savings by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.8.4 GHG Early Voluntary Reductions

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **GHG Early Voluntary Reductions**
      i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
   a. **GHG Early Voluntary Reductions**
      i. $15,000 annually (provided by MDE)
3. Distribute inputs among identified REMI PI+ sectors.

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of Labor, Licensing and Regulation, 1 June 2011. Web. 11 Nov. 2011. <http://www.dllr.state.md.us/lmi/emppay/md2010ep.shtml>.

[249] Building Energy Data Book. Buildings Energy Data Book. U.S. Energy Information Administration, Mar. 2011. Web. 11 Nov. 2011. <http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx>.

[250] A Look at Office Buildings - How Many Employees Are There. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration (EIA), 3 Jan. 2001. Web. 14 Nov. 2011. <http://www.eia.gov/emeu/consumptionbriefs/cbecs/pbawebsite/office/office_howmanyempl.htm>.

- **a. GHG Early Voluntary Reductions**
  - i. 100% spent by government for administrative costs

4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors.
   - **a. GHG Early Voluntary Reductions**
     - i. X7809—Production costs, Electric power generation, transmission, and distribution
2. Determine part of program to be affected by savings (from strategy write-up).
   - **a. GHG Early Voluntary Reductions**
     - i. Annual Reduction Target by 2020—1.03 million metric tons
     - ii. Number of years of auctions—4 years
     - iii. Number of years until Target—8 years
     - iv. Average Reductions per year—128,750 allowances annually
3. Research savings data for each policy according to part of program to be affected by savings.
   - **a. GHG Early Voluntary Reductions**
     - i. Proceeds From Auctions[251]—$169,600,423.80 (total to date)
     - ii. Allowances Sold to Date[252]— 68,507,184
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   - **a. GHG Early Voluntary Reductions**
     - i. $42,400,105.95 [($169,600,423.80 total proceeds from auctions to date / 4 years)]=annual cost from sales of allowances
     - ii. $2.48 [($169,600,423.80 total proceeds from auctions to date / 68,507,184 total carbon allowances sold to date)]=average cost of carbon allowances
     - iii. 17,126,796 [(68,507,184 total carbon allowances sold to date / 4 years)]=average carbon credits sold annually
     - iv. 16,998,046 [(17,126,796 average carbon credits sold annually—128,750 proposed annual reduction target)]=average annual carbon credit to be purchased under reductions
     - v. $42,081,364.86 [(16,998,046 average annual carbon credits purchased under reduction target * $2.48 average cost per carbon credit allowance)]=average cost to firm for carbon credits under new reduction target
     - vi. $318,741.09 [($42,400,105.95 current average annual carbon credit costs - $42,081,364.86 average carbon credit costs under target reduction policy)]=savings to firms from reductions

[251] MD Proceeds by Auction. Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Welcome. Regional Greenhouse Gas Initiative CO2 Budget Trading Program, 2011. Web. 14 Nov. 2011. <http://rggi.org/docs/MD_Proceeds_by_Auction.pdf>.
[252] Ibid.

vii. X7809—$318,741.09 annual reduction in production costs from early reduction strategies

5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.7.4 GHG Early Voluntary Reductions

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
   - **a. GHG Early Voluntary Reductions**
     - i. 63—State Government Spending
2. Determine overall cost of policy implementation for each program under the policy.
   - **a. GHG Early Voluntary Reductions**
     - i. $15,000 annually (provided by MDE)
3. Distribute inputs among identified REMI PI+ sectors.
   - **a. GHG Early Voluntary Reductions**
     - i. 100% spent by government on administrative costs
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors.
   - **a. GHG Early Voluntary Reductions**
     - i. X7809—Production costs, Electrical power distribution, transmission, and generation
2. Determine part of program to be affected by savings (from strategy write-up).
   - **a. GHG Early Voluntary Reductions**
     - i. Annual Reduction Target by 2020—1.03 million metric tons
     - ii. Number of years of auctions—4 years
     - iii. Number of years until Target—8 years
     - iv. Average Reductions per year—128,750 allowances annually
3. Research savings data for each policy according to part of program to be affected by savings.
   - **a. GHG Early Voluntary Reductions**
     - i. Proceeds From Auctions[253]—$169,600,423.80 (total to date)
     - ii. Allowances Sold to Date[254]— 68,507,184
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).

[253] MD Proceeds by Auction. Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Welcome. Regional Greenhouse Gas Initiative CO2 Budget Trading Program, 2011. Web. 14 Nov. 2011. <http://rggi.org/docs/MD_Proceeds_by_Auction.pdf>.

[254] MD Proceeds by Auction. Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Welcome. Regional Greenhouse Gas Initiative CO2 Budget Trading Program, 2011. Web. 14 Nov. 2011. <http://rggi.org/docs/MD_Proceeds_by_Auction.pdf>.

a. **GHG Early Voluntary Reductions**
   i. $42,400,105.95 [($169,600,423.80 total proceeds from auctions to date / 4 years)]=annual cost from sales of allowances
   ii. $2.48 [($169,600,423.80 total proceeds from auctions to date / 68,507,184 total carbon allowances sold to date)]=average cost of carbon allowances
   iii. 17,126,796 [(68,507,184 total carbon allowances sold to date / 4 years)]=average carbon credits sold annually
   iv. 16,998,046 [(17,126,796 average carbon credits sold annually—128,750 proposed annual reduction target)]=average annual carbon credit to be purchased under reductions
   v. $42,081,364.86 [(16,998,046 average annual carbon credits purchased under reduction target * $2.48 average cost per carbon credit allowance)]=average cost to firm for carbon credits under new reduction target
   vi. X7809—$318,741.09 [($42,400,105.95 current average annual carbon credit costs - $42,081,364.86 average carbon credit costs under target reduction policy)]=savings to firms annually from reductions

5. Input savings by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.7.5 State of Maryland Initiative to Lead by Example

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
   a. **High Performance Buildings**
      i. 99—Investment spending, Non-residential
      ii. 68—State Govt. Spending (including non-pecuniary amenity aspects)
   b. **Green Maryland Act of 2010**
      i. No investment costs were specified by the agency for this program.
   c. **Green Buildings**
      i. 47—Non-residential capital investment
2. Determine overall cost of policy implementation for each program under the policy.
   a. **High Performance Buildings**[255]
      i. $33,219,574 (spending in 2010, per MD Statestat data)
      ii. $43,563,417 (spending in 2011, per MD Statestat data)
      iii. $36,156,867 (spending in 2012, per MD Statestat data)
   b. **Green Maryland Act of 2010**
      i. No investment costs were specified by the agency for this program.
   c. **Green Buildings**
      i. $193,650,429 (total spending over 2010-2013)[256]

[255] Office of Energy Performance and Conservation, "StateStat Template," *StateStat Maryland* (September 18, 2012), Maryland Department of General Services, accessed October 17, 2012.
[256] Office of Energy Performance and Conservation, "StateStat Template," *StateStat Maryland* (September 18, 2012), Maryland Department of General Services, accessed October 17, 2012.

3. Distribute inputs among identified REMI PI+ sectors.
    a. **High Performance Buildings**
        i. 49.8% for government administrative costs/responsibilities
        ii. 50.1% spread among investment spending, non-residential
    b. **Green Maryland Act of 2010**
        i. No investment costs were specified by the agency for this program.
    c. **Green Buildings**
        i. 100% private sector spending for implementation
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Adjust for 3 percent of costs only being attributed to green building intiatives.[257]
6. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **High Performance Buildings**
        i. X10540—Electrical Fuel Costs (Individual Industry), Elementary and secondary schools; Junior colleges, colleges, universities, and professional schools; Other educational services
        ii. X10564— Electrical Fuel Costs (Individual Industry), Civic, social, professional, and similar organizations
    b. **Green Maryland Act of 2010**
        i. No operation costs/benefits specified.
    c. **Green Buildings**
        i. X6409—Exogenous final demand (amount), Electric power generation, distribution, transmission
        ii. 63—State Govt. Spending
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **High Performance Buildings**
    b. **Green Maryland Act of 2010**
        i. No operation costs/benefits specified.
    c. **Green Buildings**
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **High Performance Buildings**
        i. Average Energy Savings for retrofitted buildings[258]
            1. 2010—$13,618,966
            2. 2011-2012—$21,504,572
    b. **Green Maryland Act of 2010**
    c. **Green Buildings**
        i. Avg. Savings from Green Buildings[259]= 30%

[257] "Estimating Renewable Energy Costs" *United States Energy Information Administration,* accessed May 21, 2013.
[258] Office of Energy Performance and Conservation, "StateStat Template," *StateStat Maryland* (September 18, 2012), Maryland Department of General Services, accessed October 17, 2012.

        ii. Avg. Cost to Build a Green Building= $4 per sq foot
        iii. Avg. use of energy in a commercial building [260]=1,153,191.49
        iv. Avg. Cost per kwh[261]=$0.11
        v. Avg. Savings=$39,473.75
        vi. Number of Buildings Proposed[262]=37

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
    a. **High Performance Buildings**
        i. 2010
            1. X10540—$6,809,493 reduction in energy costs from retrofit
            2. X10564—$6,809,493 reduction in energy costs from retrofit
        ii. 2011-2020
            1. X10540—$10,752,286 reduction in energy costs from retrofit
            2. X10564—$10752,286 reduction in energy costs from retrofit
    b. **Green Maryland Act of 2010**
    c. **Green Buildings**
        i. $131,579.15 (1,153,191.49 Avg. Use in kwH in a commercial building annually * $0.11 Avg, Cost per kwH for electricity) = Average Annual Electricity Costs for a Commercial Building
        ii. $39,473.75 ($131,579.15 Average Annual Electricity Costs for a Commercial Building * 30% reduction associated with Green Buildings) = Average Annual Savings for a Green Building in Energy
        iii. $1,460,528.55 ($39,473.75 Average Annual Savings for a Green Building * 37 Proposed Green Buildings to be Built) = Average Annual Savings for Proposed Strategy
        iv. X6409—$1,460,528.55 average annual reduction in energy demand from buildings
        v. 63—$1,460,528.55 average annual increase in funds from energy reduction state can spend towards other projects
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.7.6 State of Maryland Carbon and Footprint Initiatives

Investment Phase

No investment costs were specified by the agency for this policy.

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[259] Kats, Gregory H. "Green Building Costs and Financial Benefits." NH Partnership for High Performance Schools - Home. Http://www.nhphps.org/docs/documents/GreenBuildingspaper.pdf, 2003. Web. 11 Nov. 2011. <http://www.nhphps.org/>.

[260] Building Energy Data Book. Buildings Energy Data Book. U.S. Energy Information Administration, Mar. 2011. Web. 11 Nov. 2011. <http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx>.

[261] SEDS | State Energy Data System. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration (EIA, 2009. Web. 16 Nov. 2011. <http://www.eia.gov/state/seds/hf.jsp?incfile=sep_prices/com/pr_com_MD.html&mstate=Maryland>.

[262] Maryland Green Building Council 2010 Annual Report. Maryland Green Building Council. Maryland Department of General Services, 2011. Web. 11 Nov. 2011. <http://www.dgs.maryland.gov/pdfs/2010GreenBldgReport.pdf>.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **Maryland Environment Footprint**
        i. X6409—Exogenous final demand, Electric power generation, distribution, and transmission
        ii. 68—Government spending (including non-pecuniary spending)
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **Maryland Environment Footprint**
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Maryland Environment Footprint**
        i. Electric Use in 2008 (kwH)[263]=1,732,064,108
        ii. Electric Use in 2009 (KwH)[264]=1,455,031,107
        iii. Cost per KwH[265]=0.11
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
    a. **Maryland Environment Footprint**
        i. 277,033,001 [(1,732,064,108 kilowatt Electric Use in 2008 (kwH) - 1,455,031,107 Electric Use in 2009 (KwH))] = Savings in Electric Used Annually in kilowatts
        ii. $31,609,465.41 [(277,033,001 kilowatts Savings in Electric Used Annually (kwH) * $0.11 Cost per kwH in Maryland)] = Average Annual Savings associated with cost of electric
        iii. X6409—$31,609,465.41 annual reduction in demand for energy
        iv. 68—$31,609,465 reallocation of savings from energy to new programs
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.7.7 Job Creation and Economic Development

Investment Phase

No investment costs were specified by the agency for this policy.

Operation Phase

All impacts from the operation of this program would be captured throughout the GGRA in the creation of jobs or training to meet the new demand for green jobs.

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263 Maryland Environmental Footprint. Maryland: Smart, Green and Growing. Maryland Environmental Service, Spring 2010. Web. 16 Nov. 2011. <http://www.green.maryland.gov/carbon_footprint_page.html>.
264 Ibid.
265 SEDS | State Energy Data System. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration (EIA, 2009. Web. 16 Nov. 2011. <http://www.eia.gov/state/seds/hf.jsp?incfile=sep_prices/com/pr_com_MD.html&mstate=Maryland>.

3.7.8 Public Health Initiatives Related to Climate Change

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy (taken from REMI PI+ Excel file).
    a. **State Climate Change Environmental Health and Protection Advisory Council**
        i. 68—Govt. Spending (including non-pecuniary aspects)
2. Determine overall cost of policy implementation for each program under the policy.
    a. **State Climate Change Environmental Health and Protection Advisory Council**
        i. $1,250,000 from 2010-2011 (from Center for Disease Control grant to DHMH)
3. Distribute inputs among identified REMI PI+ sectors.
    a. **State Climate Change Environmental Health and Protection Advisory Council**
        i. 100% spent by government in creation of tracking system
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **State Climate Change Environmental Health and Protection Advisory Council**
        i. 662—Consumer spending, Health insurance, income loss, worker's comp
        ii. 78—Consumption reallocation (across all other consumption categories)
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **State Climate Change Environmental Health and Protection Advisory Council**
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **State Climate Change Environmental Health and Protection Advisory Council**
        i. Avg. Cost of an ER visit for Asthma attacks[266]—$512
        ii. Number of those in MD diagnosed with Asthma[267]—11,474
        iii. Number of Deaths from Asthma in 2009[268]—221
        iv. Average Funeral Costs in Maryland[269]—$4,500

[266] Collins, Mary, and Judy Chen. "Under-Controlled Asthma ™s Economic Impact | Feature Articles | Perspectives | Payer Solutions." IMS Health. IMS Health, Spring 2010. Web. 14 Nov. 2011. <http://www.imshealth.com/portal/site/imshealth/menuitem.a46c6d4df3db4b3d88f611019418c22a/?vgnextoid=da12b0ac2e6e6210VgnVCM100000ed152ca2RCRD>.

[267] Asthma Hospitalizations in Maryland. Family Health Administration. Department of Health and Mental Hygiene, Aug. 2011. Web. 14 Nov. 2011. <http://fha.maryland.gov/pdf/mch/DataBrief-3-AsthmaHospitalizationsinMaryland2011.pdf>.

[268] Asthma Mortality in Maryland. Family Health Administration. Department of Health and Mental Hygiene, Aug. 2011. Web. 14 Nov. 2011. <http://fha.maryland.gov/pdf/mch/DataBrief2-AsthmaMortalityinMaryland2011.pdf>.

4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
    a. **State Climate Change Environmental Health and Protection Advisory Council**
        i. $5,874,688 [(11,474 Number of those in MD diagnosed with Asthma * 512 Avg. Cost of an ER visit for Asthma attacks)]=Cost to MD Households Annually
        ii. 662—$5,874,688 average reduction in health expenses from system
        iii. 78—$5,874,688 savings reallocation across all other consumption categories
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.7.9 Title V Permits for GHG Sources

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
    a. **Title V Permits for GHG Sources**
        i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
    a. **Title V Permits for GHG Sources**
        i. $40,000 annually (provided by MDE)
3. Distribute inputs among identified REMI PI+ sectors.
    a. **Title V Permits for GHG Sources**
        i. 100% spent by government on administrative costs
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

2. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **Title V Permits for GHG Sources**
        i. X7809— Production costs, Electric power generation, transmission, and distribution
        ii. 63—State Govt. Spending
3. Determine part of program to be affected by savings (from 6.1.8 write-up).
    a. **Title V Permits for GHG Sources**
        i. Minimum air pollution sources to obtain permit—17,000 sources
        ii. Minimum possible annually—100 tons per year of CO_2 equivalent
4. Research savings data for each policy according to part of program to be affected by savings.
    a. **Title V Permits for GHG Sources**

[269] Mary, Stephenson J., and Donna Brinsfield. "Funeral Planning." University of Maryland Cooperative Extension Fact Sheet. University of Maryland Cooperative Extension. Web. 14 Nov. 2011. <http://extension.umd.edu/publications/pdfs/fs409.pdf>.

i. Fees associated with Compliance[270]—$52.23 per ton + $200.00 base fee annually
ii. Number of Agencies currently holding permits[271]—120
iii. Total Minimum for Any Air Pollutant[272]—100 tons
iv. Total Minimum for Nitrogen Oxides[273]—25 tons
v. Total Minimum for Volatile Organic Components[274]—37.5 tons (varies by county, average)
vi. Total Minimum for Hazardous Air Pollutants (average)[275]—17.5 tons (single is 10 tons, and combination of variety is 25 tons)

5. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
   a. **Title V Permits for GHG Sources**
      i. $650,760.00 [(120 current permit holders * ($52.23 per ton * 100 ton minimum + $200.00 base fee)]=annual revenue to government from companies compliance with Clean Air Act
      ii. $180,690.00 [(120 current permit holders * ($52.23 per ton * 25 ton minimum + $200.00 base fee)]=annual revenue to government from companies compliance with Nitrogen Oxide Permit
      iii. $259,035.00 [(120 current permit holders * ($52.23 per ton * 37.5 ton minimum + $200.00 base fee)]=annual revenue to government from companies compliance with Volatile Organic Component Permit
      iv. $133,683.00 [(120 current permit holders * ($52.23 per ton * 17.5 ton minimum + $200.00 base fee)]=annual revenue to government from companies compliance with Hazardous Air Pollutants Permit
      v. $306,042.00 [($650,760.00 annual revenue if all apply under any air pollutant + $180,690.00 annual revenue if all apply under nitrogen oxide permit + $259,035.00 annual revenue if all apply under volatile organic component permit + $133,683.00 annual revenue if all apply under hazardous air pollutants permit)] / [(4 different types of permits)]=average possible annual minimum revenue from Title V permits
      vi. X7809—$306,042 annual increase in production costs attributable to permits
      vii. 63—$306,042 increased spending for various government projects from the revenue of permits sold

[270] "Tile V Fee Sheet" The Department of the Environment. 14 Nov. 2011 <http://www.mde.state.md.us/programs/Permits/AirManagementPermits/TitleVProgramInformation/Pages/title5feesheet.aspx>
[271] "Issued Part 70 Permits" The Department of the Environment. 14 Nov. 2011 <http://www.mde.state.md.us/programs/Permits/AirManagementPermits/TitleVProgramInformation/Pages/title5issuedpermits.aspx>
[272] "Chronology of Maryland's Part 70 Permit Program" The Department of the Environment. 14 Nov. 2011 <http://www.mde.state.md.us/programs/Permits/AirManagementPermits/TitleVProgramInformation/Pages/title5factsheet.aspx>
[273] Ibid.
[274] Ibid.
[275] Ibid.

6. Input savings/costs by sector into REMI PI+ model and run impacts.
7. Export impacts and analyze.

3.7.10 Outreach and Public Education

Investment Phase

No investment costs were specified by the agency for this policy.

Operation Phase

1. Determine relevant REMI PI+ sectors (taken from REMI PI+ Excel file).
    a. **Outreach and Public Education**
        i. 63—State Govt. Spending
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **Outreach and Public Education**
        i. Staffing costs annually—$12,500 (provided by MDE)
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **Outreach and Public Education**
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2010-2020).
    a. **Outreach and Public Education**
        i. 63—$12,500 annually
5. Input savings/costs by sector into REMI PI+ model and run impacts.
6. Export impacts and analyze.

3.7.11 GHG Prevention of Significant Deterioration Permitting Program

Investment Phase

1. Determine relevant REMI PI+ sectors for each program under the policy.
    a. **GHG Prevention of Significant Deterioration Permitting Program**
        i. 63—State Govt. Spending
2. Determine overall cost of policy implementation for each program under the policy.
    a. **GHG Prevention of Significant Deterioration Permitting Program**
        i. $40,000 annually (provided by MDE)
3. Distribute inputs among identified REMI PI+ sectors.
    a. **GHG Prevention of Significant Deterioration Permitting Program**
        i. 100% spent by government on administrative costs associated with program
4. Input sales/costs by sector into REMI PI+ model and run impacts.
5. Export impacts and analyze.

Operation Phase

1. Determine relevant REMI PI+ sectors.
    a. **GHG Prevention of Significant Deterioration Permitting Program**
        i. X7809—Production costs, Electric power generation, transmission, and distribution
        ii. 63—State Govt. Spending

2. Determine part of program to be affected by savings (from strategy write-up).
    a. **GHG Prevention of Significant Deterioration Permitting Program**
        i. Company is emitting=100,000 tons
        ii. Limit=50,000 tons
        iii. Total Over Limit=50,000 tons (Company is emitting-Limit)
3. Research savings data for each policy according to part of program to be affected by savings.
    a. **GHG Prevention of Significant Deterioration Permitting Program**
        i. Recent Clearing Price of Carbon Credits[276]=1.89 per metric ton
4. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020).
    a. **GHG Prevention of Significant Deterioration Permitting Program**
        i. $94,500 (total over limit*percent clearing price of carbon credits) =Revenue Received to reinvest in The State
        ii. X7809—$94,500 average annual increase in production costs from permit spending
        iii. 63—$94,500 average annual increase for government spending towards other programs
5. Export impacts and analyze.

[276] "Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Auction 13." Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Welcome. 7 Sept. 2011. 11 Nov. 2011 <http://www.rggi.org/market/co2_auctions/results/auction_13>.

Appendix D—Occupational Data

This appendix contains information regarding the five top-gaining industries in terms of total employment for each strategy for both the investment and operation phases. RESI matched these industries with their top occupations in terms of employment on the national level. The top occupations were taken from BLS occupational industry overview data.

These occupations provide examples of some of the jobs which may experience employment gains as a result of investment or operation of each strategy. It is important to note that RESI analyzed the total employment gain rather than the direct employment gain, so some of the occupations listed in this appendix may experience an indirect or induced employment impact. In some cases, some occupations may not experience much impact at all, if any. It is important to note that REMI PI+ does not provide impacts on the occupational level, so the data contained in this appendix serves only as examples of what job titles may be affected due to each strategy.

It is also important to note that job creation during the investment phase does not necessarily assure that such jobs will be retained. In some cases, these jobs may only exist during the implementation period. On the other hand, most operational jobs will ultimately be retained rather than created after initial strategy implementation has occurred.

This appendix is meant to act as a guide for understanding the jobs associated with the industries defined in the final report. Some strategies showed gains in or retention of employment within industries which may not seem to have a direct relation to the relevant strategy. In many cases, such impacts were driven primarily by indirect and induced effects.

Industries which saw a gain from many strategies included in this report are Professional, scientific, and technical services and Public administration. Although the types of jobs contained within these sectors may not be as transparent as Construction or Retail trade, RESI used national level BLS data to demonstrate the types of jobs that exist within these industries. For many strategies, one of the goals is to stimulate green job growth. The industries defined by REMI PI+ do not offer much insight into the exact job titles within them, but consider the following: When a company must comply with certain regulations such as GHG emissions targets or caps, they will often need to hire environmental consultants, lawyers, and eventually developers to assist in cost-effective measures while remaining compliant with regulations. These jobs would typically fall under industries such as Professional, scientific and technical services and Construction.

Some strategies' operation phase revealed a significant impact on employment within Health care and social assistance and Retail trade. These total employment impacts were generally driven by either an indirect or induced effect, as mentioned previously, coming from the change in household income. For example, under the Clean Cars Program for Maryland strategy, RESI expects that many households would probably wait until after the strategy had been implemented and new technology had been introduced to purchase a new vehicle. Once the new vehicles that are compliant with the new regulations become available, car dealerships would see an increase in sales during the operation phase of the strategy. Therefore, they would need to hire new sales representatives to meet the increased demand. This would demonstrate a possible direct effect in Retail trade. The indirect effect may be an equal or lesser effect in Health care and social assistance as a new group of people now have either an increased income or a second income and can then allocate more money toward their personal health. In addition, employers would be providing health benefits to a greater number of people. This could lead to a hiring effect in nursing for doctor's offices and hospitals as the demand for healthcare increases. This is just one example of how these strategies may affect sectors which are not directly discussed within the strategy.

The State of Maryland is home to many highly ranked higher educational institutions such as Johns Hopkins University and the University of Maryland. Students and graduates of such institutions are on the forefront of leading technological advances and medical discoveries within The State's borders on a daily basis. Employment related with many of the industries defined throughout the report as benefitting from the strategies discussed would be ideal fields for future Maryland graduates. If students were to graduate and stay within Maryland after graduation because they received a steady position, this could ultimately lead to a positive effect on The State's gross domestic product.

Please refer to the main body of the report for more information regarding impacts by strategy and phase as well as discussion of some of the potential reasons for employment gain in the top-gaining industries presented here. Please refer to Appendix B for a more detail explanation of direct, indirect, and induced impacts. The tables in Appendix D represent the top five gaining industries for each strategy and its phases in the left column, the total employment impact to the industry in the center column, and the five occupations with the highest employment in that industry in the right column.

D.1 Energy

3.1.1 Regional Greenhouse Gas Initiative (RGGI)—Investment Phase

Sales, office, administrative occupations	1.4	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	1.1	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	0.7	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	0.5	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	0.4	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.1.1 Regional Greenhouse Gas Initiative (RGGI)—Operation Phase

Protective service occupations	37.6	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Sales, office, administrative occupations	35.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	18.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	11.6	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	10.6	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

3.1.2 GHG Reductions from Imported Power—Investment Phase

Protective service occupations	0.0	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	0.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Legal occupations	0.0	Lawyers Judicial law clerks Judges, magistrates, and other judicial workers Paralegals and legal assistants Court reporters
Arts, design, entertainment, sports, media occupations	0.0	Artists and related workers Designers Entertainers and performers Sports and related workers Media and communications workers
Education, training, library occupations	0.0	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians

Sources: BLS, RESI

3.1.2 GHG Reductions from Imported Power—Operation Phase

Construction, extraction occupations	1.4	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Sales, office, administrative occupations	1.4	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	0.6	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Installation, maintenance, repair occupations	0.6	Computer, automated teller, and office machine repairers Radio and telecommunications equipment installers/repairers Aircraft mechanics and service technicians Automotive mechanics and service technicians Small engine mechanics
Computer, math, architect, engineer occupations	0.4	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers

Sources: BLS, RESI

3.1.3 Federal New Source Performance Standard—Investment Phase

Sales, office, administrative occupations	2.0	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	1.5	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	1.0	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	1.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	0.6	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.1.3 Federal New Source Performance Standard—Operation Phase

Construction, extraction occupations	2.3	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Sales, office, administrative occupations	2.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	0.9	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Installation, maintenance, repair occupations	0.9	Computer, automated teller, and office machine repairers Radio and telecommunications equipment installers/repairers Aircraft mechanics and service technicians Automotive mechanics and service technicians Small engine mechanics
Computer, math, architect, engineer occupations	0.6	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers

Sources: BLS, RESI

3.1.4 MACT—Investment Phase

Sales, office, administrative occupations	0.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	0.1	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	0.1	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	0.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Construction, extraction occupations	0.1	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers

Sources: BLS, RESI

3.1.4 MACT—Operation Phase

Protective service occupations	26.4	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Sales, office, administrative occupations	26.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	13.4	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	8.5	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	7.8	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

3.1.5 Energy Efficiency in the Residential Sector—Investment Phase

Sales, office, administrative occupations	816.5	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	614.8	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	401.0	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	395.7	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	236.5	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.1.5 Energy Efficiency in the Residential Sector—Operation Phase

Sales, office, administrative occupations	40.5	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Healthcare occupations	25.7	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	21.1	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	11.4	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Transportation, material moving occupations	3.8	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators

Sources: BLS, RESI

3.1.6 Energy Efficiency in the Commercial and Industrial Sectors—Investment Phase

Sales, office, administrative occupations	25.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	19.0	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	12.3	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	12.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	7.2	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.1.6 Energy Efficiency in the Commercial and Industrial Sectors—Investment Phase

Professional, scientific, and technical services	4.2	Lawyers Accountants and auditors Management analysts Architectural and civil drafters Market research analysts
Retail trade	3.6	Retail salespersons Cashiers Stock clerks and order fillers First-line supervisors/managers of retail sales workers Customer service representatives
Construction	1.1	Construction laborers Carpenters Electricians Operating engineers and other construction equipment operators Construction managers
Health care and social assistance	0.8	Registered nurses Nursing aides, orderlies, and attendants Home health aides Licensed practical and licensed vocational nurses Medical and health services managers
Administrative and support and waste management and remediation services	0.7	Janitors and cleaners, except maids and housekeeping cleaners Security guards Landscaping and grounds keeping workers Laborers and freight, stock, and material movers, hand Office clerks, general

Sources: BLS, RESI

3.1.6 Energy Efficiency in the Commercial and Industrial Sectors—Operation Phase

Sales, office, administrative occupations	219.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Building, grounds, personal care, service occupations	88.0	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Management, business, financial occupations	79.5	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Food preparation, serving related occupations	65.1	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Healthcare occupations	47.6	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.1.7 Energy Efficiency—Appliances and Other Products—Investment Phase

Farm, fishing, forestry occupations	0.0	Animal breeders Agricultural inspectors Fishers and hunters Forest and conservation workers Logging workers
Community, social service occupations	-0.1	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors
Legal occupations	-0.2	Lawyers Judicial law clerks Judges, magistrates, and other judicial workers Paralegals and legal assistants Court reporters
Life, physical, social science occupations	-0.2	Agricultural and food scientists Biological scientists Conservation scientists and foresters Epidemiologists Geoscientists
Arts, design, entertainment, sports, media occupations	-0.3	Artists and related workers Designers Entertainers and performers Sports and related workers Media and communications workers

Sources: BLS, RESI

3.1.7 Energy Efficiency—Appliances and Other Products—Operation Phase

Sales, office, administrative occupations	9.3	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Healthcare occupations	6.0	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	4.8	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	2.5	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Transportation, material moving occupations	0.9	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators

Sources: BLS, RESI

3.1.8 Energy Efficiency in the Power Sector—General—Investment Phase

Computer, math, architect, engineer occupations	32.4	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers
Sales, office, administrative occupations	29.4	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Production occupations	14.9	Assemblers and fabricators Food processing workers Metal workers and plastic workers Printing workers Textile, apparel, and furnishings workers
Management, business, financial occupations	14.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	7.4	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians

Sources: BLS, RESI

3.1.8 Energy Efficiency in the Power Sector—General—Operation Phase

Construction, extraction occupations	39.9	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Sales, office, administrative occupations	39.5	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	16.7	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Installation, maintenance, repair occupations	16.1	Computer, automated teller, and office machine repairers Radio and telecommunications equipment installers/repairers Aircraft mechanics and service technicians Automotive mechanics and service technicians Small engine mechanics
Computer, math, architect, engineer occupations	10.5	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers

Sources: BLS, RESI

3.1.9 Maryland Renewable Energy Portfolio Standard Subprogram—Investment Phase

Sales, office, administrative occupations	211.5	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Computer, math, architect, engineer occupations	210.3	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers
Management, business, financial occupations	94.4	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Production occupations	59.6	Assemblers and fabricators Food processing workers Metal workers and plastic workers Printing workers Textile, apparel, and furnishings workers
Construction, extraction occupations	56.0	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians

Sources: BLS, RESI

3.1.9 Maryland Renewable Energy Portfolio Standard Subprogram—Operation Phase

Farm, fishing, forestry occupations	-0.7	Animal breeders Agricultural inspectors Fishers and hunters Forest and conservation workers Logging workers
Community, social service occupations	-2.3	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors
Legal occupations	-5.7	Lawyers Judicial law clerks Judges, magistrates, and other judicial workers Paralegals and legal assistants Court reporters
Arts, design, entertainment, sports, media occupations	-6.4	Artists and related workers Designers Entertainers and performers Sports and related workers Media and communications workers
Life, physical, social science occupations	-6.6	Agricultural and food scientists Biological scientists Conservation scientists and foresters Epidemiologists Geoscientists

Sources: BLS, RESI

3.1.10 Incentives and Grant Subprograms to Support Renewable Energy—Investment Phase

Protective service occupations	23.4	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Healthcare occupations	5.3	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Sales, office, administrative occupations	5.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Building, grounds, personal care, service occupations	3.5	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Education, training, library occupations	2.6	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians

Sources: BLS, RESI

3.1.10 Incentives and Grant Subprograms to Support Renewable Energy—Operation Phase

Building, grounds, personal care, service occupations	16.7	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	11.3	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Sales, office, administrative occupations	7.8	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Healthcare occupations	4.9	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Arts, design, entertainment, sports, media occupations	0.9	Artists and related workers Designers Entertainers and performers Sports and related workers Media and communications workers

Sources: BLS, RESI

3.1.11 Offshore Wind Initiatives to Support Renewable Energy—Investment Phase

Sales, office, administrative occupations	16.4	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Computer, math, architect, engineer occupations	16.3	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers
Management, business, financial occupations	7.3	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	4.6	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Production occupations	4.3	Assemblers and fabricators Food processing workers Metal workers and plastic workers Printing workers Textile, apparel, and furnishings workers

Sources: BLS, RESI

3.1.11 Offshore Wind Initiatives to Support Renewable Energy—Operation Phase

Sales, office, administrative occupations	12.0	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Healthcare occupations	5.7	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Construction, extraction occupations	4.8	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Building, grounds, personal care, service occupations	4.7	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Management, business, financial occupations	2.8	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors

Sources: BLS, RESI

D.2 Transportation

3.2.1 Maryland Clean Cars Subprogram—Investment Phase

Sales, office, administrative occupations	495.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Transportation, material moving occupations	68.2	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators
Management, business, financial occupations	50.3	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Installation, maintenance, repair occupations	45.1	Computer, automated teller, and office machine repairers Radio and telecommunications equipment installers/repairers Aircraft mechanics and service technicians Automotive mechanics and service technicians Small engine mechanics
Construction, extraction occupations	43.5	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians

Sources: BLS, RESI

3.2.1 Maryland Clean Cars Subprogram—Operation Phase

Farm, fishing, forestry occupations	-0.7	Animal breeders Agricultural inspectors Fishers and hunters Forest and conservation workers Logging workers
Community, social service occupations	-0.7	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors
Legal occupations	-1.1	Lawyers Judicial law clerks Judges, magistrates, and other judicial workers Paralegals and legal assistants Court reporters
Life, physical, social science occupations	-1.2	Agricultural and food scientists Biological scientists Conservation scientists and foresters Epidemiologists Geoscientists
Education, training, library occupations	-3.3	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians

Sources: BLS, RESI

3.2.2 Federal Medium- and Heavy-Duty GHG Standards—Investment Phase

Farm, fishing, forestry occupations	-2.1	Animal breeders Agricultural inspectors Fishers and hunters Forest and conservation workers Logging workers
Community, social service occupations	-5.5	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors
Life, physical, social science occupations	-15.7	Agricultural and food scientists Biological scientists Conservation scientists and foresters Epidemiologists Geoscientists
Education, training, library occupations	-16.4	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians
Legal occupations	-17.5	Lawyers Judicial law clerks Judges, magistrates, and other judicial workers Paralegals and legal assistants Court reporters

Sources: BLS, RESI

3.2.2 Federal Medium- and Heavy-Duty GHG Standards—Investment Phase

Sales, office, administrative occupations	46.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Healthcare occupations	20.4	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Construction, extraction occupations	20.2	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Building, grounds, personal care, service occupations	16.5	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Management, business, financial occupations	12.4	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors

Sources: BLS, RESI

3.2.3 Clean Fuel Standard—Investment Phase

Farm, fishing, forestry occupations	-0.4	Animal breeders Agricultural inspectors Fishers and hunters Forest and conservation workers Logging workers
Community, social service occupations	-1.0	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors
Life, physical, social science occupations	-2.9	Agricultural and food scientists Biological scientists Conservation scientists and foresters Epidemiologists Geoscientists
Education, training, library occupations	-3.1	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians
Legal occupations	-3.3	Lawyers Judicial law clerks Judges, magistrates, and other judicial workers Paralegals and legal assistants Court reporters

Sources: BLS, RESI

3.2.3 Clean Fuel Standard—Operation Phase

Sales, office, administrative occupations	5.8	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Healthcare occupations	4.3	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	3.2	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	1.7	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Transportation, material moving occupations	0.6	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators

Sources: BLS, RESI

3.2.4 Transportation Climate Initiative—Investment Phase

Community, social service occupations	0.0	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors
Farm, fishing, forestry occupations	0.0	Animal breeders Agricultural inspectors Fishers and hunters Forest and conservation workers Logging workers
Life, physical, social science occupations	0.0	Agricultural and food scientists Biological scientists Conservation scientists and foresters Epidemiologists Geoscientists
Arts, design, entertainment, sports, media occupations	0.0	Artists and related workers Designers Entertainers and performers Sports and related workers Media and communications workers
Production occupations	0.0	Assemblers and fabricators Food processing workers Metal workers and plastic workers Printing workers Textile, apparel, and furnishings workers

Sources: BLS, RESI

3.2.5 Public Transportation Initiatives—Investment Phase

Sales, office, administrative occupations	554.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	403.1	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	271.1	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	267.8	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	161.4	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.2.5 Public Transportation Initiatives—Operation Phase

Healthcare occupations	104.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	96.5	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Transportation, material moving occupations	76.2	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators
Food preparation, serving related occupations	44.3	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Protective service occupations	43.0	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators

Sources: BLS, RESI

3.2.6 Initiatives to Double Transit Ridership by 2020—Investment Phase

Sales, office, administrative occupations	1,609.0	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	1,147.2	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	784.8	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	776.9	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	469.6	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.2.6 Initiatives to Double Transit Ridership by 2020—Operation Phase

Healthcare occupations	164.7	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	139.2	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	77.8	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Transportation, material moving occupations	25.7	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators
Construction, extraction occupations	21.3	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians

Sources: BLS, RESI

3.2.7 Intercity Transportation Initiatives—Investment Phase

Sales, office, administrative occupations	193.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	142.9	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	95.5	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	93.7	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	56.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.2.7 Intercity Transportation Initiatives—Operation Phase

Transportation, material moving occupations	92.7	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators
Sales, office, administrative occupations	20.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Building, grounds, personal care, service occupations	14.1	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Healthcare occupations	9.7	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Management, business, financial occupations	6.8	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors

Sources: BLS, RESI

3.2.8 Bike and Pedestrian Initiatives—Investment Phase

Sales, office, administrative occupations	607.7	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	454.4	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	300.1	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	295.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	176.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.2.8 Bike and Pedestrian Initiatives—Operation Phase

Healthcare occupations	0.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	0.0	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	0.0	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Construction, extraction occupations	0.0	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	0.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors

Sources: BLS, RESI

3.2.9 Pricing Initiatives—Investment Phase

Sales, office, administrative occupations	987.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	729.0	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	486.9	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	478.5	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	287.0	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.2.9 Pricing Initiatives—Operation Phase

Healthcare occupations	172.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	164.2	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	58.9	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Education, training, library occupations	19.0	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians
Management, business, financial occupations	18.3	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors

Sources: BLS, RESI

3.2.10 Transportation Technology Initiatives—Investment Phase

Sales, office, administrative occupations	5.9	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	4.5	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	2.9	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	2.8	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	1.7	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.2.10 Transportation Technology Initiatives—Operation Phase

Healthcare occupations	141.7	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	128.1	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	41.8	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Education, training, library occupations	14.7	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians
Community, social service occupations	10.5	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors

Sources: BLS, RESI

3.2.11 Electric Vehicle Initiatives—Investment Phase

Sales, office, administrative occupations	8.6	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	6.2	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	4.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	4.2	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	2.5	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.2.11 Electric Vehicle Initiatives—Operation Phase

Healthcare occupations	2.7	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	2.5	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	0.8	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Education, training, library occupations	0.3	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians
Community, social service occupations	0.2	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors

Sources: BLS, RESI

3.2.12 Low-Emitting Vehicles Initiatives—Investment Phase

Sales, office, administrative occupations	6.3	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	4.7	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	3.2	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	3.1	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	1.8	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.2.12 Low-Emitting Vehicles Initiatives—Operation Phase

Healthcare occupations	3.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	2.7	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	0.9	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Education, training, library occupations	0.3	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians
Community, social service occupations	0.2	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors

Sources: BLS, RESI

3.2.14 Airport Initiatives—Investment Phase

Sales, office, administrative occupations	151.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	112.5	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	75.8	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors
Management, business, financial occupations	73.7	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	44.0	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.2.14 Airport Initiatives—Operation Phase[277]

Management, business, financial occupations	0.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Computer, math, architect, engineer occupations	0.0	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers
Life, physical, social science occupations	0.0	Agricultural and food scientists Biological scientists Conservation scientists and foresters Epidemiologists Geoscientists
Community, social service occupations	0.0	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors
Legal occupations	0.0	Lawyers Judicial law clerks Judges, magistrates, and other judicial workers Paralegals and legal assistants Court reporters

Sources: BLS, RESI

[277] The operation phase of this policy did not have significant impacts on the gain or loss of employment in any occupational category.

3.2.15 Port Initiatives—Investment Phase

Sales, office, administrative occupations	4.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	3.1	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	2.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	2.0	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	1.2	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.2.15 Port Initiatives—Operation Phase[278]

Management, business, financial occupations	0.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Computer, math, architect, engineer occupations	0.0	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers
Life, physical, social science occupations	0.0	Agricultural and food scientists Biological scientists Conservation scientists and foresters Epidemiologists Geoscientists
Community, social service occupations	0.0	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors
Legal occupations	0.0	Lawyers Judicial law clerks Judges, magistrates, and other judicial workers Paralegals and legal assistants Court reporters

*
Sources: BLS, RESI

[278] The operation phase of this policy did not have significant impacts on the gain or loss of employment in any occupational category.

3.2.16 Freight and Freight Rail Strategies—Investment Phase

Sales, office, administrative occupations	4.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	3.1	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	2.0	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	2.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	1.2	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.2.16 Freight and Freight Rail Strategies—Operation Phase

Healthcare occupations	1.7	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	1.5	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	0.5	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Education, training, library occupations	0.2	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians
Community, social service occupations	0.1	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors

Sources: BLS, RESI

3.2.17 Renewable Fuels Standard—Operation Phase

Healthcare occupations	4.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	3.6	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	1.2	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Education, training, library occupations	0.4	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians
Community, social service occupations	0.3	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors

Sources: BLS, RESI

3.2.18 CAFE Standards: Model Years 2008-2011—Operation Phase

Healthcare occupations	2.5	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	2.3	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	0.7	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Education, training, library occupations	0.2	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians
Community, social service occupations	0.2	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors

Sources: BLS, RESI

3.2.19 Promoting Hybrid and Electric Vehicles—Investment Phase

Sales, office, administrative occupations	0.4	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	0.3	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	0.2	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	0.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Building, grounds, personal care, service occupations	0.1	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

3.2.19 Promoting Hybrid and Electric Vehicles—Operation Phase

Sales, office, administrative occupations	11.6	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Healthcare occupations	7.4	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	5.8	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	3.3	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Transportation, material moving occupations	1.2	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators

Sources: BLS, RESI

3.2.20 PAYD Insurance in Maryland—Operation Phase

Computer, math, architect, engineer occupations	0.0	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers
Healthcare occupations	0.0	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	0.0	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Sales, office, administrative occupations	0.0	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Community, social service occupations	0.0	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors

Sources: BLS, RESI

D.3 Agriculture and Forestry

3.3.1 Managing Forests to Capture Carbon—Investment Phase

Sales, office, administrative occupations	1.4	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	1.0	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	0.7	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	0.7	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	0.4	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.3.1 Managing Forests to Capture Carbon—Operation Phase

Farm, fishing, forestry occupations	9.3	Animal breeders Agricultural inspectors Fishers and hunters Forest and conservation workers Logging workers
Management, business, financial occupations	2.7	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Sales, office, administrative occupations	1.7	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Transportation, material moving occupations	1.1	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators
Building, grounds, personal care, service occupations	1.0	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

3.3.2 Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Investment Phase

Sales, office, administrative occupations	0.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	0.2	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	0.1	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	0.1	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	0.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.3.2 Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Operation Phase

Protective service occupations	110.5	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Sales, office, administrative occupations	91.6	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Construction, extraction occupations	44.6	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	42.6	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Computer, math, architect, engineer occupations	28.7	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers

Sources: BLS, RESI

3.3.3 Increasing Urban Trees to Capture Carbon—Investment Phase

Sales, office, administrative occupations	0.4	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	0.3	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	0.2	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	0.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Building, grounds, personal care, service occupations	0.1	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

3.3.3 Increasing Urban Trees to Capture Carbon—Operation Phase

Sales, office, administrative occupations	50.5	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Building, grounds, personal care, service occupations	32.3	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	20.9	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Healthcare occupations	19.3	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Management, business, financial occupations	16.4	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors

Sources: BLS, RESI

3.3.4 Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Investment Phase

Sales, office, administrative occupations	12.7	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	9.4	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	6.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	5.9	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	3.8	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.3.4 Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Operation Phase

Food preparation, serving related occupations	11.2	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Sales, office, administrative occupations	8.0	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Building, grounds, personal care, service occupations	5.1	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Transportation, material moving occupations	1.6	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators
Management, business, financial occupations	1.6	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors

Sources: BLS, RESI

3.3.5 Geological Opportunities to Store Carbon—Investment Phase

Sales, office, administrative occupations	0.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Healthcare occupations	0.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Management, business, financial occupations	0.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Arts, design, entertainment, sports, media occupations	0.0	Artists and related workers Designers Entertainers and performers Sports and related workers Media and communications workers
Building, grounds, personal care, service occupations	0.0	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

3.3.5 Geological Opportunities to Store Carbon—Operation Phase

Sales, office, administrative occupations	39.5	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	13.4	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Building, grounds, personal care, service occupations	11.1	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	8.6	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Installation, maintenance, repair occupations	8.0	Computer, automated teller, and office machine repairers Radio and telecommunications equipment installers/repairers Aircraft mechanics and service technicians Automotive mechanics and service technicians Small engine mechanics

Sources: BLS, RESI

3.3.6 Planting Forests in Maryland—Investment Phase

Farm, fishing, forestry occupations	22.4	Animal breeders Agricultural inspectors Fishers and hunters Forest and conservation workers Logging workers
Management, business, financial occupations	7.3	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Transportation, material moving occupations	7.1	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators
Building, grounds, personal care, service occupations	5.1	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Sales, office, administrative occupations	3.4	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters

Sources: BLS, RESI

3.3.6 Planting Forests in Maryland—Operation Phase

Sales, office, administrative occupations	0.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Healthcare occupations	0.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	0.0	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	0.0	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Transportation, material moving occupations	0.0	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators

Sources: BLS, RESI

3.3.7 Biomass for Energy Production—Investment Phase

Sales, office, administrative occupations	41.4	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	30.7	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	20.9	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	20.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	12.0	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.3.7 Biomass for Energy Production—Operation Phase

Construction, extraction occupations	1.2	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Sales, office, administrative occupations	1.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	0.5	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Installation, maintenance, repair occupations	0.4	Computer, automated teller, and office machine repairers Radio and telecommunications equipment installers/repairers Aircraft mechanics and service technicians Automotive mechanics and service technicians Small engine mechanics
Computer, math, architect, engineer occupations	0.3	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers

Sources: BLS, RESI

3.3.8 Conservation of Agricultural Land for GHG Benefits—Investment Phase

Sales, office, administrative occupations	18.9	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	14.3	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	9.3	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	9.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	5.5	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.3.8 Conservation of Agricultural Land for GHG Benefits—Operation Phase

Farm, fishing, forestry occupations	459.5	Animal breeders Agricultural inspectors Fishers and hunters Forest and conservation workers Logging workers
Management, business, financial occupations	193.7	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Sales, office, administrative occupations	85.9	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Transportation, material moving occupations	41.4	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators
Building, grounds, personal care, service occupations	36.5	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

3.3.9 Buy Local for GHG Benefits—Investment Phase

Sales, office, administrative occupations	5.0	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	3.9	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	2.4	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	2.4	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	1.4	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.3.9 Buy Local for GHG Benefits—Operation Phase

Farm, fishing, forestry occupations	29.4	Animal breeders Agricultural inspectors Fishers and hunters Forest and conservation workers Logging workers
Management, business, financial occupations	12.5	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Sales, office, administrative occupations	5.6	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Transportation, material moving occupations	2.7	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators
Building, grounds, personal care, service occupations	2.4	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

3.3.10 Nutrient Trading for GHG Benefits—Investment Phase

Sales, office, administrative occupations	1.6	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	1.2	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	0.8	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	0.8	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	0.4	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.3.10 Nutrient Trading for GHG Benefits—Operation Phase

Sales, office, administrative occupations	12.3	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Construction, extraction occupations	11.2	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Protective service occupations	7.3	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	5.8	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	3.2	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

D.4 Recycling

3.4.1 Recycling and Source Reduction—Operation Phase

Transportation, material moving occupations	2.9	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators
Community, social service occupations	0.0	Counselors Social workers Community and social service specialists Clergy Religious activities and education directors
Farm, fishing, forestry occupations	-0.1	Animal breeders Agricultural inspectors Fishers and hunters Forest and conservation workers Logging workers
Arts, design, entertainment, sports, media occupations	-0.2	Artists and related workers Designers Entertainers and performers Sports and related workers Media and communications workers
Production occupations	-0.3	Assemblers and fabricators Food processing workers Metal workers and plastic workers Printing workers Textile, apparel, and furnishings workers

Sources: BLS, RESI

D.5 Buildings

3.5.1 Building Codes—Investment Phase

Sales, office, administrative occupations	3.3	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	2.4	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	1.6	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	1.6	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	0.9	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.5.1 Building Codes—Operation Phase

Sales, office, administrative occupations	14.3	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	9.6	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	3.9	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Computer, math, architect, engineer occupations	3.5	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers
Building, grounds, personal care, service occupations	2.7	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

3.5.2 BeSMART—Investment Phase

Sales, office, administrative occupations	0.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	0.1	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	0.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	0.0	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	0.0	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.5.2 BeSMART—Operation Phase

Management, business, financial occupations	0.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	0.0	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Food preparation, serving related occupations	0.0	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Sales, office, administrative occupations	0.0	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	0.0	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators

Sources: BLS, RESI

3.5.3 Weatherization and Energy Efficiency for Low-Income Houses—Investment Phase

Sales, office, administrative occupations	1.3	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	1.1	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	0.7	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	0.6	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	0.4	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.5.3 Weatherization and Energy Efficiency for Low-Income Houses—Operation Phase

Healthcare occupations	0.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	0.1	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	0.1	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Management, business, financial occupations	0.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Education, training, library occupations	0.0	Postsecondary teachers Preschool, primary, and secondary teachers Special education teachers Librarians Archivists, curators, and museum technicians

Sources: BLS, RESI

D.6 Land Use

3.6.1 Reducing Transportation Issues through Smart Growth—Operation Phase

Construction, extraction occupations	6.1	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Sales, office, administrative occupations	1.7	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	0.9	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Installation, maintenance, repair occupations	0.8	Computer, automated teller, and office machine repairers Radio and telecommunications equipment installers/repairers Aircraft mechanics and service technicians Automotive mechanics and service technicians Small engine mechanics
Transportation, material moving occupations	0.5	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators

Sources: BLS, RESI

3.6.2 GHG Targets for Local Government's Transportation and Land Use Planning—Operation Phase

Sales, office, administrative occupations	10.3	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Healthcare occupations	6.3	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	5.0	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	2.9	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Transportation, material moving occupations	1.1	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators

Sources: BLS, RESI

3.6.3 Land Use Planning GHG Benefits—Investment Phase

Sales, office, administrative occupations	7.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	5.7	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	3.4	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	3.3	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	2.0	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.6.3 Land Use Planning GHG Benefits—Operation Phase

Construction, extraction occupations	49.8	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Sales, office, administrative occupations	14.5	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	7.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Installation, maintenance, repair occupations	6.4	Computer, automated teller, and office machine repairers Radio and telecommunications equipment installers/repairers Aircraft mechanics and service technicians Automotive mechanics and service technicians Small engine mechanics
Transportation, material moving occupations	4.0	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Subway and streetcar operators

Sources: BLS, RESI

3.6.4 Growth Boundary GHG Benefits—Investment Phase

Protective service occupations	1,690.9	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Sales, office, administrative occupations	982.9	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	455.7	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	446.2	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Construction, extraction occupations	242.3	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians

Sources: BLS, RESI

3.6.4 Growth Boundary GHG Benefits—Operation Phase

Construction, extraction occupations	189.9	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Sales, office, administrative occupations	154.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Production occupations	59.1	Assemblers and fabricators Food processing workers Metal workers and plastic workers Printing workers Textile, apparel, and furnishings workers
Management, business, financial occupations	58.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Installation, maintenance, repair occupations	49.2	Computer, automated teller, and office machine repairers Radio and telecommunications equipment installers/repairers Aircraft mechanics and service technicians Automotive mechanics and service technicians Small engine mechanics

Sources: BLS, RESI

D.7 Innovative Initiatives
3.7.1 Leadership-by-Example—Local Government—Investment Phase

Sales, office, administrative occupations	33.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Construction, extraction occupations	23.8	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Protective service occupations	18.7	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	14.7	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Food preparation, serving related occupations	9.0	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers

Sources: BLS, RESI

3.7.1 Leadership-by-Example—Local Government—Operation Phase

Sales, office, administrative occupations	51.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	31.9	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Building, grounds, personal care, service occupations	26.8	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	19.4	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Construction, extraction occupations	12.8	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians

Sources: BLS, RESI

3.7.2 Leadership-by-Example—Federal Government—Investment Phase

Sales, office, administrative occupations	16.4	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	12.3	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	8.0	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	7.9	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	4.7	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.7.2 Leadership-by-Example—Federal Government—Operation Phase

Sales, office, administrative occupations	206.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	174.9	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	105.3	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	78.5	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	68.8	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.7.3 Leadership-by-Example—Maryland University Lead-by-Example Initiatives—Investment Phase

Sales, office, administrative occupations	15.8	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	11.9	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Construction, extraction occupations	7.7	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Management, business, financial occupations	7.7	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	4.5	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.7.3 Leadership-by-Example—Maryland University Lead-by-Example Initiatives—Operation Phase

Sales, office, administrative occupations	16.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	15.4	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	8.4	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	5.6	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	5.0	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

3.7.4 Voluntary Stationary Source Reductions—Investment Phase

Sales, office, administrative occupations	0.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	0.1	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	0.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	0.0	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Building, grounds, personal care, service occupations	0.0	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

3.7.4 Voluntary Stationary Source Reductions—Operation Phase

Construction, extraction occupations	0.1	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Sales, office, administrative occupations	0.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	0.2	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Installation, maintenance, repair occupations	0.2	Computer, automated teller, and office machine repairers Radio and telecommunications equipment installers/repairers Aircraft mechanics and service technicians Automotive mechanics and service technicians Small engine mechanics
Computer, math, architect, engineer occupations	0.1	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers

Sources: BLS, RESI

3.7.5 State of Maryland Initiatives to Lead by Example—Investment Phase

Sales, office, administrative occupations	1.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	0.6	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	0.4	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Computer, math, architect, engineer occupations	0.4	Actuaries Software developers and programmers Database and system administrators Computer support specialists Aerospace, agricultural, biomedical, and other engineers
Healthcare occupations	0.3	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.7.5 State of Maryland Initiatives to Lead by Example—Operation Phase

Sales, office, administrative occupations	56.5	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	34.6	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Building, grounds, personal care, service occupations	28.3	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	20.2	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Construction, extraction occupations	14.8	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians

Sources: BLS, RESI

3.7.6 State of Maryland Carbon and Footprint Initiatives—Operation Phase

Sales, office, administrative occupations	129.0	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	102.7	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	62.9	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	47.8	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	39.6	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.7.7 Job Creation and Economic Development Initiatives Related to Climate Change—Operation Phase

All jobs would be accounted for in previous GGRA programs through green job training to meet new demand.

Sources: BLS, RESI

3.7.8 Public Health Initiatives Related to Climate Change—Investment Phase

Sales, office, administrative occupations	1.1	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	0.8	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	0.5	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Construction, extraction occupations	0.5	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians
Healthcare occupations	0.3	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.7.8 Public Health Initiatives Related to Climate Change—Operation Phase

Sales, office, administrative occupations	6.6	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Healthcare occupations	3.6	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	3.0	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Food preparation, serving related occupations	2.0	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers
Transportation, material moving occupations	1.0	Aircraft cargo handling supervisors Air traffic controllers Ambulance drivers and attendants Driver/Sales workers and truck drivers Retail sales workers

Sources: BLS, RESI

3.7.9 Title V Permits for GHG Sources—Investment Phase

Sales, office, administrative occupations	0.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	0.1	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	0.1	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	0.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Construction, extraction occupations	0.1	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians

Sources: BLS, RESI

3.7.9 Title V Permits for GHG Sources—Operation Phase

Protective service occupations	0.9	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Sales, office, administrative occupations	0.8	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	0.4	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Building, grounds, personal care, service occupations	0.3	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators
Healthcare occupations	0.3	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists

Sources: BLS, RESI

3.7.10 Outreach and Public Education—Investment Phase

Sales, office, administrative occupations	0.0	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	0.0	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Protective service occupations	0.0	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Healthcare occupations	0.0	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Food preparation, serving related occupations	0.0	Cooks Supervisors of food preparation workers Bartenders Waiters and waitresses Dishwashers

Sources: BLS, RESI

3.7.11 GHG Prevention of Significant Deterioration Permitting Program—Investment Phase

Sales, office, administrative occupations	0.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Protective service occupations	0.1	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Management, business, financial occupations	0.1	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	0.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Construction, extraction occupations	0.1	Supervisors of construction trade workers Carpenters Brick masons, block masons, and stonemasons Construction equipment operators Electricians

Sources: BLS, RESI

3.7.11 GHG Prevention of Significant Deterioration Permitting Program—Operation Phase

Protective service occupations	0.2	Fire fighters and inspectors Bailiffs, correctional officers, and jailers Fish and game wardens Animal control workers Private detectives and investigators
Sales, office, administrative occupations	0.2	Retail sales workers Advertising sales agents Insurance sales agents Sales representatives in wholesale and manufacturing Models, demonstrators, and product promoters
Management, business, financial occupations	0.1	Legislators Advertising, marketing, and sales managers Compliance officers Cost estimators Accountants and auditors
Healthcare occupations	0.1	Dentists Dietitians and nutritionists Physicians and surgeons Nurses and home health aides Occupational therapists
Building, grounds, personal care, service occupations	0.1	Supervisors of cleaning and maintenance workers Housekeeping and janitorial workers Pest control workers Landscaping and grounds keeping workers Pesticide handlers, sprayers, and applicators

Sources: BLS, RESI

Appendix E—References by Subject Area

E.1 Energy

2009 County Business Patterns. Censtats Database. NAICS, 2009. Web. 11 Nov. 2011. <http://censtats.census.gov/cgi-bin/cbpnaic/cbpsect.pl>.

A Guide to Energy-Efficient Heating and Cooling. ENERGY STAR. United States Environmental Protection Agency, Aug. 2009. Web. 16 Nov. 2011. <http://www.energystar.gov/ia/partners/publications/pubdocs/HeatingCoolingGuide%20 FINAL_9-4-09.pdf>.

Appliances. SMECO - Southern Maryland Electric Cooperative. Rebates for New Appliances. Web. 16 Nov. 2011. <https://www.smeco.coop/save/appliance/>.

"Average Energy Prices in the Washington-Baltimore Area." U.S. Bureau of Labor Statistics. 27 Sept. 2011. 11 Nov. 2011 <http://www.bls.gov/ro3/apwb.htm#wb_energy_table1>.

“Average Home Heating Oil Prices.” U.S. Energy Information Agency. EIA. Gov. Web. 16 Nov 2011. < http://www.eia.gov/>

Barnitt, Robb A. "In-Use Performance Comparison of Hybrid Electric, CNG & Diesel." National Renewable Energy Laboratory (NREL) Home Page. U.S. Department of Energy, June 2008. Web. 14 Nov. 2011. <http://www.nrel.gov/vehiclesandfuels/fleettest>.

“Clean Energy Production Tax Credit.” Maryland Energy Administration. Accessed October 17, 2012. http://energy.maryland.gov/Business/CleanEnergyTaxCredit.html.

Commercial and Industrial Rebate Program. Allegheny Energy, Inc. Allegheny Energy, Inc., 25 June 2011. Web. 16 Nov. 2011. <http://www.alleghenypower.com/EngConserv/MDBus/Lighting.asp>.

Delmarva - Appliance Rebate Program. Delmarva Power. Pepco Holdings Inc., 2011. Web. 16 Nov. 2011. <http://homeenergysavings.delmarva.com/md/appliance-rebate>.

Early Reduction CO2 Allowance Awards. Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program. Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program, 18 Dec. 2009. Web. 16 Nov. 2011. <http://www.rggi.org/docs/md_proceeds_by_auction.pdf>.

EERE State Activities and Partnerships: Energy Consumption in Maryland Homes. U.S. DOE Energy Efficiency and Renewable Energy (EERE) Home Page. U.S. DOE Energy Efficiency and Renewable, 15 Aug. 2008. Web. 16 Nov. 2011. <http://apps1.eere.energy.gov/states/residential.cfm/state=MD>.

Energy Savings Program - Delmarva Power. Energy Savings Program - Delmarva Power. Pepco Holdings Inc., 2010. Web. 16 Nov. 2011. <https://cienergyefficiency.delmarva.com/Lighting.aspx>.

Energy Solutions for Business Lighting & Controls | BGE Smart Energy Savers Program. Smart Energy Savers Programs | BGE Smart Energy Savers Program. Baltimore Gas and Electric, 2010. Web. 16 Nov. 2011. <https://www.bgesmartenergy.com/business/energy-solutions-business/lighting-controls>.

"Frequently Asked Questions: How Much Electricity Does an American Home Use?" United States Energy Information Administration. Accessed October 17, 2012. http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3.

Fuel Cost Comparison: Wood vs. Natural Gas. Forester's Coop. Forester's Coop. Web. 16 Nov. 2011. <http://www.forco-op.com/project/wood_fuel_comp.pdf>.

Innovation. Performance. Savings. ENERGY STAR. United States Department of Energy, 2011. Web. 16 Nov. 2011. <http://www.energystar.gov/ia/partners/manuf_res/CFL_PRG_FINAL.pdf>.

Jane E. Lawton Conservation Loan Program (JELLP). Maryland Energy Administration. Maryland Energy Administration. Web. 16 Nov. 2011. <http://energy.maryland.gov/govt/janeelawton.html>.

Lighting and Appliances Appliance Rebates | BGE Smart Energy Savers Program. Smart Energy Savers Programs | BGE Smart Energy Savers Program. Baltimore Gas and Electric, 2010. Web. 16 Nov. 2011. <https://www.bgesmartenergy.com/residential/lighting-appliances/appliance-rebates>.

Lowest Diesel Fuel Prices in the Last 24 Hours. Maryland Gas Prices - Find Cheap Gas Prices in Maryland. 2011. Web. 14 Nov. 2011. <http://www.marylandgasprices.com/index.aspx?fuel=D>.

Maryland | Retail Means Jobs. Retail Means Jobs | Retail Supports 1 in 4 American Jobs | 42 Million Strong. PricewaterhouseCoopers LLP, July-Aug. 2011. Web. 11 Nov. 2011. <http://www.retailmeansjobs.com/data/MD/0>.

"Maryland Auto Outlook." Www.mdauto.org. 9 Aug. 2011. Maryland Automobile Dealers Association. 11 Nov. 2011 <http://www.mdauto.org/admin/publications/AutoOutlookQuarter22011.pdf>.

Maryland Energy Administration. "Maryland Governor Martin O'Malley Celebrates the Completion of the Largest Solar Farm in the State." Press release, Emmitsburg, Maryland, 2012.

Maryland Energy Administration. “Maryland Offshore Wind Energy Act of 2012 Facts & Figures.” Press release, Annapolis, Maryland, 2012.

"Maryland Energy Consumption Data."Redux Energy: Sustainable Geospatial Products and Services Network. 11 Nov. 2011. Maryland Energy Portal - Maryland's Carbon Footprint. 11 Nov. 2011 <http://www.eredux.com/states/state_detail.php?id=1129>.

Maryland Home Energy Loan Program. Maryland Home Energy Loan Program. Maryland Clean Energy Centre, 2010. Web. 16 Nov. 2011. <http://www.mcecloans.com/Module/Ext/ExtInfo.aspx?ModulePageAdmin=0fe789d7-d5fc-4297-9917-db58ccb8a660&&ModulePageVisitor=4b0b3b8a-4f4a-4192-98e8-4f0e35b75d90>.

Maryland QuickFacts from the US Census Bureau. State and County QuickFacts. U.S. Census Bureau, 13 Oct. 2011. Web. 11 Nov. 2011. <http://quickfacts.census.gov/qfd/states/24000.html>.

Maryland Save Energy Now. Maryland Energy Administration. Maryland Energy Administration. Web. 16 Nov. 2011. <http://energy.maryland.gov/sen/index.html>.

MEA-Project Sunburst. Maryland Energy Administration. Maryland Energy Administration, 2011. Web. 16 Nov. 2011. <http://energy.maryland.gov/govt/sunburst.html>.

Motavalli, Jim. "In a Blackout, Nissan, Mitsubishi and Toyota E.V.'s Could Function as Generators - NYTimes.com." Automobiles - Wheels Blog - NYTimes.com 1 Sept. 2011. 22 Nov. 2011 <http://wheels.blogs.nytimes.com/2011/09/01/in-a-blackout-nissan-mitsubishi-and-toyota-e-v-s-could-function-as-generators/>.

Natural Gas Weekly Update. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration, 9 Nov. 2011. Web. 14 Nov. 2011. <http://www.eia.gov/oog/info/ngw/ngupdate.asp>.

Princeton Energy Resources International, LLC, and Exter Associates, Inc. "The Potential for Biomass Cofiring in Maryland." Maryland Powerplant Research Program. Mar. 2006. Maryland Department of Natural Resources (DNR). 11 Nov. 2011 <http://esm.versar.com/pprp/bibliography/PPES_06_02/PPES_06_02.pdf>.

“Project Sunburst.” Maryland Energy Administration. Accessed October 17, 2012. http://energy.maryland.gov/Govt/sunburst.html.

"Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Auction 13." Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Welcome. 7 Sept. 2011. 11 Nov. 2011 <http://www.rggi.org/market/co2_auctions/results/auction_13>.

Reported E85 Prices. E85 Prices. E85 Prices, 2011. Web. 14 Nov. 2011. <http://e85prices.com/>.

Residential Clean Energy Grant Program. Maryland Energy Administration. Maryland Energy Administration, 2011. Web. 16 Nov. 2011. <http://energy.maryland.gov/Residential/cleanenergygrants/index.html#updates>.

Search for Cars That Don't Need Gas. Fuel Economy. Fuel Economy, 2011. Web. 14 Nov. 2011. <http://www.fueleconomy.gov/feg/byfueltype.htm>.

StateStat. Maryland StateStat Report. Department of Housing & Community Development, July 2011. Web. 11 Nov. 2011. <http://www.statestat.maryland.gov/reports/20110825_DHCD_Template.pdf>.

Strong Finish to 2011 Natural Gas Storage Injection Season. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration (EIA), Oct. 2011. Web. 14 Nov. 2011. <http://www.eia.gov/>.

Weatherization and Intergovernmental Program: Weatherization Assistance Program. EERE: EERE Server Maintenance. U.S. Department of Energy, 25 Apr. 2011. Web. 11 Nov. 2011. <http://www1.eere.energy.gov/wip/wap.html>.

” Windswept Grant Program.” Maryland Energy Administration. Accessed October 17, 2012. http://energy.maryland.gov/windswept/index.html.

E.2 Transportation

2002 Economic Census: Vehicle Inventory and Use Survey; Geographic Area Series. Sept. 2004. US Census Bureau. 14 Nov. 2011 <http://www.census.gov/prod/ec02/ec02tv-md.pdf>.

2009 National Household Travel. National Household Travel Survey. U.S. Department of Transportation, 2009. Web. 14 Nov. 2011. <http://nhts.ornl.gov/2009/pub/stt.pdf>.

2010 Annual Report. Rabbittransit-Welcome. Rabbittransit, 2011. Web. 14 Nov. 2011. <http://www.rabbittransit.org/docs/2010_Annual_Report.pdf>.

AAA Association Communication, "Your Driving Costs." Last modified 2012. Accessed October 2012. http://newsroom.aaa.com/wp-content/uploads/2012/04/YourDrivingCosts2012.pdf.

Allison Hybrid H 40 EP | H 50 EP. Allisontransmission.com. 2011. Allison Transmission. 14 Nov. 2011 <http://www.allisontransmission.com/servlet/DownloadFile?Dir=publications/pubs&FileToGet=SA5983EN.pdf>

Auto Insurance. Insurance Information Institute. U.S. Department of Labor, Bureau of Labor Statistics; National Association of Realtors, 2011. Web. 11 Nov. 2011. <http://www.iii.org/media/facts/statsbyissue/auto/>.

Average Annual Miles per Driver by Age Group. 4 April 2011. U.S. Department of Transportation (USDOT), Federal Highway Administration (FHA), Office of Highway Policy Information (OHPI). Web. 11 Nov. 2011. <http://www.fhwa.dot.gov/ohim/onh00/bar8.htm>.

Average Energy Prices in the Washington-Baltimore Area. Mid-Atlantic Information Office. 27 Sept. 2011. U.S. Bureau of Labor Statistics (BLS). 11 Nov. 2011 <http://www.bls.gov/ro3/apwb.htm#wb_energy_table1>.

"Average Home Heating Oil Prices." U.S. Energy Information Agency. EIA. Gov. Web. 16 Nov 2011. <http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RCLC1&f=D >

Average Fuel Economy Standards for Light Trucks. Department of Transportation. 14 Nov. 2011 <http://www.nhtsa.gov/DOT/NHTSA/Rulemaking/Rules/Associated%20Files/2006FinalRule.pdf>

Baker, Michael, and Cambridge Systematics. "Maryland Climate Action Plan Draft 2012." Maryland Department of Transportation. Maryland Department of Transportation, 11 Apr. 2011. Web. 16 Nov. 2011. <http://www.mdot.maryland.gov/Planning/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf>.

"Baltimore Ready to Install 9 Electric Vehicle Charging Stations." General Services / Press Releases. 2010. City of Baltimore, Maryland - Official Website. 14 Nov. 2011 <http://baltimorecity.gov/Government/AgenciesDepartments/GeneralServices/PressReleases/tabid/1028/articleType/ArticleView/articleId/1143/Baltimore-Ready-to-Install-9-Electric-Vehicle-Charging-Stations.aspx>.

Barnitt, Robb A. "In-Use Performance Comparison of Hybrid Electric, CNG & Diesel." National Renewable Energy Laboratory (NREL) Home Page. U.S. Department of Energy, June 2008. Web. 14 Nov. 2011. <http://www.nrel.gov/vehiclesandfuels/fleettest>.

Bicycle Helmets. American College of Emergency Physicians. American College of Emergency Physicians, 2011. Web. 11 Nov. 2011. <http://www.acep.org/content.aspx?id=25986>.

Bureau of Transportation Statistics. "Table 4-23: Average Fuel Efficiency of U.S. Light Duty Vehicles." Research and Innovative Technology Administration. Accessed October 17, 2012. http://www.bts.gov/publications/national_transportation_statistics/html/table_04_23.htm.

Car Loan Calculator | Monthly Payments | Incentives - Cars.com. New Cars, Used Cars, Car Reviews, Car Finance Advice - Cars.com. 2011. Cars.com. 14 Nov. 2011 <http://www.cars.com/finance/>.

Chronology of Maryland's Part 70 Permit Program. The Department of the Environment. 14 Nov. 2011 <http://www.mde.state.md.us/programs/Permits/AirManagementPermits/TitleVProgramInformation/Pages/title5factsheet.aspx>

Civilian Labor Force, Employment & Unemployment by Place of Residence (LAUS) - Maryland - Division of Workforce Development and Adult Learning. Welcome to the Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 21 Oct. 2011. Web. 14 Nov. 2011. <http://www.dllr.state.md.us/lmi/laus/maryland.shtml>.

"Clean Fuels Standard." Northeast States for Coordinated Air Use Management. Accessed October 17, 2012. http://www.nescaum.org/topics/clean-fuels-standard.

Colleges - Miles and Minutes. 2011. Baltimore Collegetown Network. 14 Nov. 2011 <http://www.baltimorecollegetown.org/colleges/miles-and-minutes/>.

Csere, Csaba. "How Automakers Will Meet 2016 CAFE Standards - Feature - Car and Driver." Car Reviews - 2011 Car Reviews and 2012 New Cars at Car and Driver. May 2011. Car and Driver. 11 Nov. 2011 <http://www.caranddriver.com/features/how-automakers-will-meet-2016-cafe-standards>.

"Daily Garage." Parking. Baltimore/Washington International Thurgood Marshall Airport, 2011. Web. 19 Aug. 2011.

Daily Fuel Gauge Report—national, state and local average prices for gasoline, diesel and E-85. 11 Nov. 2011. Oil Price Information Service (OPIS). 11 Nov. 2011 <http://fuelgaugereport.aaa.com/?redirectto=http://fuelgaugereport.opisnet.com/index.asp>.

Data - Prices. Maryland. Nov. 2011. U.S. Energy Information Administration (EIA). 14 Nov. 2011 <http://www.eia.gov/state/state-energy-profiles-data.cfm?sid=MD#Prices>.

Departmental Mission Statement. Department of Transportation. University of Maryland, 2011. Web. 14 Nov. 2011. <http://www.transportation.umd.edu/images/about/pdfs/ANNUAL%20REPORT%20FY%2011.pdf>.

Documents—Resource Types—SFpark. SFpark. Municipal Transportation Agency, 2011. Web. 16 Nov. 2011. <http://sfpark.org/resource-type/documents/>.

Dresser, Michael. "New cars may ease MARC crowding - Baltimore Sun." Featured Articles From The Baltimore Sun. 20 Aug. 2008. The Baltimore Sun. 14 Nov. 2011 <http://articles.baltimoresun.com/2008-08-20/news/0808190131_1_marc-new-cars-passenger-cars>.

"Electric Vehicle Charging Stations." 2010. EVsRoll.com. 14 Nov. 2011 <http://www.evsroll.com/Electric_Vehicle_Charging_Stations.html>.

Employment and Payrolls - Industry Series - Maryland 2009 - Employment and Payrolls - Division of Workforce Development and Adult Learning. Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 1 June 2011. Web. 11 Nov. 2011. <http://www.dllr.state.md.us/lmi/emppay/md2010ep.shtml>.

Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator." Last modified 2012. Accessed October 2012. http://www.epa.gov/cleanenergy/energy-resources/calculator.html.

"EPA and NHTSA Propose First-Ever Program to Reduce Greenhouse Gas Emissions and Improve Fuel Efficiency of Medium- and Heavy-Duty Vehicles | US EPA." Transportation and Climate. Oct. 2010. US Environmental Protection Agency (EPA). 14 Nov. 2011 <http://www.epa.gov/oms/climate/regulations/420f10901.htm>.

Express Bus Monthly Pass | Maryland Transit Administration. Maryland Transit Administration. Department of Transportation, 2011. Web. 11 Nov. 2011. <https://mta.maryland.gov/pass-store/express-bus-monthly-pass>.

Facts About Bicycling as a Commute Option. California Bicycling Information from Bike Link. Web. 14 Nov. 2011. <http://www.californiabikecommute.com/>.

Freight Railroads in Maryland. Association of American Railroads. 2009. Web. 11 Nov. 2011. < http://www.aar.org/Railroads-States/Maryland-2009.pdf>.

Free Wheelin' Bike Program. City of Annapolis, MD - Official Website. City of Annapolis, MD, 2011. Web. 11 Nov. 2011. <http://www.annapolis.gov/government/departments/Transportation/BikeAnnapolis/FreeWheelin.aspx>.

Fuel Efficiency. CSX Corporation. Web. 11 Nov. 2011. < http://www.csx.com/index.cfm/about-csx/projects-and-partnerships/fuel-efficiency/>.

Governor's Delivery Unit. Maryland StateStat. Maryland StateStat, 2011. Web. 11 Nov. 2011. <http://www.statestat.maryland.gov/gdutransit.asp>.

Green Port of Baltimore. Air Quality. Maryland Department of Transportation; Port Administration. 11 Nov. 2011 <http://mpa.maryland.gov/content/air-quality.php>.

"How We Calculate Your Carbon Footprint." Carbon offsets for your carbon footprint & fighting global warming. 2011. CarbonFund.org. 14 Nov. 2011 <http://www.carbonfund.org/site/pages/carbon_calculators/category/Assumptions#Transportation>.

ISDH: ISDH Home. IN.gov: Home. IN.gov. Web. 14 Nov. 2011. <http://www.in.gov/isdh/files/Idling_Brochure.>.

Issued Part 70 Permits. The Department of the Environment. 14 Nov. 2011 http://www.mde.state.md.us/programs/Permits/AirManagementPermits/TitleVProgramInformation/Pages/title5issuedpermits.aspx

Journal of Public Transportation. 4th ed. Vol. 10. Ser. 2007. Guaranteed Ride Home Programs. Federal Transpiration Administration. Web. 14 Nov. 2011. <http://www.nctr.usf.edu/jpt/pdf/JPT%2010-4%20Menczer.pdf>.

KFH Group, Inc. "Harford County Transportation Development Plan." Harford County. June 2007. Office of Planning, Maryland Transit Administration (MTA). 14 Nov. 2011 <http://www.harfordcountymd.gov/services/community/doc/985.pdf>.

Lowest Diesel Fuel Prices in the Last 24 Hours. Maryland Gas Prices - Find Cheap Gas Prices in Maryland. 2011. Web. 14 Nov. 2011. <http://www.marylandgasprices.com/index.aspx?fuel=D>.

MARC Growth and Investment Plan. Maryland Transit Administration. Maryland Transit Administration, Sept. 2007. Web. 14 Nov. 2011. <http://mta.maryland.gov/sites/default/files/marcplanfull.pdf>.

MARC Parking Details | Maryland Transit Administration. Home | Maryland Transit Administration. Nov. 2011. Maryland Transit Administration (MTA). 14 Nov. 2011 <http://mta.maryland.gov/marc-parking-details>.

MARC Station Information | Maryland Transit Administration. Home | Maryland Transit Administration. Maryland Transit Administration, 14 Nov. 2011. Web. 14 Nov. 2011. <http://mta.maryland.gov/marc-station-information>.

MARC Train Service Order Form. CommuterDirect.com®. 2011. MARC. 14 Nov. 2011 <https://www.commuterpage.com/orderforms/transitorders_v3.cfm?sysid=12>.

“MARC Train System Parking Information.” Maryland Transit Administration. Department of Transportation, Aug. 2010. Web. 19 Aug. 2011.

Maryland Auto Outlook. Www.mdauto.org. 9 Aug. 2011. Maryland Automobile Dealers Association. 11 Nov. 2011 <http://www.mdauto.org/admin/publications/AutoOutlookQuarter22011.pdf>.

Maryland Moves. Baltimore Metropolitan Council. Baltimore Metropolitan Council for the Regional Transportation Board May 2006. Web. 16 Nov. 2011. <http://www.baltometro.org/eNews/MM-5-06.pdf>.

Maryland Transit Administration, "Red Line Financial Plan Synopsis." Last modified 2012. Accessed October 2012. http://www.baltimoreredline.com/images/stories/redline_documents/preliminary_engineering/04_financial_plan/01_Financial_Plan_Synopsis.pdf.

Maryland Transit Administration, "Purple Line Financial Plan." Last modified 2012. Accessed October 2012. http://dlslibrary.state.md.us/publications/JCR/2010/2010_61(PL).pdf.

Maryland QuickFacts from the US Census Bureau. State and County QuickFacts. U.S. Census Bureau, 13 Oct. 2011. Web. 11 Nov. 2011. <http://quickfacts.census.gov/qfd/states/24000.html>.

MdTA Toll Facilities. MdTA Index. Maryland Transportation Authority, 2011. Web. 14 Nov. 2011. <http://www.mdta.maryland.gov/TollFacilities/facilities.html>.

Maryland Department of Transportation. “Draft 2012 Implementation Play—Appendix.” Maryland Climate Action Plan. 2011. Accessed October 17, 2012. http://www.mdot.maryland.gov/Office%20of%20Planning%20and%20Capital%20Programming/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf.

Menczer, William B. Journal of Public Transportation. 4th ed. Vol. 10. Ser. 2007. Guaranteed Ride Home Programs. Federal Transportation Administration. Web. 14 Nov. 2011. <http://www.nctr.usf.edu/jpt/pdf/JPT%2010-4%20Menczer.pdf>.

Monthly Statistical Report. BWI Airport. BWI Airport, 01 Aug. 2011. Web. 14 Nov. 2011. <http://www.bwiairport.com/files/assets/stats/August%202011.pdf#zoom=100>.

Motavalli, Jim. "In a Blackout, Nissan, Mitsubishi and Toyota E.V.'s Could Function as Generators - NYTimes.com." Automobiles - Wheels Blog - NYTimes.com 1 Sept. 2011. 22 Nov. 2011 <http://wheels.blogs.nytimes.com/2011/09/01/in-a-blackout-nissan-mitsubishi-and-toyota-e-v-s-could-function-as-generators/>.

Motor Vehicle Administration. “2011 Car Sales Statistics.” Department of Transportation. Accessed October 17, 2012. http://www.mva.maryland.gov/About-MVA/statistics/11sum.htm.

National Transit Information. National Transit Database. National Transit Database, 2011. Web. 14 Nov. 2011. <http://www.ntdprogram.gov/ntdprogram/cs?action=showRegionAgencies&region=3>.

Natural Gas Weekly Update. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration, 9 Nov. 2011. Web. 14 Nov. 2011. <http://www.eia.gov/oog/info/ngw/ngupdate.asp>.

“New cars may ease MARC crowding.” The Baltimore Sun. The Baltimore Sun, 20 Aug. 2008. Web. 19 Aug. 2011.

New Hybrid Crane to Reduce the Carbon Footprint. About MAERSK. 31 March 2011. MAERSK. 11 Nov. 2011. <http://www.maersk.com/AboutMaersk/News/Pages/20110331-154630.aspx>.

O'Malley, Martin, Anthony Brown, and Beverly Swaim-Staley. Maryland Department of Transportation, "Maryland Climate Action Plan." Last modified 2012. Accessed October 2012. http://www.mdot.maryland.gov/Office of Planning and Capital Programming/Plans_Programs_Reports/Documents/Climate_Change_2011_Appendix.pdf.

Parking. Baltimore Washington International Thurgood Marshall Airport. 11 Nov. 2011 < http://www.bwiairport.com/en/parking/information-rates/daily-garage>.

Pathways to Reduced Transportation CO2 in the Year 2050. Cornell University. 11 Nov. 2011 <http://www.cee.cornell.edu/academics/graduate/loader.cfm?csModule=security/getfile&PageID=84226>.

Port of Baltimore. 2009. Ports America - Home. PortsAmerica.com 11 Nov. 2011 <http://www.portsamerica.com/baltimore-maryland.html>.

Project Benefits. Maryland Hybrid Truck Initiative (MHTI) a U.S. DOE Clean Cities project. 14 Nov. 2011 <http://www.marylandhti.com/project-benefits/>.

Rail Track Mileage and Number of Class I Rail Carriers, United States, 1830-2008. The Geography of Transport Systems. Web. 14 Nov. 2011. < http://people.hofstra.edu/geotrans/eng/ch3en/conc3en/usrail18402003.html>.

RabbitEXPRESS—Fares and Accommodations. Rabbittransit - Welcome! York County Transportation Authority, 2011. Web. 14 Nov. 2011. <http://www.rabbittransit.org/express/pages/cashfarechart.html>.

Regular Fares | Maryland Transit Administration. Home | Maryland Transit Administration. Maryland Transit Administration, 14 Nov. 2011. Web. 14 Nov. 2011. <http://mta.maryland.gov/regular-fares>.

Reported E85 Prices. E85 Prices. E85 Prices, 2011. Web. 14 Nov. 2011. <http://e85prices.com/>.

Residence Halls at a Glance. Department of Resident Life | University of Maryland, College Park. Department of Resident Life | University of Maryland, College Park, 2011. Web. 14 Nov. 2011. <http://www.resnet.umd.edu/hallsatglance/>.

"Riding Public Transit Saves Individuals $9,242 Annually." APTA Homepage. 1 Dec. 2010. American Public Transportation Association (APTA). 14 Nov. 2011 <http://www.apta.com/mediacenter/pressreleases/2010/Pages/100112_Transit_Savings.aspx>.

RITA | BTS | Table 4-15: Bus Fuel Consumption and Travel. RITA | Bureau of Transportation Statistics (BTS). Bureau of Transportation, 26 Apr. 2010. Web. 14 Nov. 2011. <http://www.bts.gov/publications/national_transportation_statistics/html/table_04_15.html>.

"RITA | ITS | Benefits: The Texas Traffic Light Synchronization program reduced delays by 24.6 percent by updating traffic signal control equipment and optimizing signal timing." RITA | ITS | Welcome to the Costs Database. 10 Aug. 2005. U.S. Department of Transportation (USDOT). 11 Nov. 2011 <http://www.itscosts.its.dot.gov/its/benecost.nsf/ID/D0DCC197DC7382BE852573D8006F7EDA?OpenDocument>.

Saka, Anthony A., Dennis K. Agboh, Simon Ndiritu, and Richard A. Glassco. "An Estimation of Mobile Emissions Reduction." RITA | National Transportation Library. National Transportation Centre, Mar. 2000. Web. 14 Nov. 2011. <http://ntl.bts.gov/lib/16000/16800/16888/PB2000105915.pdf>.

Search for Cars That Don't Need Gas. Fuel Economy. Fuel Economy, 2011. Web. 14 Nov. 2011. <http://www.fueleconomy.gov/feg/byfueltype.htm>.

Shoup, Donald C. "Cruising for Parking." Transport Policy. Donald C. Shoup, 24 July 2006. Web. 11 Nov. 2011. <http://shoup.bol.ucla.edu/>.

Staff Bios | Georgetown Climate Center. Georgetown Climate Center |. Georgetown Climate Center. Web. 14 Nov. 2011. <http://www.georgetownclimate.org/about-us/staff-bios>.

Starcrest Consulting Group, LLC. "Rubber Tired Gantry (RTG) Crane Load Factor Study." Nov. 2009. Port of Los Angeles; Port of Long Beach. 14 Nov. 2011 <http://www.polb.com/civica/filebank/blobdload.asp?BlobID=6915>.

"State & Urbanized Area Statistics - Our Nation's Highways - 2000." Home | Federal Highway Administration. 4 Apr. 2011. Federal Highway Administration (FHWA). 11 Nov. 2011 <http://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm>.

Strong Finish to 2011 Natural Gas Storage Injection Season. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration (EIA), Oct. 2011. Web. 14 Nov. 2011. <http://www.eia.gov/>.

Task Force on Renewable Alternative Fuels. State of Maryland. 31 Dec. 2007. Web. 14 Nov. 2011. < http://www.mda.state.md.us/pdf/altfuelsreport.pdf>.

Taxi Fares in Major U.S. Cities. Schaller Consulting Home Page. Schaller Consulting, Jan. 2006. Web. 14 Nov. 2011. <http://www.schallerconsult.com/taxi/fares1.htm>.

The Federal Reserve Bank of Minneapolis, "Consumer Price Index." Last modified 2012. http://www.minneapolisfed.org/community_education/teacher/calc/hist1913.cfm.

Tile V Fee Sheet. The Department of the Environment. 14 Nov. 2011 <http://www.mde.state.md.us/programs/Permits/AirManagementPermits/TitleVProgramInformation/Pages/title5feesheet.aspx>

Transit Fare. City of Annapolis, MD - Official Website. The City of Annapolis, MD, 14 Nov. 2011. Web. 14 Nov. 2011. <http://www.annapolis.gov/Government/Departments/Transportation/TransitFare.aspx>.

Truck and Locomotive Idling Solutions. South East Diesel Collaborative, 25 June 2008. Web. 14 Nov. 2011. <http://www.southeastdiesel.org/Presentations%20for%203rd%20Annual%20Meeting/Day%202/Idle%20Reduct%20Tech-%20anthony%20erb.pdf>.

Truck Stop Electrification. California Energy Commission. California Energy Commission, June 2006. Web. 16 Nov. 2011. <http://www.energy.ca.gov/2006publications/CEC-600-2006-001/CEC-600-2006-001-FS.PDF>.

United States Environmental Protection Agency. 2011. "Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles: EPA Response to Comments Document for Join Rulemaking." August 2011. Accessed October 17, 2012. http://www.epa.gov/oms/climate/documents/420r11004.pdf.

"U.S. EPA Sensitive Population Grant for the City of Baltimore and the City of Annapolis (Fire Trucks and Ambulances)." Maryland Department of the Environment (MDE). 14 Nov. 2011 <http://www.mde.state.md.us/programs/Air/MobileSources/DieselVehicleInformation/DieselRetrofitProjects/Pages/balto_annapcity_retrofit.aspx>.

United States Census Bureau. “ACS Demographic and Housing Estimates: 2010 American Community Survey 1-Year Estimates.” American FactFinder, (Maryland and Baltimore City, Maryland). Accessed October 17, 2012. http://factfinder2.census.gov/bkmk/table/1.0/en/ACS/10_1YR/DP05/0400000US24|0500000US24510.

United States Census Bureau’s Center for Economic Studies. “OnTheMap.” Longitudinal Employer-Household Dynamics. Accessed October 17, 2012. http://onthemap.ces.census.gov/.

United States Departmant of Labor, "Bureau of Labor Statistics." Last modified 2012. Accessed October 2012. http://data.bls.gov/timeseries/APU000074714.

Welcome to the Annapolis Official CVB Website: Getting Around Annapolis. Welcome to the Annapolis Official CVB Website: Home. Annapolis and the Chesapeake Bay, 2011. Web. 11 Nov. 2011. <http://www.visitannapolis.org/visitor-info/getting-here/getting-around-annapolis/index.aspx>.

Welcome to the Annapolis Official CVB Website: Visitors Center. Welcome to the Annapolis Official CVB Website: Home. Annapolis and the Chesapeake Bay, 2011. Web. 14 Nov. 2011. <http://www.visitannapolis.org/visitor-info/visitors-center/index.aspx>.

Wetlands Restoration/Constructed Wetlands. Brookhaven National Laboratory. 14 Nov. 2011 <http://www.bnl.gov/erd/peconic/factsheet/wetlands.pdf>.

E.3 Agriculture & Forestry

5 Star Grant Program | Wetlands | Office of Wetlands, Oceans, and Watersheds | US EPA. US Environmental Protection Agency. EPA, 05 Mar. 2011. Web. 11 Nov. 2011. <http://www.epa.gov/owow/wetlands/restore/5star/>.

Adalja, Aaron, James C. Hanson, and Amy G. Crone. “Assessing the Need for a Statewide Farmers’ Market Association in Maryland.” Fact Sheet 934, 2011. University of Maryland Extension and Maryland Department of Agriculture. http://agresearch.umd.edu/CANRP/Localfood/files/2011_UME_FS%20934.pdf.

Becker, Geoffrey S. “Farmers’ Markets: The USDA Role.” CRS Report for Congress RS21652, Updated January 3, 2006. Congressional Research Service and the Library of Congress. http://www.nationalaglawcenter.org/assets/crs/RS21652.pdf.

“Chesapeake Bay TMDL.” United States Environmental Protection Agency. Accessed October 17, 2012. http://www.epa.gov/chesapeakebaytmdl/.

"The Chesapeake Bay TMDL, Maryland's Watershed Implementation Plan and Maryland's 2012-2013 Milestone Goals." Maryland Department of the Environment. Accessed October 17, 2012. http://www.mde.state.md.us/PROGRAMS/WATER/TMDL/CHESAPEAKEBAYTMDL/Pages/programs/waterprograms/tmdl/cb_tmdl/index.aspx.

Constructed Wetlands for Wastewater Treatment and Wildlife Habitat | Constructed Wetlands | US EPA. US Environmental Protection Agency. USEPA, 1993. Web. 11 Nov. 2011. <http://www.epa.gov/owow/wetlands/construc/>.

"Cost of Net Farmland Change." Maryland Smart, Green & Growing. Accessed October 17, 2012. http://www.green.maryland.gov/mdgpi/12a.asp.

Dougherty, Rebecca. March 2011. "2010 Maryland State Parks Economic Impact and Visitor Study." Department of Business and Economic Development. Accessed October 17, 2012. http://www.dnr.state.md.us/publiclands/pdfs/economicimpactstudy2010.pdf.

Ecosystem Services Working Group Final Report. Maryland Department of Natural Resources. Maryland Department of Natural Resources, Oct. 2011. Web. 14 Nov. 2011. <http://www.dnr.state.md.us/dnrnews/pdfs/ESWGFinalReportOct2011.pdf>.

Guiding Principles for Constructed Treatment Wetlands: Providing for Water Quality and Wildlife Habitat | Constructed Wetlands | US EPA. Home | Water | US EPA. USEPA, Sept.-Oct. 2011. Web. 11 Nov. 2011. <http://water.epa.gov/type/wetlands/constructed/constructed_index.cfm>.

"Housing and Community Development." Maryland Department of Housing and Community Development, 2011. Accessed October 17, 2012. http://www.dbm.maryland.gov/agencies/operbudget/Documents/2012/Proposed/houscomm.pdf.

Jones, CY, Evan Branosky, Mindy Selman, and Michelle Perez. "How Nutrient Trading Could Help Restore the Chesapeake Bay." World Resource Institute. World Resource Institute, Feb. 2010. Web. 14 Nov. 2011. <http://pdf.wri.org/working_papers/how_nutrient_trading_could_help_restore_the_chesapeake_bay.pdf>.

Land Values 2011 Summary. National Agricultural Statistics Services. United States Department of Agriculture, 4 Aug. 2011. Web. 16 Nov. 2011. <http://usda01.library.cornell.edu/usda/current/AgriLandVa/AgriLandVa-08-04-2011.pdf>.

Maryland | Retail Means Jobs. Retail Means Jobs | Retail Supports 1 in 4 American Jobs | 42 Million Strong. PricewaterhouseCoopers LLP, July-Aug. 2011. Web. 11 Nov. 2011. <http://www.retailmeansjobs.com/data/MD/0>.

Maryland Department of Planning Staff. “Maryland Smart Growth Sub-Cabinet Report on State Spending Inside and Outside of the Priority Funding Areas for Fiscal Years 2006-2009 and 2009 Annual Report.” Maryland Smart, Green & Growing, December 2009. Maryland Department of Planning. http://planning.maryland.gov/PDF/OurProducts/Publications/AnnualReports/SG_Sub_Cab_2010.pdf.

Maryland Genuine Progress Indicator. Maryland: Smart, Green and Growing. Maryland: Smart, Green and Growing. Web. 14 Nov. 2011. <http://www.green.maryland.gov/mdgpi/8a.asp>.

“Maryland Farmers’ Market.” The Official Site of the Maryland Office of Tourism. Accessed October 17, 2012. http://visitmaryland.org/events/pages/marylandfarmersmarkets.aspx.

Maryland QuickFacts from the US Census Bureau. State and County QuickFacts. U.S. Census Bureau, 13 Oct. 2011. Web. 11 Nov. 2011. <http://quickfacts.census.gov/qfd/states/24000.html>.

MD Proceeds by Auction. Regional Greenhouse Gas Initiative (RGGI) CO2 Budget Trading Program - Welcome. Regional Greenhouse Gas Initiative CO2 Budget Trading Program, 2011. Web. 14 Nov. 2011. <http://rggi.org/docs/MD_Proceeds_by_Auction.pdf>.

Nowak, David J., Susan M. Stein, Paula B. Randler, Eric J. Greenfield, Sara J. Comas, Mary A. Carr, and Ralph J. Alig. “Sustaining America’s Urban Trees and Forests: A Forests on the Edge Report.” General Technical Report NRS-62, June 2010. Newton Square, Pennsylvania: United States Department of Agriculture. http://www.fs.fed.us/openspace/fote/reports/nrs-62_sustaining_americas_urban.pdf.

Office of Energy Performance and Conservation. “StateStat Template.” StateStat Maryland, September 18, 2012. Maryland Department of General Services. Accessed October 17, 2012. http://www.statestat.maryland.gov/reports/20120918_DGS_Template.pdf.

So Maryland, So Good Farm Guide. Southern Maryland Agricultural Development Commission, 2011. Web. 11 Nov. 2011. <http://www.smadc.com/farmguide/FarmGuideWEB.pdf>.

This Week in Petroleum. U.S. Energy Information Administration (EIA). EIA, 09 Nov. 2011. Web. 11 Nov. 2011. <http://38.96.246.204/oog/info/twip/twip.asp>.

Wetland Publications. Environmental Laboratory. U.S. Army Corps of Engineers, Environmental, Apr.-May 2006. Web. 11 Nov. 2011. <http://el.erdc.usace.army.mil/wetlands/wlpubs.html>.

E.4 Recycling

"Maryland Auto Outlook." Www.mdauto.org. 9 Aug. 2011. Maryland Automobile Dealers Association. 11 Nov. 2011 <http://www.mdauto.org/admin/publications/AutoOutlookQuarter22011.pdf>.

Average Annual Miles per Driver by Age Group. 4 April 2011. U.S. Department of Transportation (USDOT), Federal Highway Administration (FHA), Office of Highway Policy Information (OHPI). Web. 11 Nov. 2011. <http://www.fhwa.dot.gov/ohim/onh00/bar8.htm>.

County Recyclables by Commodity in Tons for Calendar Year 2008. Marylend Department of the Environment (MDE). 2008. Web. 11 Nov. 2011. <www.mde.maryland.gov/assets/document/recycling_chart.pdf>.

Csere, Csaba. "How Automakers Will Meet 2016 CAFE Standards - Feature - Car and Driver." Car Reviews - 2011 Car Reviews and 2012 New Cars at Car and Driver. May 2011. Car and Driver. 11 Nov. 2011 <http://www.caranddriver.com/features/how-automakers-will-meet-2016-cafe-standards>.

E.5 Buildings

Building Energy Data Book. Buildings Energy Data Book. U.S. Energy Information Administration, Mar. 2011. Web. 11 Nov. 2011. <http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx>.

Code Enforcement Bureau. Baltimore County, MD Government Home Page. Code Enforcement Bureau, 17 June 2011. Web. 11 Nov. 2011. <http://www.baltimorecountymd.gov/agencies/permits/pdmfaq/pdmfaq_cdenfo.html#q3>

Construction and Building Inspectors. U.S. Bureau of Labor Statistics. Bureau of Labor Statistics, 17 Dec. 2009. Web. 11 Nov. 2011. <http://www.bls.gov/oco/ocos004.htm>.

Department of Housing and Community Development. "Response to Department of Legislative Services (DLS): Operating Budget Analysis." State of Maryland. Accessed October 17, 2012. http://dbm.maryland.gov/agencies/operbudget/FY2013Testimony/S00.pdf.

"Guide to Integrating Renewable Energy in Federal Construction." U.S. Energy Information Administration, Apr. 2013. Web. 21 May 2013. <http://www1.eere.energy.gov/femp/reconstructionguide/budgeting_costs.html>

Housing Statistics: Year End 2010. Maryland Association of Realtors Homepage. Maryland Association of Realtors, 2010. Web. 11 Nov. 2011. <http://www.mdrealtor.org/LinkClick.aspx?fileticket=aGcV7fnZEBk%3d&tabid=161&mid=543>.

Kats, Gregory H. "Green Building Costs and Financial Benefits." NH Partnership for High Performance Schools - Home. Http://www.nhphps.org/docs/documents/GreenBuildingspaper.pdf, 2003. Web. 11 Nov. 2011. <http://www.nhphps.org/>.

Listokin, David, and David Hattis. "Building Codes and Housing." 2004. Web. 11 Nov. 2011. <http://www.huduser.org/rbc/pdf/building_codes.pdf>.

Maryland Green Building Council 2010 Annual Report. Maryland Green Building Council. Maryland Department of General Services, 2011. Web. 11 Nov. 2011. <http://www.dgs.maryland.gov/pdfs/2010GreenBldgReport.pdf>.

StateStat. Maryland StateStat Report. Department of Housing & Community Development, July 2011. Web. 11 Nov. 2011. <http://www.statestat.maryland.gov/reports/20110825_DHCD_Template.pdf>.

E.6 Land Use

2000 Census of Population and Housing. U.S. Census Bureau, April 2004. Web. 11 Nov. 2011. <http://www.census.gov/prod/cen2000/phc3-us-pt1.pdf>.

Housing Statistics: Year End 2010. Maryland Association of Realtors Homepage. Maryland Association of Realtors, 2010. Web. 11 Nov. 2011. <http://www.mdrealtor.org/LinkClick.aspx?fileticket=aGcV7fnZEBk%3d&tabid=161&mid=543>.

How We Calculate. Carbonfund.org. Web. 11 Nov. 2011. < http://www.carbonfund.org/site/pages/carbon_calculators/category/Assumptions>.

Maryland QuickFacts from the US Census Bureau. State and County QuickFacts. U.S. Census Bureau, 13 Oct. 2011. Web. 11 Nov. 2011. <http://quickfacts.census.gov/qfd/states/24000.html>.

PlanMaryland Revised Draft—September 2011 Highlights. Plan Maryland, 21 Sept. 2011. Web. 11 Nov. 2011. < http://plan.maryland.gov/PDF/draftPlan/PlanMarylandHighlightsSept2011.pdf>.

Profile of Selected Housing Characteristics: 2000. U.S. Census Bureau. Web. 11 Nov. 2011. < http://factfinder.census.gov/servlet/QTTable?_bm=y&-geo_id=04000US24&-qr_name=DEC_2000_SF3_U_DP4&-ds_name=DEC_2000_SF3_U&-redoLog=false>.

State and Urbanized Area Statistics. U.S. Department of Transportation, 4 April. 2011. Web. 11 Nov. 2011. < http://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm>.

The Sustainable Communities Tax Credit. Maryland Sustainable Growth Commission. Web. 11 Nov. 2011. < http://www.governor.maryland.gov/documents/sustainablecredits.pdf>.

USA QuickFacts from the US Census Bureau. State and County QuickFacts. U.S. Census Bureau, 13 Oct. 2011. Web. 11 Nov. 2011. <http://quickfacts.census.gov/qfd/states/00000.html>.

E.7 Innovative Initiatives

2009 County Business Patterns. Censtats Database. NAICS, 2009. Web. 11 Nov. 2011. <http://censtats.census.gov/cgi-bin/cbpnaic/cbpsect.pl>.

A Look at Office Buildings - How Many Employees Are There. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration (EIA), 3 Jan. 2001. Web. 14 Nov. 2011. <http://www.eia.gov/emeu/consumptionbriefs/cbecs/pbawebsite/office/office_howmanyempl.htm>.

Ask Green America - Recycled Paper FAQ. Ask Green America - Knowledgbase Login. Green Irene, 2011. Web. 11 Nov. 2011. <http://askgreenamerica.custhelp.com/app/answers/detail/a_id/1340/~/recycled-paper-fa>

Asthma Hospitalizations in Maryland. Family Health Administration. Department of Health and Mental Hygiene, Aug. 2011. Web. 14 Nov. 2011. <http://fha.maryland.gov/pdf/mch/DataBrief-3-AsthmaHospitalizationsinMaryland2011.pdf>.

Asthma Mortality in Maryland. Family Health Administration. Department of Health and Mental Hygiene, Aug. 2011. Web. 14 Nov. 2011. <http://fha.maryland.gov/pdf/mch/DataBrief2-AsthmaMortalityinMaryland2011.pdf>.

Asthma Hospitalizations in Maryland. Family Health Administration. Department of Health and Mental Hygiene, Aug. 2011. Web. 14 Nov. 2011. <http://fha.maryland.gov/pdf/mch/DataBrief-3-AsthmaHospitalizationsinMaryland2011.pdf>.

Asthma Mortality in Maryland. Family Health Administration. Department of Health and Mental Hygiene, Aug. 2011. Web. 14 Nov. 2011. <http://fha.maryland.gov/pdf/mch/DataBrief2-AsthmaMortalityinMaryland2011.pdf>. Collins, Mary, and Judy Chen. "Under-Controlled Asthma ™s Economic Impact | Feature Articles | Perspectives | Payer Solutions." IMS Health. IMS Health, Spring 2010. Web. 14 Nov. 2011. <http://www.imshealth.com/portal/site/imshealth/menuitem.a46c6d4df3db4b3d88f611019418c22a/?vgnextoid=da12b0ac2e6e6210VgnVCM100000ed152ca2RCRD>.

Collins, Mary, and Judy Chen. "Under-Controlled Asthma ™s Economic Impact | Feature Articles | Perspectives | Payer Solutions." IMS Health. IMS Health, Spring 2010. Web. 14 Nov. 2011. <http://www.imshealth.com/portal/site/imshealth/menuitem.a46c6d4df3db4b3d88f611019418c22a/?vgnextoid=da12b0ac2e6e6210VgnVCM100000ed152ca2RCRD>.

Commercial Sector. Buildings Energy Data Book. Buildings Energy Data Book, Mar. 2011. Web. 14 Nov. 2011. <http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx>.

"Creating Green Jobs, Clean Energy & a Sustainable Future for Maryland: A Report to Governor Martin O'Malley." Maryland Smart, Green & Growing, July 2010. Green Jobs & Industry Task Force. http://www.choosemaryland.org/aboutdbed/Documents/Publications/GreenJobsTaskForceREPORT_FINAL.pdf.

Employment and Payrolls - Industry Series - Maryland 2009 - Employment and Payrolls - Division of Workforce Development and Adult Learning. Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 1 June 2011. Web. 11 Nov. 2011. <http://www.dllr.state.md.us/lmi/emppay/md2010ep.shtml>.

Employment and Payrolls - Industry Series - Maryland 2009 - Employment and Payrolls - Division of Workforce Development and Adult Learning. Maryland Department of Labor, Licensing and Regulation. Maryland Department of Labor, Licensing and Regulation, 1 June 2011. Web. 11 Nov. 2011. <http://www.dllr.state.md.us/lmi/emppay/md2010ep.shtml>.

"Guide to Integrating Renewable Energy in Federal Construction." U.S. Energy Information Administration, Apr. 2013. Web. 21 May 2013. <http://www1.eere.energy.gov/femp/reconstructionguide/budgeting_costs.html>

Mary, Stephenson J., and Donna Brinsfield. "Funeral Planning." University of Maryland Cooperative Extension Fact Sheet. University of Maryland Cooperative Extension. Web. 14 Nov. 2011. <http://extension.umd.edu/publications/pdfs/fs409.pdf>.

Mary, Stephenson J., and Donna Brinsfield. "Funeral Planning." University of Maryland Cooperative Extension Fact Sheet. University of Maryland Cooperative Extension. Web. 14 Nov. 2011. <http://extension.umd.edu/publications/pdfs/fs409.pdf>.

Maryland Environmental Footprint. Maryland: Smart, Green and Growing. Maryland Environmental Service, Spring 2010. Web. 16 Nov. 2011. <http://www.green.maryland.gov/carbon_footprint_page.html>.

OfficeMax 50% Recycled Multipurpose Paper. Office Supplies, Office Furniture & Office Technology at OfficeMax. Office Supplies, OfficeFurniture & Office Technology at

OfficeMax, 2011. Web. 14 Nov. 2011. <http://www.officemax.com/office-supplies/paper/recycled-paper/product-prod2110264>

OfficeMax 50% Recycled Multipurpose Paper. Office Supplies, Office Furniture & Office Technology at OfficeMax. OfficeMax, 2011. Web. 11 Nov. 2011. <http://www.officemax.com/office-supplies/paper/copy-multipurpose-paper/product-ARS22305>.

SEDS | State Energy Data System. U.S. Energy Information Administration (EIA). U.S. Energy Information Administration (EIA, 2009. Web. 16 Nov. 2011. <http://www.eia.gov/state/seds/hf.jsp?incfile=sep_prices/com/pr_com_MD.html&mstate=Maryland>.

Water on Tap. US Environmental Protection Agency. US Environmental Protection Agency. Web. 11 Nov. 2011. <http://www.epa.gov/>.

All Comments and Responses

Alana Wase

Board of County Commissioners Frederick County, MD

Bob Geiger and Catherine Buckler

Carroll County Department of Land Use, Planning, and Development

Consumer Energy Alliance

Dan Morrow

Elizabeth H. Singer

Energy Recovery Council

Environment Maryland Research & Policy Center

Katelyn Hasz

Liz Feighner

Mary Wolfe

Maryland Association of Counties

Maryland Association of Realtors

Maryland Conservation Council

Maryland State Builders Association

MD-National Capital Building Industry Association

National Association of Home Builders

Susan Jacobson

Commenter: Alana Wase

TO: Maryland Department of the Environment

FROM: Alana Wase

DATE: August 17, 2012

RE: Comments to the Maryland Greenhouse Gas Reductions Act Draft Plan

Dear Maryland Department of the Environment:

I want to first thank you for the opportunity to comment on our State's draft Greenhouse Gas Emissions Reduction Plan. I would also like to commend the effort that your agency in particular has expended to pull this plan together. I believe that the foundation that your agency has laid for accomplishing the 25% reductions by 2020 and more beyond, is excellent and appreciate your dedication to ensuring that the State reach its mandated reductions. As we each share a deep interest in the plan's success, I offer the following comments as additional opportunities to further ensure the integrity of the plan and its overall purpose.

1) The level of detail regarding each of the 65 programs must be significantly increased.

For a number of the policies chosen to reach the State's emissions reductions there is scarce detail as to how each program will unfold. Other than stating which agency will have the responsibility and how many emissions the State predicts will be reduced from that policy, substance is lacking. This level of detail is inadequate both statutorily and for the overall purpose the plan. The Annotated Code of Maryland in §2-1205(D) states, "The final plan required under subsection (C) of this section shall include: (1) *adopted regulations that implement all plan measures for which state agencies have existing statutory authority*; and (2) a summary of any new legislative authority needed to fully implement the plan and a timeline for seeking legislative authority."

Currently, as written, it is only the programs which are already underway which have adequate levels of detail. Each individual program, regardless of if it is underway or not, statutorily is required to have its regulations written if the relevant agency has existing authority to implement the strategy. Additionally, each program should have its own timeline, indicating major milestones in the program's development and implementation, stating specifically the month and year as to when each agency aims to reach each program's development and success. This will force agencies implementing multiple programs to strategically stagger the planning, rolling out, and implementation of each strategy. It also offers agencies an opportunity to design their own metrics for tracking the plan's progress. Ultimately, the finer the granularity of each program's plan, the easier it is in both implementation and evaluation of progress. Although some flexibility must be allowed for later developments, the current level of program specificity leaves much to be desired.

2) Governor O'Malley should play a more direct role in overseeing the development of the plan and its implementation.

The Maryland Department of the Environment ("MDE") has been the lead agency tasked with ensuring the plan's development. While MDE should continue playing the role of coordinator, which they have done an excellent job of doing, the Governor, as Executive, is needed to put more pressure on fellow agencies tasked with developing and implementing programs. From an outsider's perspective, given the scant detail which many agencies have provided regarding programs which they have been given three years worth of notice to design and describe in the draft plan, it is difficult to believe other agencies are taking this responsibility seriously.

The Governor, as Executive, has displayed tremendous leadership to the public in his support for the Greenhouse Gas Reduction Act. In order for the statute to be successful, the Governor, or someone from his staff, must demand more from agency heads regarding further development of the plan as well as providing additional backstop support for MDE's role as coordinator among other state agencies which it has no authority over.

3) Progress should be monitored quarterly by the Governor and tracked publicly- both at the individual program level as well as from an aggregated agency wide level.

Each agency should not only report progress to MDE, a sister agency, but rather quarterly reports should be filed by each agency to a staff person of the Governor who should be responsible updating the Governor quarterly on progress. Secondly, the visibility of progress and each strategy's goals must be increased. Currently, the Governor has included the Greenhouse Gas Reduction Act as one of his top fifteen policies which he tracks progress on via StateStat, this is an excellent start. While this graph is tremendously helpful at getting a glance at whether the State is on track, there should be additional links for a more granular view of the individual emissions reduction programs and their progress. One way this could be done would be by aggregating each program by agency so that the Governor and the public could see how each agency is doing towards progress, significantly increasing transparency. This may also instill additional support for the plan across other agencies and create healthy competition.

4) The State should continuously be working to build public support for the plan.

As the plan will call on a number of additional legislative measures and the statute requires an affirmative vote in 2016 to uphold the cap, involved agencies should help increase awareness and support for the plan whenever possible. One way to do this would be for MDE to develop a colorful one-pager highlighting the plan. Perhaps on one side it could feature the plan in general, the goals to be met, the purpose of the law and the economic and environmental benefits. On the other side it could be tailored to list out specific policies of the plan. Agencies responsible for multiple programs could even tailor the backside of the flyer to detail the programs which they are responsible for implementing. This may help instill dedication from other agencies while increasing transparency and accountability. Finally, MDE should be in charge of maintaining a listserv of organizations willing to distribute any of the materials developed for the public for general awareness on the Greenhouse Gas Reductions Act. There are a number of school clubs, nonprofits, religious organizations and more who would welcome the opportunity to help spread the word on the good work the State is doing.

5) The State should consider a life-cycle analysis of emissions resulting from energy consumption.

The Statute states explicitly that emissions are to be calculated from a "consumption" based approach. This was designed because Maryland imports roughly 30% of its electricity from out of state and we wanted to accurately reduce greenhouse gases emitted not only from electricity generated within the state but also generated out of state and consumed in-state. This forward thinking approach should be applauded, however the State should not stop there.

MDE should consider the viability of also including in its emissions inventory and reductions emissions which occur as a result of mining and extracting carbon fuels. Just as the legislature saw it unfit to only consider the greenhouse gas emissions resulting from electricity only generated in Maryland, but included all electricity consumed in Maryland, it would be wise to adopt as holistic approach concerning emissions resulting from energy consumed from the fuel extraction process throughout generation. This would provide for a more accurate approach to comparing the true cost of various electricity sources and would provide additional support for renewables.

6) A new policy or program should be added to the plan regarding fracking.

In large part, the single most important factor for the State's reduction in greenhouse gas emissions (and the nation) to date has been the increased transition to cheap natural gas which displaces coal. While the State should celebrate these emission reductions, the plan should expressly state a program or policy of new legislative action to put into place safe and stringent natural gas regulations should the state allow for fracking. It would be poor foresight for the State to allow this burgeoning industry which can be responsible for achieving significant reductions in emissions to perform any lower than the strictest environmental standards. It would be highly ineffective if we were to embrace natural gas as an inexpensive fuel and a solution to global warming at the expense of polluting our waterways.

In summary I want to express my sincerest gratitude to MDE and the Governor for their hard work and dedication to our environment. I previously worked for the Maryland Sierra Club for three and a half years and the Greenhouse Gas Reduction Act was the first piece of legislation which I worked on closely at the Sierra Club. It is thus, near and dear to my heart. I have followed the stakeholder process since passage of the law and confess that this Act was one of my main motivations for leaving the Sierra Club and attending law school. I am extremely committed to the Act and its implementation. I commend those who have worked so hard to see this plan through and look forward to further development and implementation of the plan.

Sincerely,

Alana Wase

Response:

1) The level of detail in the plan has been increased, and more links to specific programs have been provided.

2) New legislative authority that is needed will be addressed in the Plan. In cases where authority is already in place, the regulations are listed and discussed. Where there is a need for additional regulations and/or authority, this is included in Chapter 9: Next Steps.

3) The Governor's office is tracking implementation of the plan through the Governor's Delivery Unit (GDU) (https://data.maryland.gov/goals/greenhouse-gases). The Governor has been directly involved in development of the Plan. He has made the Plan into a "stat" process for the state of Maryland, called ClimateSTAT. The Plan itself is a living document that will be changed and edited as the implementation process occurs.

4) MDE is working on a number of communication products and messaging to build public support for the Plan. A separate executive summary of the Plan is being developed as well as communication and messaging for the entire plan and the concept of greenhouse gas reduction. Throughout the next few years, MDE plans to have ongoing stakeholder meetings and discussions leading to further edits to the Plan, which is considered a living document. The responses to comments provided on the Plan will also be communicated to the public on MDE's website, as well as being included in an Appendix of the final Plan.

5) Maryland has been involved in a regional effort in the Northeast to develop a Clean Fuels Standard which considers the life cycle GHG impacts of transportation fuels. The direction and future of the program is currently being re-evaluated. The State has removed any Clean

Fuel Credits from the Plan until the program is better defined. Conducting a full life cycle analysis of other programs in the Plan would present tremendous technical, methodological and resource challenges and, other than addressing natural gas benefits in the power sector, is not feasible to include in the Plan at this time.

6) In the final Plan, hydraulic fracturing or fracking is addressed in Chapter 6. A State Taskforce is currently evaluating fracking separately from the Greenhouse Gas Reduction Plan. While MDE is concerned about gas emissions from other states effecting Maryland, no programs concerning fracking will commence until the Taskforce has published their report. Further, given the limited quantity of shale gas located in Maryland, fracking is less unlikely to contribute as significantly to greenhouse gas emissions as compared to neighboring states.

Commenter: Board of County Commissioners, Frederick County, Maryland

BOARD OF COUNTY COMMISSIONERS FREDERICK COUNTY, MARYLAND

Winchester Hall • 12 East Church Street • Frederick, Maryland 2170 l
301-600-1100 • FAX: 301-600-1849 • TTY: Use Maryland Relay
www.frederickcountymd.gov

August 23, 2012

Robert M. Summers, Ph.D.
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, MD 21230

Re: Maryland's 2011 Greenhouse Gas Emissions Reduction Act of2009 Draft Plan

Dear Secretary Summers:

On behalf of the Board of County Commissioners ("Board") of Frederick County, Maryland, the following comments on Maryland 's 2011 Greenhouse Gas Emissions Reduction Act (GGRA) of2009 Draft Plan (Plan) are being submitted for consideration as part of the public comment period . Though the formal comment period for this Plan ended August 17, 2012, Mr. Luke Wisniewski suggested that the Maryland Department of the Environment (MDE) would accept public comment from Frederick County if received by August 24, 2012. We greatly appreciate the extra time to digest the 361 page plan and its 1,000-plus page Appendix.

Frederick County Government supports the comments made by the Maryland-Association of Counties (MACo) on August 17, 2012. However, we have additional comments. In general, the Plan has a disproportionate effect on rural counties, which by definition does not have the existing or planned dense development of urban areas, or the same mass transit opportunities.

The Plan has specific requirements for local governments as described in Appendix C. Frederick County Government would likely be directly and disproportionately affected by:

- Transportation-13: Evaluate the GHG Emissions Impacts from Major New Projects and Plans: The Maryland Department of Transportation would require greenhouse gas emissions to be evaluated in environmental studies for large transportation projects, and

could require mitigation. This could add significant costs to transportation projects that disproportionately affect rural areas.

- Land Use-1: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency: The Maryland Department of Planning (MDP) would require development projects and regional land use planning to "sharply reduce the rate" of increasing vehicle miles traveled, mitigate increased greenhouse gases, charge a fee for increased VMTs, and develop goals that local transportation plans and projects must achieve in order to receive state transportation funds. The MDP also proposes a law to create "emission caps for the transportation sector, implemented through development or adjustment of regional and local land use, transit, and affordable housing plans, and other transportation and land use strategies" parallel to California's Senate Bill 375. This item would have a major impact on local government planning authority, and would disproportionately affect rural counties.

- Land Use-2: Transportation GHG Targets for Local Governments and Metropolitan Planning Organizations: MDP would "establish transportation GHG targets for local governments and metropolitan planning organizations," require that "75 percent of Maryland's new development between 2011 and 2020 will be compact development," and additional requirements in common with Land Use 1 above. The 75% requirement should be a state average and not a one size fits all rate, else it disproportionately affects rural counties.

- Land Use-3: Funding Mechanisms for Smart Growth and Land Use-4: GHG Benefits from Priority Funding Areas and Other Growth Boundaries share the same issues as Land Use 1 above.

In addition to MACo's recommendations, we strongly urge MDE and its sister agencies to address the disproportionate economic impacts to rural counties in the GGRA Plan, and to eliminate elements that take away local land use authority.

Thank you for giving Frederick County this opportunity to provide public comment. Please contact Ms. Shannon Moore, Frederick County's Office of Sustainability and Environmental Resources Manager, at (301) 600-1413 should you have any questions regarding this information.

Sincerely,

BOARD OF COUNTY COMMISSIONERS
OF FREDERICK COUNTY, MARYLAND

By: Blaine R. Young, President

BRY/SKM/jmg

cc: Board of County Commissioners
David B. Dunn, County Manager
Michael G. Marschner, Special Projects Manager, County Manager's Office
Eric E. Soter, Director, Community Development Division
Shannon K. Moore, Manager, Office of Sustainability and Environmental Resources, Community Development Division

Response:

1) Transportation-13:
   a) MDOT is only requiring greenhouse gas (GHG) emissions to be evaluated, on a case by case basis, in environmental studies for large transportation projects in the Plan. It will not require counties to do so. The Plan outlines several potential strategies under the Transportation – 13 Program, but does not immediately put these strategies into effect. These potential strategies are tools that could possibly be used to reduce GHG emissions in the transportation sector. The National Environmental Planning Act already requires environmental studies to be conducted on large projects. Adding a GHG emissions evaluation to these environmental studies would not significantly increase the costs or time of the evaluation. This additional work could possibly result in changes that increase the cost of the project and/or time to construct transportation projects but will not target urban areas exclusively; both rural and urban areas will be equally impacted. As far as mitigation for GHG emissions, this is currently not required. The Plan does not require mitigation, and MDOT has not determined if mitigation would even occur at all.
   b) The State will continue to pursue its regulation to establish long range GHG targets for transportation planning, but will not require any additional work on the part of local governments or metro planning organizations in light of, and as part of, the federal conformity process. This is a separate process from the development of the GGRA Plan.

2) Land Use 1-4:
   a) The State has not made a commitment to levy Vehicle Miles Traveled (VMT) fees. It is one of many options being considered. MDOT, along with transportation agencies in other Northeast states, considers a VMT fee as a potential revenue source. VMT fees could be designed so as not to disproportionately affect rural counties.
   b) MDP understands the concerns in regard to impacts on rural areas and on local governments. Any policies developed will include the opportunity for input by local governments and counties. Making a difference now, rather than later, is important to prevent increases in greenhouse gas emissions by promoting efficient development and

land use. The longer efforts to reduce greenhouse gases are stalled, the more expensive and difficult achieving reductions becomes.

c) This Plan is an idea and guide on how to reach the goals and how to implement mechanisms for reductions. Regulations are implementation mechanisms that can possibly be put in place to reduce greenhouse gas emissions but are not part of the Plan itself. The state has already asked for other mechanisms rather than regulations, to implement policies.

d) The 75% goal for compact development is a goal, not a requirement of the Plan. This goal will be used to direct the state on whether additional or different programs and policies are needed.

Commenter: Bob Geiger and Catherine Buckler

From: Bob Geiger / Catherine Buckler <bobandcath@prodigy.net>
To: <climate@mde.state.md.us>
Date: 8/16/2012 3:48 PM
Subject: comments on GGRA Draft

I am submitting comments on the GGRA Draft. First of all I want to thank the department for its work and for the presentation at the July 17 public comment meeting in Silver Spring. At some point, the state needs to look at giving the utilities a structure (often referred to as "de-coupling") that provides incentives for less energy sonsumption rather than rewarding them for more energy consumption. A second comment is that when considering the effects of different automobile fuels, please consider the life cycle effects, such as the total carbon footprint associated with the fuels dereived from Canadian tar sands. In addition to those comments, I second the points raised by the Chesapeake Climate Action Network. We need a renewable energy portfolio structure that recognizes truly clean energy.
Sincerely,
Bob Geiger
1027 Carson St.
Silver Spring, MD 20901

August 16, 2012

Response:

1) The state of Maryland has already enacted a utilities structure which provides incentives for lower energy consumption, also called decoupling. EmPOWER Maryland is the program currently in place that reduces energy consumption. The Plan does not review decoupling since it is already in place in Maryland.

2) Transportation – 3:
   Innovative Initiatives – 2:
   a) Maryland has been involved in a regional effort in the Northeast to develop a Clean Fuels Standard which considers the life cycle GHG impacts of transportation fuels. The direction and future of the program is currently being re-evaluated. The State has removed any Clean Fuel Credits from the Plan until the program is better defined. Conducting a full life cycle analysis of other programs in the Plan would present tremendous technical, methodological and resource challenges and, other than addressing natural gas benefits in the power sector, is not feasible to include in the Plan at this time.

Commenter: Department of Land Use, Planning & Development Carroll County

Philip R. Hager, Director
Thomas S. Devilbiss, Deputy Director
410-386-2145. fax 410•386•2120
Toll Free 1-888-302-8978
MD Relay service 7•1•1/1-800-735-2258

Department of
Land Use, Planning & Development
Carroll County Government
225 North Center Street
Westminster, Maryland 21157

August 10, 2012

George "Tad" Aburn, Director
Air & Radiation Management Administration
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, Maryland 21230

Re: Greenhouse Gas (GHG) Reduction Act Draft Plan

Dear Mr. Aburn:

The Department of Land Use, Planning & Development (LUPD) staff has reviewed the draft plan. We would like to offer comments, particularly on those implementing measures and programs that relate to transportation and land use issues. The most- relevant programs are grouped by sector, with the related comments following each grouping.

• Transportation - 9: Pricing Initiatives
AND
• Transportation - 13: Evaluate the GHG Emissions Impacts from Major New Project and Plans

Maryland Department of the Environment (MDE) is developing regulations to begin implementing the piece of this program that would run separate from but parallel to the transportation conformity process, in which Carroll County participates as a member of Baltimore Metropolitan Council (BMC). This new program would establish voluntary, long-term planning targets for GHG emissions. The proposal would require a report to be developed and considered very late in the process. These regulations are expected to be in place by the end of 2012.

Comments:

• LUPD staff has been responding to the proposed regulations and attending meetings to provide comment. It is evident that MDE staff is not well versed on the transportation planning process. Coordination with the appropriate local, State (MDOT), and regional (Baltimore Metropolitan Council) agencies throughout the drafting of regulations has been absent which results in an uninformed proposal that is not feasible to implement. If this proposed regulation is meant to influence the types of transportation projects that are included in local and State transportation plans, and ultimately funded and implemented, information related to the effects of proposed projects on air quality need to be considered during the early planning stages. In addition, it is difficult to understand how the GHG targets can be voluntary once a regulation is associated with them.

• Associating these proposed regulations with the setting of long-term planning targets for GHG suggests that additional requirements or restrictions will be proposed to influence what a local jurisdiction may include in its comprehensive plan, particularly in the transportation and land use elements. This conflicts with the role of local governments as prescribed in the land Use Article and is another example of State overreach into local land use authority. Any additional regulations or requirements should include coordination with the appropriate local and regional agencies and be adequately vetted through the public process and the legislature to ensure comprehensive input on local implementability and impacts.

• Imposing additional fees on residents, developers, property owners, and/or other transportation facility users increases the cost, making it more difficult to proceed through the process, which could be fiscally devastating to both property owners and local governments. It also makes it more difficult for Marylanders' to afford to live in the state, which especially impacts border counties such as Carroll. Achieving the goals of PlanMaryland, the intent of Smart Growth, and the State Visions of the Land Use Article, such as economic development and Infrastructure (5 and 8), cannot be accomplished if living or building in Maryland, including rural counties, is too expensive. Revenues from economic development and new residential growth allow local governments to continue to maintain the level of service for facilities on which its residents and businesses rely.

• Variable vehicle miles traveled (VMT) pricing, such as is suggested through the "pay-as-you-go" example in the draft plan, places additional strain on residents in an already-suffering economy. The use of VMTs as a measure of effectiveness at reducing emissions disproportionately discriminates against communities that do not have rail or subway access- paid for by federal funds. Commuting from rural communities may mean more miles traveled. However, a correlation does not necessarily exist between miles traveled and emissions. In fact, duration of travel is a greater indicator than length of travel; slow-moving congested traffic generates far more pollution than vehicles travelling at posted speeds in rural communities. For example, a 10-mile commute that requires 30 minutes of travel time generates more pollution than a 30-mile commute at 30 minutes of travel time. In addition, VMT at the individual person or household level is too variable to use as a basis for pricing and additional costs and fees. While we do not support the concept at all, at the very least, commuter VMTs would be more appropriate than VMTs as a whole, if this can even be accurately disaggregated. Basing fees on a total VMT penalizes people who travel by car for vacation - many of which may not be able to afford to travel by train or air, or it may not even be an option for that destination. It also does not take into account those whose jobs necessitate daily travel from one customer to another. Additionally, detecting the changes that result from people changing jobs would be difficult to accurately and fairly capture.

• This program would result in a significant increase to the workload of existing comprehensive planning and development review staff. The additional review criteria would also lengthen the development review process timeframe.

• Ag and Forestry -10: Nutrient Trading for GHG Benefits

The plan suggests that many of the practices that reduce nutrients also store carbon and lower GHG emissions. Therefore, the State will take advantage of the existing Maryland Nutrient Trading Program to provide a platform for the addition of a voluntary carbon component. Maryland Department of Agriculture (MDA) is developing the program component to add carbon credits to the Nutrient Trading Program, which would be "stacked" onto existing nutrient credits as tradable commodities. This idea is based on the assumption that this would increase the potential value of the total credit package.

Comments:
Since the draft growth offset policy was just released in late July, staff is still in the process of understanding it and attending associated meetings. Along with reviewing and understanding the recommendations and impacts of the proposed plan, the County also will need to review and understand the Nutrient Trading Program to fully evaluate potential concerns and impacts associated with adding carbon to that program. At the very least, we are concerned with the additional cost of development and the local jurisdiction's control of local land use and growth policy. To completely strangle new development would have devastating fiscal impacts on local governments. The offset requirements and criteria will take away local land use control; local governments will not be able to realize their comprehensive plans under these conditions and will insert State agencies into local development plan approvals. Local governments will no longer be able to dictate the type of land uses desired to meet their goals and population projections. identify where to accommodate those needs, or be able to afford an adequate level of service for the citizens.

- **Land Use- 1: Reducing Transportation Emissions through Smart Growth and Land Use/Location Efficiency**
- **Land Use - 2: GHG Targets for Local Government's Transportation and Land Use Planning**
- **Land Use - 3: Land Use Planning GHG Benefits**

AND

- **Land Use - 4: Growth Boundary GHG Benefits (Priority Funding Area GHG Benefits)**

These strategies are based on the notion that land use patterns affect Marylanders' ability to travel to various destinations. Therefore, "developing incentives and requirements for regional land use patterns that achieve land use and location efficiency reduce motor vehicle dependence" [Pg 251],thereby reducing VMTs and, subsequently, GHG emissions.

These strategies indicate that "the only method to ensure a reduction in overall transportation emissions over time is to sharply reduce the rate of VMT, which will require a significant adjustment of land use patterns away from automobile-oriented development.• [Pgs 253, 254, 255, & 256)

The plan suggests that in addition to continued implementation of current smart growth programs and policies, State agencies will implement recommendations such as the following:

- Investigate the feasibility of implementing California SB 375 In Maryland;
- Develop sustainability criteria that local transportation plans and projects must achieve to receive State transportation funds;
- Investigate the feasibility of implementing Rule 9510 of the San Joaquin Valley Air Pollution Control District in Maryland;
- Perform a VMT Fee Pilot Project Study in Maryland, examining the use of variable VMT pricing to both reduce GHG emissions and fund State transportation needs;
- Update the existing transportation model (maintained by 8MC) to take GHG reduction benefits into account; and
- Develop additional metrics to determine progress.

The plan states that additional statutory or regulatory authority along with new State policies, will be needed to implement some of these recommendations.

Comments:
These concepts are based on the fallacy that VMTs are the single best indicator of environmental degradation resulting from air pollution. In fact, trip duration, particularly at slow speeds, is a far better indicator. While significant impact on local land use planning is the goal of these strategies, these could be significant negative impacts and could be exacerbated by the incorrect choice of measures and indicators. Additionally, any one of these programs will considerably increase staff workload and the amount of time it takes to get through a planning or development process.

- Requiring local land use plans to meet certain GHG emissions criteria, for which the associated transportation projects would need to be consistent, would insert into the already-cumbersome planning process additional processes and criteria to meet for a local jurisdiction to be eligible to include a transportation project in a plan. This also could unduly give greater weight to transportation issues, rather than a more comprehensive, holistic approach, thereby diminishing the value of other land use and comprehensive planning issues that should also be considered and balanced. It also becomes very narrowly focused in terms of outcomes. It is the job of local government to develop local goals and land use strategies. If the State is going to subsume this responsibility, the additional workload and time for review should be absorbed by the State as well. Additionally, these measures seek to once again apply a statewide standard to all local jurisdictions, ignoring the fact that there is tremendous individuality and diversity between and among Maryland's subdivisions. This is a continuation of an erroneous course of action that the State embarked upon through the impel mentation of PlanMaryland. As stated ad nauseam, one size does not fit all.

.

• 'Requiring local targets for emissions reductions, proposed to be measured through VMTs. will likely result in many of the same issues and concerns generated through the process of pinpointing the baseline and specific reductions needed for nutrients through the Phase n Watershed Implementation Plan. Identifying specific targets through modeling generally cannot be done precisely enough at a small geographic scale to provide any certainty to the baseline figures or that could be attributed to specific implementation practices.

• Requiring development plan projects to meet certain GHG emissions requirements as a condition of approval as well as increasing the cost and making it more difficult to proceed through the process, could be fiscally devastating to both property owners and local governments. While property owners need to have some degree of certainty that the value of their land investment will not be completely diminished, it also is imperative for local governments to maintain some level of growth to provide economic development and associated revenues, as well as the ability to determine the most appropriate location for these activities, whether new growth or redevelopment. These revenues allow local governments to continue to maintain the level of service for facilities on which its residents and businesses rely. Imposing additional fees on residents, developers, property owners, and/or other transportation facility users also contributes to this problem. Furthermore, we do not support any efforts to insert direct State involvement in the process of local land use and development approvals. This clearly would diminish the local land use authority, even if done indirectly.

• The California initiatives include mandating more restrictive requirements for local plan housing elements. This process is a "catch 22" situation, where requiring higher-density housing necessitates additional transportation needs. However, because of projected increases in VMTs, the County would not be able to get funds for additional transportation projects. Additionally, while the State may call for a higher density for new development, at the same time, many of Carroll's municipalities are not able to achieve higher densities due to restrictions on water or wastewater capacity imposed by the State and/or the high cost of improvements to upgrade these facilities.

•Local governments already have many requirements and unfunded mandates with which to comply. We have had to do much more with much less, and imposing more restrictive plan content and timeline requirements on local planning documents and processes does not serve to improve the quality of the results of these planning processes, especially since there is no evidence clearly establishing that any of these policies will result in the desired reductions or outcomes.

• Timeframe for Review

With the many different State initiatives that have bombarded local governments in the past year or so, we are finding it difficult to keep up with all of the issues and to ensure adequate time to review and comment on each. Thus, while we believe this plan and its implementing tools are very important and have significant impacts on local governments and implications for local planning, we also feel that our comments may not adequately cover all of the implications and concerns, nor adequately express the magnitude of what we believe the impacts may be. **We would respectfully request the deadline for comment be extended until after the 2013 General Assembly closes to ensure that local governments have adequate time to review the draft and identify impacts and comments, particularly in combination with the other recent State lnitiatives.**

Moreover, given the far-reaching impacts, it would be more appropriate to include the State legislature in the development and review of these mandates. The legislature was bypassed in the review and approval of PlanMaryland and many bills were introduced attempting to address this concern. Another plan of this magnitude avoiding the legislative process does not serve to ameliorate these concerns or promote the public's best interest.

Thank you for carefully considering our concerns and comments. We sincerely hope that revisions to the programs and strategies in this document will be made to address these concerns. We have invited MDP to present on the land use and transportation aspects of this plan to our Board of County Commissioners. We would welcome MDE's participation as well.

Sincerely,

Philip R. Hager
Director
Carroll County Land Use, Planning & Development

Response:

1) Transportation-9 and Transportation-13
   a) MDE staff has been coordinating with local, regional, and state agencies and organizations throughout the drafting of the Plan. Coordination with various agencies has occurred through a number of meetings. Individual meeting with local governments have also occurred when requested. MDE has also participated in local stakeholder meetings which were inclusive and open to the public. Some of the groups present and active in the planning process have been the Baltimore Metropolitan Council, the Washington Metropolitan Area Transit Authority Metropolitan Washington Transportation Planning Board, Maryland Association of Counties, as well as individual counties and specific environmental groups.
   b) The State will continue to pursue its regulation to establish long range GHG targets for transportation planning, (COMAR 26.11.37), but will not require any additional work on the part of local governments in light of the federal conformity process. This is a separate process from the development of the GGRA Plan. The State has solicited input on the feasibility of implementing other mechanisms as alternatives to a regulation. Recommendations included in the Plan will not trigger implementation of any targets set under the rulemaking process.
   c) The State has not made a commitment to levy Vehicle Miles Traveled (VMT) fees. It is one of many options being considered. It is one of many options being considered. MDOT, along with transportation agencies in other Northeast states, considers a VMT fee as a potential revenue source. VMT fees could be designed so as not to disproportionately affect rural counties.
   d) The National Environmental Planning Act already requires environmental studies to be conducted on large projects. Adding a GHG emissions evaluation to these environmental studies would not significantly increase the costs or time of the evaluation. This additional work could possibly result in changes that increase the cost of the project

and/or time to construct transportation projects but will not target urban areas exclusively; both rural and urban areas will be equally impacted. As far as mitigation for GHG emissions, this is currently not required. The Plan does not require mitigation, and MDOT has not determined if mitigation would even occur at all.

2) Agriculture and Forestry 10
   a) The accounting for growth proposal has been removed from the Plan and will be reevaluated by a new advisory committee.

3) Land Use 1-4:
   a) The State has not made a commitment to levy Vehicle Miles Traveled (VMT) fees. It is one of many options being considered. MDOT, along with transportation agencies in other Northeast states, considers a VMT fee as a potential revenue source. VMT fees could be designed so as not to disproportionately affect rural counties. VMT fees could be designed so as not to disproportionately affect rural counties.
   b) The VMT Fee Pilot Project study in Maryland is an idea put forward as a way to generate needed revenues as well as reduce harmful emissions, but the state understands that there are many possibly negative issues with this program. One issue that is agreed upon is that the program might not be successful in Maryland, which as a small state may work differently from larger western states. All parties involved are considering the feasibility of implementing such a pilot, with significant input from local governments. Local governments will still retain their authority over land use decisions. If this program were to be implemented, it would be a partnership with local, state, and federal governments.
   c) MDP understands the concerns in regard to impacts on rural areas and on local governments. Any policies developed will include the opportunity for input by local governments and counties. Making a difference now, rather than later, is important to prevent increases in greenhouse gas emissions by promoting efficient development and land use. The longer efforts to reduce greenhouse gases are stalled, the more expensive and difficult achieving reductions becomes.
   d) This Plan is an idea and guide on how to reach the goals and how to implement mechanisms for reductions. Regulations are implementation mechanisms that can possibly be put in place to reduce greenhouse gas emissions but are not part of the Plan itself. The state has already asked for other mechanisms rather than regulations, to implement policies.

4) Timeframe for review:
   a) The state will continue to work with local governments and other interested parties on implementation, and as required by GGRA, will be doing a 2015 report to the legislature about what’s working, what’s not working, and what needs to be changed.

Commenter: Consumer Energy Alliance

From: Natalie Joubert <NJoubert@hbwresources.com>
To: "climate@mde.state.md.us" <climate@mde.state.md.us>
CC: Michael Whatley <MWhatley@hbwresources.com>
Date: 8/17/2012 3:52 PM
Subject: Public Comments on MD Greenhouse Gas Emissions Reduction Act of 2009 Draft Plan
Attachments: CEA Comments to MD Dept of Environment__GGRA Plan 2011.pdf

Dear Secretary Summers:

On behalf of Consumer Energy Alliance, please find attached comments on the Maryland Department of the Environment 2011 Greenhouse Gas Emissions Reduction Act of 2009 Draft Plan, signed by CEA Executive Vice President Michael Whatley. If you have any questions, please direct them to Michael Whatley (202-674-1750; mwhatley@consumerenergyalliance.org<mailto:mwhatley@consumerenergyalliance.org>) or myself.

Thank you for the opportunity to comment on this important matter.

Sincerely,

Natalie Joubert

Natalie Joubert
Consumer Energy Alliance
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(202) 429-4931 (office)
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August 17, 2012

Secretary Robert Summers
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, MD 21230

RE: Comments on Maryland's 2011 Greenhouse Gas Emissions Reduction Act of 2009 (GGRA) Plan

Dear Secretary Summers:

On behalf of Consumer Energy Alliance (CEA), I would like to submit the following comments regarding "Maryland's Plan to Reduce Greenhouse Gas Emissions," published by the Maryland Department of the Environment on December 31, 2011.

Consumer Energy Alliance, a non-profit, non-partisan organization, was formed to help support the thoughtful development and utilization of all domestic energy resources to improve domestic energy security and reduce consumer prices. CEA has over 200 consumer and energy organizations across the country and more than 300,000 individuals that are dedicated to the development and implementation of a balanced energy policy that will ensure affordable, reliable energy while protecting the environment.

CEA would like to address the Plan's inclusion of a "Clean Fuels Standard (CFS)" as one of the options available to reduce greenhouse gas (GHG) emissions from the transportation sector. As the report notes, governors from 11 states in the Northeast and Mid-Atlantic region signed a Memorandum of Understanding in December 2009 to conduct an economic analysis of a clean fuel standard (initially named a "low carbon fuel standard"), develop recommendations on the program, and draft a regulatory framework for the states. The Northeast States for Coordinated Air Use Management (NESCAUM) has since provided technical support to these states and has issued a report entitled, "Economic Analysis of a Program to Promote Clean Transportation Fuels in the Northeast/Mid-Atlantic Region," released in August 2011.

CEA believes that the assumptions relied upon by NESCAUM in its economic analysis are unrealistic and unsupportable, and that its conclusions demonstrating broad economic benefits from a potential Northeast/Mid-Atlantic regional CFS must therefore be critically flawed and unreliable.

In response to the release of the economic analysis by NESCAUM in August 2011, CEA commissioned a report by IHS CERA and IHS Global Insight to conduct an independent assessment of the analysis. The assessment completed by the IHS team demonstrates that the assumptions employed for prices, availability, infrastructure and technological performance of low-carbon fuels and alternative vehicles are unreasonable, unsupportable and unattainable in the 2013-2022 timeframe of the NESCAUM analysis. The IHS assessment concludes that the assumptions underlying the scenario analyses presented in the NESCAUM economic analysis cannot be realistically achieved in the 2013-2022 timeframe for any of the scenarios in the analysis and that each of the scenarios presented in the

NESCAUM report claim economic benefits and lower costs association with low-carbon fuels that are unattainable under any reasonable set of expectations for the period to 2022. For these reasons, CEA strongly discourages Maryland from relying heavily on NESCAUM's economic analysis to support implementation of a CFS as a cost-effective means of reducing GHG emissions. I have included a detailed review of these assumptions is included in the attached appendix.

In addition to the IHS assessment, a separate study released in March 2011 by Consumer Energy Alliance, with analysis conducted by SAIC, confirmed that a regional, Northeast/Mid-Atlantic low carbon fuel standard (LCFS) program would result in significant negative economic impact to all 11 states while achieving a maximum, weighted-average, regional reduction of only 4.9 percent carbon intensity in the area's fuel pool. In order to achieve this modest carbon-intensity reduction, it would cost the region at least $306 billion (nominal 2009 dollars) and a loss of at least 147,000 jobs. For fuel consumers, gasoline prices would at least double, increasingly significantly in 2021.

At the state level, the study concludes that an LCFS would result in a 4.09 percent reduction in the carbon intensity of the Maryland fuel pool, leading to a cumulative carbon reduction of 3.0 gCO_2/KBtu over a ten-year period. However, the program would also result in the cumulative loss of 15,500 Maryland jobs and a $2.6 billion (nominal 2009 dollars) decline in gross domestic product. Additionally, gasoline prices in Maryland would increase by 116 percent over the course of the same time frame.

While this modest reduction in carbon intensity may contribute slightly to Maryland's goal of a 25 percent reduction in GHG emissions by 2020, a Clean Fuel Standard clearly and significant violates one of the Plan's principal objectives to "have a positive impact on job creation and contribute to Maryland's economic recovery."

In conclusion, CEA strongly urges the Maryland Department of the Environment to more closely examine the potential economic impacts of a Clean Fuel Standard program prior to its inclusion as part of the state's final GHG reduction plan. We believe it is in the interest of Maryland's workers, businesses and fuel consumers to explore other GHG emission reductions strategies that achieve demonstrated GHG reductions without posing a risk of economic harm.

Please contact me directly at 202-674-1750 if you have any questions or would like to discuss either of the reports referenced in these comments. I have included links to each of these studies below:
IHS "Assessment of the NESCAUM Economic Analysis of a Clean Transportation Fuels Program for the Northeast/Mid-Atlantic Region"

http://www.secureourfuels.org/wp-content/uploads/2011/11/IHS-CERA-Economic-Analysis-ofa-

Clean-Transportation-Fuels-Program.pdf

Consumer Energy Alliance, “Analysis of the Economic Impact of a Regional Low Carbon Fuel Standard on Northeast/Mid-Atlantic States”

http://www.secureourfuels.org/wp-content/uploads/2012/03/FINALCEA_LCFS_REPORTMASTER_DRAFT_DOCUMENT_3-23-2012.pdf

Thank you again for the opportunity to provide these comments.

Sincerely,

Michael Whatley
Executive Vice President

Attached: Appendix on IHS Assessment of the NESCAUM Economic Analysis

Appendix

IHS CERA & IHS Global Insight Report: "Assessment of the NESCAUM Economic Analysis of a Clean Transportation Fuels Program for the Northeast/Mid-Atlantic Region"

In August 2011, the Northeast States for Coordinated Air Use Management (NESCAUM) released its economic analysis of a proposed "Clean Fuels Standard" (CFS) or "Low-Carbon Fuel Standard" (LCFS) for the Northeast and Mid-Atlantic. While NESCAUM's report concludes that a CFS will lead to job growth and lower fuel prices, IHS concluded that these assessments are based on unrealistic and incorrect assumptions for the availability, price, infrastructure and technological performance of clean fuels in the region, assumptions that are far apart from expert and government opinion.

1. <u>Assumptions about the availability of next generation biofuels:</u> NESCAUM's assumptions about the availability of next generation biofuels, including cellulosic ethanol are dramatically higher than EPA estimates and contradict a recent report by the National Academy of Sciences regarding the projected availability of cellulosic ethanol. For example, NESCAUM assumes that cellulosic ethanol availability in the Northeast/Mid-Atlantic region in at 70 million gallons in 2013 going up to 2.6 billion gallons by 2022, whereas the EPA projects a potential national availability as low as 3.5 million gallons nationally in 2012 and recognizes that there have been zero gallons produced and commercially available in either 2010 or 2011.

2. <u>Price Assumptions regarding advanced biofuels:</u> NESCAUM assumes that not only will advanced biofuels such as cellulosic ethanol and renewable diesel be available in sufficient quantities to meet the carbon intensity reduction goals of the CFS program, but that they will also be cheaper than traditional gasoline and diesel. Given that there are no gallons being commercially produced today, as well as the fact that the National Academy of Sciences has concluded that biofuels will be economic only at a crude oil price above $191 per barrel, NESCAUM's price assumptions are not merely unsupportable, they are completely unrealistic.

3. <u>Price Assumptions regarding Plug-in Hybrid Electric Vehicles (PHEVs):</u> NESCAUM assumes that there will be no cost differential between PHEVs and internal combustion engine (ICE) vehicles whereas EPA and the National Highway and Transportation Safety Administration (NHTSA) projects a $16,000 differential.

4. <u>Price Assumptions regarding Battery Electric Vehicles (BEVs):</u> NESCAUM assumes that BEVs will range from $15,000 in 2013 down to $3,000 in 2022 higher in price compared to ICE vehicles, which is substantially lower than projections by the California Air Resources Board and the Department of Energy's Sandia Laboratory.

5. <u>Assumptions about the availability of PHEVs:</u> NESCAUM assumes PHEV sales in the Northeast/Mid-

Atlantic region of approximately 50,000 vehicles in 2013 up to approximately 275,000 vehicles in 2022, which is dramatically higher than the federal Energy Information Administration (EIA) projections of less than 10,000 nationwide in 2013 rising to approximately 25,000 nationwide in 2022.

6. Assumptions about the availability of BEVs: NESCAUM assumes that there will be between 250,000 and 300,000 BEV sales in the region in 2022 under the biofuels future scenario and natural gas future scenario and approximately 800,000 BEV sales in the region in 2022 under the electricity future. These are in stark contrast to EIA projections of less than 10,000 BEV sales nationwide annually during the entire 2013-2022 timeframe.

Response:

1) Clean Fuel Standard
    a) While identified in the Plan as an emerging program, Maryland is not taking any GHG credits for the Clean Fuel Standard Program in the updated Plan. The Clean Fuel Standard Program is an emerging policy which will continue to be evaluated in the future. The Plan does not attribute any benefits from it. With further analysis and updates to the Plan it could possibly be included with more discussion by stakeholders. Instead of relying solely on the NESCAUM analysis, the State of Maryland has closely worked with SAIC to conduct additional economic analyses which will be included in the final Plan.

Commenter: Dan Morrow

From: Dan Morrow <dmorrow7@gmail.com>
To: <climate@mde.state.md.us>
CC: <bhug@mde.state.md.us>
Date: 8/16/2012 2:15 PM
Subject: Suggestions for draft GGRA Plan
Attachments: Proposal for Study of Cap and Dividend--Morrow Aug 2012.doc; Part.002

Let me first express my appreciation to MDE and the entire team from many departments who have prepared the first draft of the GRRA Plan: it is a very good document and outlines a substantial set of programs and policies.

In response to the request for public comments on the draft GGRA Plan (posted on June 20, 2012), I would like to submit the following suggestions for further improvements:

1. On why Marylanders should act to reduce greenhouse gas emissions. The draft does a good job of explaining why Maryland should take action: to take responsibility for doing its share in response to the global problem; to provide leadership among US states on climate action; to realize the substantial, local co-benefits that accompany reductions in greenhouse gas emissions; and to generate new jobs related to investments in energy efficiency and renewable energy production. Perhaps the latter argument could be augmented by including this idea: as recognition of the need to mitigate climate change grows around the world, there will eventually but inevitably be national policies that mandate reductions in greenhouse gas emissions, and, by taking action now, Maryland can stay "ahead of the curve" on energy efficiency and on low-carbon energy production so that Maryland businesses can protect their competitiveness in the national and global economy.

2. On strengthening the RGGI. The draft report makes clear that Maryland's continued participation in the RGGI is an essential component of the Plan: even with its current targets, the RGGI is projected to account for over 17 mmt of Maryland's GHG reductions out of the total of about 60 mmt by 2020. The draft also mentions that a comprehensive review of the RGGI is being undertaken during 2012 by the participating states. Although I don't know the status of that review and the subsequent timetable for decisions about any modifications to the RGGI, it seems to me that the Plan should be a vehicle by which Maryland puts forward its position on RGGI's future and also lay the foundation for future RGGI innovations. In that context, I would like to make two suggestions.

-- First, the Plan should advocate that the cap on GHG emissions by power plants covered by RGGI should be reduced relative to the original program. It seems clear that the recent economic recession and the dramatic decrease in the price of natural gas in the US will make it possible for power companies to achieve the original 2018 cap rather easily, and this creates an opportunity to move forward more aggressively to reduce the cap.

-- Second, the Plan should include authorization for a study of the feasibility of eventually switching Maryland's RGGI program to a "cap-and-dividend" program in which most of the proceeds from the auction of allowances would be distributed to citizens directly. As discussed in more detail in the attached note, such a study--which Maryland could undertake initially on its own and then expand to include other interested RGGI states--would be motivated by recognition that, at some point in the future, the auction proceeds might exceed the requirements for public funding of investments in energy efficiency and renewable energy. At that point, distributing the auction proceeds as dividends to citizens would have important economic and political advantages. Having a plan for such an eventual transformation of the program might reduce near-term political resistance to reducing the cap. Undertaking such a study would be an important way in which Maryland could continue to exercise a leadership role with respect to climate action policies.

3. On the presentation of the science of climate change. In the sections of Chapter 1that summarize the science, the draft report refers primarily to the International Panel on Climate Change(IPCC)--for example, in the box on p. 19 and on p. 27. Because some Marylanders might be suspicious or skeptical about this international, UN-linked group, it might be useful to give greater, if not primary, attention, to the report by the National Academy of Science on America's Climate Choices, which is referenced only briefly on p. 22 and p. 52, and also to refer briefly to the many other US science organizations that have endorsed the basic science of climate change.

I hope that my suggestions are clear and useful. Thanks for the opportunity to share my ideas.

Dan Morrow

Proposal for a Feasibility Study
of Transforming RGGI into a Cap-and-Dividend Program

By Dan Morrow
August 16, 2012

This note puts forwards a proposal for including within Maryland's Greenhouse Gas Reduction Act (GGRA) Plan (the Plan) authorization for a study of the feasibility of eventually transforming Maryland's Regional Greenhouse Gas Initiative (RGGI) program into a "cap-and-dividend" program in which most of the proceeds from the auction of emission allowances would be distributed directly to Maryland citizens.

The Plan as an Instrument for Leadership and Innovation within RGGI

This proposal is based on the premises that participation in RGGI will be a core component of the Plan[1] and, furthermore, as part of the Plan, Maryland should seek to increase RGGI's effectiveness by setting more ambitious targets for reducing regional CO2 emissions. In that context, the Plan can potentially have its greatest impact by providing leadership and catalyzing innovation within RGGI, and RGGI in turn can influence the evolution of cap-and-trade programs around the world.[2] A study that identifies a way forward toward transforming RGGI into a cap-and-dividend program could thereby have a significant impact on global efforts to mitigate climate change.

On the Basic Rationale for a Cap-and-Dividend Program

A program in which all or most of the proceeds from auctioning RGGI allowances are distributed to citizens as dividend payments would have significant economic and political advantages.[3] Economically, it would ensure that citizens are compensated for the increase in

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[1] According to the draft Plan (pp. 128 and 135), participation in RGGI would contribute 17.71 million metric tons of CO2 emission reductions by 2020—over one-fourth of total reduction of 64 million metric tons projected among all sectors under the draft Plan. Hence the Plan cannot succeed unless RGGI is successfully implemented. This and other references to the draft Plan in this note refer to the draft posted at http://www.mde.state.md.us/programs/Air/ClimateChange/Documents/2011%20Draft%20Plan/2011GGRADRAFTPlan.pdf

[2] As stated in the draft Plan (p. 144), "…an important secondary goal [of RGGI] was to demonstrate that a GHG cap-and-trade program could work."

[3] There is an extensive literature on the concept of a cap-and-dividend program and similar programs in which revenues generated by a cap-and-trade program and/or a carbon tax are distributed directly to citizens. As examples, see (a) Boyce, James K., and Matthew Riddle, 2007. "Cap and Dividend: How to Curb Global Warming While Protecting the Incomes of American Families", Working Paper Series No. 150, Political Economy Research Institute, University of Massachusetts Amherst. http://www.capanddividend.org/files/WP150.pdf and (b) Wheeler, David, 2008. "Why Warner-Lieberman Failed and How to Get America's Working Families behind the Next Cap-and-Trade Bill" Center for Global Development Working Paper Number 149, July 17. http://www.cgdev.org/content/publications/detail/16387/. Also for a recent political history of proposed

electricity prices that will likely result from gradually reducing the regional cap on emissions and thereby increasing the price of emission allowances. This would maintain aggregate demand in the regional economy while creating the correct price incentive for reducing demand for electricity. More specifically, a cap-and-dividend program might be the best way to manage the tension between two important objectives. On the one hand, the GGRA law requires that the Plan to reduce GHG emissions should have "No adverse impact on the reliability and *affordability* [emphasis added] of electricity and fuel supplies" (p. 41). On the other hand, especially in the medium-to-long run, reducing GHG emissions will require increasing the price of carbon-based electricity relative to the price of low- or no-carbon sources of energy. A cap-and-dividend program could reconcile these two potentially competing objectives because citizens would have the additional income and Maryland businesses would have additional demand for their goods and services such that both citizens and business could afford higher electricity rates. Politically, such a cap-and-dividend program would therefore likely reduce resistance to the reduction in the RGGI cap.

However, it is not practical to create a cap-and-dividend program until proceeds from the auction allowances on a per capita basis are much larger than at present. Since RGGI's first auction in 2008, total proceeds have been about $891 million, which amounts to less than $6 per year per person in the RGGI states.[4] Even if the proceeds could be distributed to citizens very efficiently, it is not likely to be administratively cost-effective to distribute such a small per capita dividend. But, as RGGI moves forward in reducing the cap on regional emissions and increasing auction proceeds, which it must do in order to have a significant impact on emissions, the potential per capita dividend will likely become large enough to justify the administrative cost of distribution.

Furthermore, it would not be desirable in the near-term to divert the auction proceeds from their current uses. For the RGGI states as a whole, about 63% of auction proceeds have been invested in programs, such as Maryland's EmPower program, to improve energy efficiency and to accelerate deployment of renewable energy technologies.[5] There is very strong justification for such uses of the proceeds: as stated on the RGGI website, "reinvestment of auction proceeds in energy efficiency and renewable energy programs allow cap-and-trade programs to address CO2 emissions at both the supply side (power plants) and the demand side (energy use), delivering emission reductions at lower cost." Specifically, in Maryland, the auction proceeds are placed in the Strategic Energy Investment Fund (SEIF), which provides funding for energy efficiency and renewable energy programs. These on-going programs are critically important components of the Plan.

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legislation for national cap-and-dividend program—the CLEAR Act sponsored by Senators Cantwell and Collins, see the blog by the Chesapeake Climate Action Network (CCAN) at http://www.chesapeakeclimate.org/resources/cap-and-dividend-policy-updates.

[4] Because New Jersey has withdrawn from RGGI, these figures exclude the proceeds from auctions by New Jersey and exclude the New Jersey population from the per capita estimate.

[5] See RGGI Inc,. "Investments of Proceeds from RGGI CO2 Allowances," February 2011. http://www.rggi.org/docs/Investment_of_RGGI_Allowance_Proceeds.pdf.

Nevertheless, as the RGGI emissions cap is reduced and auction proceeds increase, it is likely that available proceeds will eventually exceed the funding requirements for public investments in energy efficiency and renewable energy. The intent of such programs is not to fully finance all such economically justified investments but only to improve public awareness of the net benefits of such investments, build private sector capacity to implement them, and, at least for some time, provide just enough subsidy to induce private agents to undertake these investments. As these goals are achieved, at some point in the future, the need for public financing for these investments will diminish.

Key Questions for the Proposed Study

With these considerations in mind, the proposed study might usefully focus on these key questions:

1. What are plausible, alternative scenarios for the growth of proceeds from Maryland's auction of RGGI allowances?
2. What are the projected public funding requirements over the next decade for programs to encourage energy efficiency and expansion of renewable energy within Maryland?
3. What are alternative guiding principles for the distribution of auction proceeds as dividend payments to Maryland citizens (e.g., equal per capita distributions versus targeted distributions)?
4. What are possible administrative mechanisms by which a substantial share of auction proceeds could be distributed to Maryland citizens, and how do these possible mechanisms compare in terms of administrative cost-effectiveness, economic impacts, and political acceptability?
5. Taking into account the answers to the above questions, is there likely to be some point in the future when it would be desirable for Maryland to switch at least a significant share of its auction proceeds into a dividend program?

As written, these questions presume that the study would focus only on Maryland and its future use of proceeds from its auction. Of course, if other RGGI states become interested, it would be appropriate to complement the Maryland study by a regional study.[6]

Maryland's Rationale for Undertaking this Study

Among the RGGI states, Maryland has the strongest rationale for undertaking this study because it is already a pioneer in the distribution of auction proceeds to citizens. Under the legislation that authorized Maryland's participation in RGGI and guides the uses of Maryland's auction proceeds, a significant share of those proceeds are committed to the Electric Universal

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[6] As indicated in the draft Plan (p. 144), in 2012, the RGGI states will undertake a comprehensive program review, which will include an evaluation of the existing emissions cap and consideration of various options to strengthen the program." Ideally, the RGGI states jointly might launch a study of the possibility of eventually transforming RGGI into a cap-and-dividend program. However, this note presumes that there is not yet sufficiently broad interest in such a study and therefore that Maryland would need to take the initiative for such a study within the framework of its GRRA Plan.

Service Program (EUSP), which provide electric bill payment assistance to low-income consumers across the state. Among the RGGI states, this is by far the largest program involving the distribution of auction proceeds to citizens. The proposed study could include a review of the EUSP to date and could consider the implications of the EUSP experience for future expansion of distribution of auction proceeds to citizens.

However, the proposed study should not limit itself to consideration of a distribution mechanism such as the EUSP. The EUSP pays a portion of the electric bill only for eligible low-income households. Despite its obvious merits, this has potential disadvantages: first, such a "means-tested" program probably has a higher administrative cost per capita than a program without means-testing; second, any means-tested program might attract less political support than a program in which all citizens or households receive a dividend payment; and third, any payment that in fact or in perception offsets the cost of electricity would have the undesirable effect of subsidizing electricity consumption rather than the desired effect of providing untied income.

Implementing the Proposed Study

It seems most appropriate that the Maryland Department of the Environment (MDE) would be take the lead in the proposed study given that it has overall responsibility for RGGI implementation as well as responsibility for Program Analysis, Goals and Overall Implementation of the Plan. It would be important to involve the Maryland Energy Administration (MEA) given its responsibility for the EmPower program and programs to encourage renewable energy production. It would also seem useful to involve independent consultants in the study who are best able to make objective assessments of the existing programs and their requirements over the longer term.

Concluding Remark on Maryland Leading by Example

As stated in the draft Plan (p. 3), "Through the adoption and implementation of a robust State climate action Plan, Maryland can lead the nation by example." The proposed study could be an important vehicle by which Maryland provides leadership on climate action by laying the groundwork for a very significant innovation in the RGGI and perhaps eventually in cap-and-trade programs around the world.

[7] See RGGI Inc. *op. cit*. at http://www.rggi.org/docs/Investment_of_RGGI_Allowance_Proceeds.pdf

Response:

1) Maryland is participating in a stakeholder process currently occurring to revise the RGGI program. The Plan includes information about tightening the cap, but at this time more information will be included after the external stakeholder process comes to a conclusion.

2) Revenue gained from the RGGI program is quite small compared to the number of participants in the program. Thus, it has been found that the money from this program is better used on energy efficiency. The Plan will not include a feasibility study, as it would be

an inappropriate venue for the study. A feasibility study could be conducted in the state of Maryland as a part of the RGGI stakeholder process.

3) The chapters on Climate Change have been edited and updated in the final Plan.

Commenter: Elizabeth Singer

Cutting carbon emissions from fossil fuels is one of the most important actions that state government working with NGO's and the private sector can take today and in future years and decades. Collectively, we must attempt to slow climate warming and the resulting damage to our food supply, water, air and land.

Thank you for holding town hall meetings for the public to question and comment on the Maryland Greenhouse Gas Reduction Plan. I attended the Town Hall in Silver Spring on July 17 and found it extremely informative and consequential. The draft plan is excellent, but it should be strengthened, especially in three areas: the Regional Greenhouse Gas Initiative (RGGI), the Renewable Portfolio Standard (RPS) and EmPower Maryland.

The law calls for reducing GHG emissions to 25 % below 2006 levels by 2020. This goal should be strengthened by including reductions to GHG of 20% below the current emissions levels by 2020. Today's levels are lower and should be locked in.

Also, the plan relies on limiting coal through cap and trade. The substitution of natural gas produced by hydraulic fracturing for coal is not a good value. The associated emissions of methane and of fuel for the fleet of trucks required for at the drilling sites should be counted in the natural gas emissions tracking process.

In the spring 2011 Maryland legislative session, trash incineration was stuck in the Tier 1 category of of the state's renewable energy portfolio, even though it is toxic and contributes to carbon emissions. Incineration should be taken out of Tier 1.

"Black liquor" and wood waste, which emit carbon and other pollutants like smog and ozone, should not receive renewable energy credits.

The Greenhouse Gas Reduction Plan should address the fact that EmPower needs strengthening. For example, I urge you to include ways to get the Public Service Commission to approve utility programs that achieve real savings and reward and penalize poor energy saving performance. Additional ways to finance efficiencies should be made available to ratepayers.

As a citizen of Maryland, I will be urging my Howard County Delegation to approve legislation for Offshore Wind Energy and other legislation to support clean, renewable sources of energy. I urge you to develop the best plan possible to implement the Greenhouse Emission Reduction Act of 2009.

Elizabeth H. Singer
6180 Devon Dr.
Columbia, MD 21044
443-812-2525
Climate Change Initiative of Howard County

Response:

1) In the final Plan, hydraulic fracturing or fracking is addressed in Chapter 6. A State Taskforce is currently evaluating fracking separately from the Greenhouse Gas Reduction Plan. While MDE is concerned about gas emissions from other states effecting Maryland, no programs concerning fracking will commence until the Taskforce has published their report. Further,

given the limited quantity of shale gas located in Maryland, fracking is less unlikely to contribute as significantly to greenhouse gas emissions as compared to neighboring states.

2) Black liquor and wood waste is addressed in the final Plan. With modifications to RPS, there could be increased carbon savings. At this time, the Plan does not recommend changes to RPS, although we recognize that carbon emissions from RPS can directly increase or decrease carbon emissions in the State.

3) Within the Plan itself, EmPOWER Maryland will not be specifically modified. However, EmPOWER Maryland involves a stakeholder process in which issues of incentives and penalties are an ongoing discussion. This program within the Plan will be modified as changes are made to how the program works by the outside stakeholder group.

Commenter: Energy Recovery Council

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WASHINGTON, DC 20036
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August 17, 2012

Ms. Kathy M. Kinsey
Deputy Secretary for Operations
and Regulatory Programs
Maryland Department of the Environment
Office of the Secretary
1800 Washington Boulevard
Baltimore, MD 21230-1718

RE: Comments on Maryland's Plan to Reduce Greenhouse Gas Emissions, December 31, 2011

Dear Deputy Secretary Kinsey:

On behalf of the Energy Recovery Council (ERC), I am providing the following comments on Maryland's draft Plan to Reduce Greenhouse Gas Emissions, dated December 31, 2011. Wasteto-energy has been recognized around the world as an important tool in reducing greenhouse gas emissions. Unfortunately, the draft plan fails to recognize the importance of waste-to-energy in reducing greenhouse gas emissions and includes basic errors in determining the impact of the waste management sector on Maryland's greenhouse gas profile.

ERC represents companies and local governments engaged in the nation's waste-to-energy sector. There are 86 waste-to-energy facilities in the United States which produce clean, renewable energy through the combustion of municipal solid waste in specially designed power plants equipped with the most modern pollution control equipment to clean emissions. Trash volume is reduced by 90% and the remaining residue is safely reused or disposed in landfills. The 86 waste-to-energy plants in the nation have a baseload electric generation capacity of approximately 2,700 megawatts and process more than 28 millions tons of trash per year.

There are three waste-to-energy facilities operating in Maryland (Baltimore, Dickerson, and Joppa). These three facilities process more than 4,400 tons of trash per day and have a baseload electric generating capacity of more than 120 megawatts. In addition, two more facilities are being developed Baltimore and Frederick. In part due to the law signed by Governor O'Malley on May 17, 2011 which elevated waste-to-energy to a Tier 1 renewable in the state's renewable portfolio standard, Maryland is recognized as one of the state's that has the greatest understanding of the benefits of waste-to-energy.

The December 31, 2011 report appropriately discusses the role waste management can play in mitigating greenhouse gases. Unfortunately, it draws some fundamentally flawed conclusions based on inaccurate information. Using a life cycle analysis, waste-to-energy is not the largest contributor of greenhouse gases in the waste management sector. Rather, waste-to-energy is part

of the solution to reducing greenhouse gases. This has been substantiated by experts around the world. For example, the World Economic Forum in its 2009 report, “Green Investing: Towards
2
a Clean Energy Infrastructure,” identifies waste-to-energy as one of eight technologies likely to make a meaningful contribution to a future low-carbon energy system.

Experience shows that WTE is the principal alternative to landfilling post-recycled MSW. Without WTE capacity, jurisdictions across the U.S. and the world have had to rely on disposal of MSW, landfilling millions of tons of it which subsequently generates high volumes of methane. The section on waste management on page 77 of the draft report shows an inverse relationship of waste-to-energy on greenhouse gas emissions. Figure 3-12 shows that landfills have no baseline GHG emission in 2006. This is clearly an error. EPA data shows that landfills are the largest source of methane in the United States, and that methane is 23 times more potent that carbon dioxide. The figures for waste-to-energy in Figure 3-12 are also very inconsistent (and much higher) than those found in EPA’s Greenhouse Gas Data Publication Tool found on the U.S. EPA website. According to that tool, 24 landfills in Maryland emitted 1.3 million metric tonnes of CO2e in 2010. By comparison, the 3 waste-to-energy facilities in Maryland emitted 0.53 million metric tonnes in 2010. Both figures exclude biogenic CO2 emissions, since biogenic CO2 has a carbon dioxide equivalent weight of zero.

In addition, the ERC believes that the State of Maryland should take into consideration life cycle analyses when analyzing greenhouse gas emissions. Using a life cycle approach, waste-toenergy is demonstrated to be the best waste management option for both energy and environmental parameters and specifically for greenhouse gas emissions. Life cycle studies have shown that one ton of greenhouse gases are avoided for every ton of trash processed at a wasteto-energy facility. Applied to Maryland’s waste-to-energy facilities that are processing approximately 1.6 million tons of trash per year, waste-to-energy facilities prevent the release of approximately 1.6 million tons of carbon dioxide equivalents that would have been released into the atmosphere annually if waste-to-energy was not employed.

Waste-to-Energy reduces greenhouse gas emissions
To elaborate further, waste-to-energy achieves the reduction of greenhouse gas emission through three separate mechanisms: 1) by generating electrical power or steam, waste-to-energy avoids carbon dioxide (CO2) emissions from fossil fuel- based electrical generation; 2) the waste-toenergy combustion process effectively avoids all potential methane emissions from landfills, thereby avoiding any potential release of methane in the future; and 3) the recovery of ferrous and nonferrous metals from municipal solid waste by waste-to-energy is more energy efficient than production from raw materials.

These three mechanisms provide a true accounting of the greenhouse gas emission reduction potential of waste-to-energy. A life-cycle analysis, such as the U.S. Environmental Protection Agency’s Municipal Solid Waste Decision Support Tool, is the most accurate method for understanding and quantifying the complete accounting of any waste management option. A life-cycle approach should be used to allow decision makers to weigh and compare all greenhouse gas impacts associated with various activities and management options.

The Decision Support Tool is a peer-reviewed tool1 that enables the user to directly compare the energy and environmental consequences of various management options for a specific or general
1 Available through US EPA and its contractor RTI International.

situation. Technical papers authored by EPA2 report on the use of the Decision Support Tool to study municipal solid waste management options.

These studies used a life-cycle analysis to determine the environmental and energy impacts for various combinations of recycling, landfilling, and waste-to-energy. The results of the studies show that waste-to-energy yielded the best results—maximum energy with the least environmental impact (emissions of greenhouse gas, nitrogen oxide, fine particulate precursors, etc.). In brief, waste-to-energy has been demonstrated to be the best waste management option for both energy and environmental parameters and specifically for greenhouse gas emissions. When the Decision Support Tool is applied to the nationwide scope of waste-to-energy facilities that are processing 28 million tons of trash, it has been shown that the waste-to-energy industry prevents the release of approximately 28 million tons of carbon dioxide equivalents that would have been released into the atmosphere if waste-to-energy was not employed.

International Recognition of Waste-to-Energy

The ability of waste-to-energy to prevent greenhouse gas emissions on a life-cycle basis and mitigate climate change has been recognized in the actions taken by foreign nations trying to comply with Kyoto targets.

The Intergovernmental Panel on Climate Change (IPCC), the Nobel Prize winning independent panel of scientific and technical experts, has recognized waste-to-energy as a key greenhouse gas emission mitigation technology.

The World Economic Forum in its 2009 report, “Green Investing: Towards a Clean Energy Infrastructure,” identifies waste-to-energy as one of eight technologies likely to make a meaningful contribution to a future low-carbon energy system.

In the European Union, waste-to-energy facilities are not required to have a permit or credits for emissions of CO2, because of their greenhouse gas mitigation potential. In the 2005 report, “Waste Sector’s Contribution to Climate Protection”, the German Ministry of the Environment stated that “…waste incineration plants and co-incineration display the greatest potential for reducing emissions of greenhouse gases.” The report concluded that the use of waste combustion with energy recovery coupled with the reduction in landfilling of biodegradable waste will assist the European Union-15 in meeting its obligations under the Kyoto Protocol. In a 2008 briefing, the European Environment Agency attributes reductions in waste management greenhouse gas emissions to waste-to-energy.

Under the Kyoto Protocol, by displacing fossil fuel-fired electricity generation and eliminating methane production from landfills, waste-to-energy plants can generate tradable credits (Certified Emission Reductions [CERs3]) through approved Clean Development Mechanism

2 *“Moving From Solid Waste Disposal to Management in the United States,” Thorneloe (EPA) and Weitz (RTI)*
October, 2005, and “Application of the U.S. Decision Support Tool for Materials and Waste Management,”
Thorneloe (EPA), Weitz (RTI), Jambeck (UNH), 2006

3 CDM protocol (AM0025 v7) and associated memorandum, "Avoided emissions from organic waste through
alternative waste treatment processes."
4
protocols. These CERs are accepted as a compliance tool in the European Union Emissions Trading Scheme.

In summary, waste-to-energy is recognized as a greenhouse gas mitigation technology that is eligible for offsets through independent approved protocols. Treatment of waste-to-energy as a source of greenhouse gas emissions would be inconsistent with internationally accepted science and accounting procedures. Just as importantly, it would put the United States at a disadvantage in meeting CO2 reduction targets because an important tool used by other countries would not be available domestically.

Domestic Recognition of Waste-to-Energy

The ability of waste-to-energy to reduce greenhouse gas emissions has been embraced domestically. The Nature Conservancy (TNC) has an August 2011 feature on their website which helps explain how and why trash should help solve our energy problems. Joe Fargione, lead scientist with the TNC's North America Region said, "There is no silver bullet for solving the problem of producing renewable energy, but waste-to-energy can be an important part of the solution**.** Waste from energy is not only renewable, it avoids putting the waste into landfills that produce methane gas, a greenhouse gas 23 times more potent than carbon dioxide. Therefore, waste-to-energy provides significant greenhouse gas emission reduction benefits." (http://www.nature.org/ourscience/sciencefeatures/ask-the-conservationist-august-2011.xml). This is a widely recognized position.

The ability of waste-to-energy to reduce greenhouse gas emissions has been embraced domestically as well. The U.S. Conference of Mayors adopted a resolution in 2004 recognizing the greenhouse gas reduction benefits of waste-to-energy. In addition, the U.S. Mayors Climate Protection Agreement supports a 7 percent reduction in greenhouse gases from 1990 levels by 2012. The Agreement recognizes waste-to-energy technology as a means to achieve that goal. As of the date of this letter, more than 1,000 mayors have signed the agreement.

The Global Roundtable on Climate Change (GROCC), convened by Columbia University's Earth Institute, issued a statement on February 20, 2007 identifying waste-to-energy as a means to reduce CO2 emissions from the electric generating sector and methane emissions from landfills. The GROCC, which brought together high-level, critical stakeholders from all regions of the world, recognized the importance of waste-to-energy's role in reducing greenhouse gas emissions. The breadth of support for the GROCC position is evidenced by those that have signed the joint statement, including Dr. James Hansen of the NASA Goddard Institute for Space Studies, as well as entities as diverse as American Electric Power and Environmental Defense.

The Lee County (FL) waste-to-energy facility has been certified by the Voluntary Carbon Standard to generate carbon offsets which can be sold to those entities wishing to acquire carbon credits. The credits are based on electricity generated by the new capacity added by a recent expansion of its waste-to-energy facility. By emitting less greenhouse gases than its alternatives, the county has banked more than 80,000 carbon credits. Lee County's waste-to-energy plant is the first in the nation to sell its own carbon credits on the voluntary market. The money generated by these credits will go to offset garbage collection fees.

Conclusion
In closing, waste-to-energy is a critical tool in reducing greenhouse gases from the solid waste sector. The draft Maryland plan should be corrected to reflect accurate comparisons between waste-to-energy and landfills. In addition, the ERC believes that life cycle analysis is the most accurate method with which to analyze greenhouse gas emissions in the waste sector. Without taking such analyses into account, policy makers will be drawing conclusions based on less the all the relevant facts. Please contact me if you have any questions regarding our comments, and thank you for your consideration.

Sincerely,

Ted Michaels
President

Response:

1) Waste to energy
   a) The final Plan includes significant updates including a new waste to energy section in Chapter 6. This section discusses the potential benefits of using a waste to energy program. There will be further examination of waste to energy as a mechanism to reduce greenhouse gas emissions, and the Plan itself is a working document that can still change.
   b) Life cycle effects could be added to every part of the Plan, but as of right now, this is a huge struggle to include due to conflicting views of different stakeholders. However, there are key areas where this program is becoming more prevalent, especially in clean fuel and natural gas benefits in the power sector. Although a life cycle approach is not included as part of the programs outlined in the final Plan, including life cycle approaches to reducing greenhouse gases will be explored more in the future.

Commenter: Environment Maryland Research & Policy Center

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August 2012

Comments on Maryland's Draft Greenhouse Gas Reduction Plan

Environment Maryland Research & Policy Center thanks the Maryland Department of the Environment for the opportunity to comment on *Maryland's Plan to Reduce Greenhouse Gas Emissions* (hereafter, the "draft plan") and for MDE's work implementing a number of key policies to reduce emissions in the state.

The Greenhouse Gas Emissions Reduction Act (GGRA) requires the adoption of a plan to achieve at least a 25 percent reduction in statewide greenhouse gas emissions by 2020, complete with "adopted regulations that implement all plan measures for which state agencies have existing legislative authority" and "a summary of any new legislative authority needed" to achieve the goals of the plan. A credible, well-designed, actionable plan in 2012 is necessary if Maryland is to achieve the goals of the GGRA – particularly given the lead time needed for the development and implementation of the necessary policies.

We recognize that the task of compiling a plan of this scale and technical complexity is a massive undertaking and understand that the draft plan submitted for comment by MDE is a "work in progress" and that technical analysis continues. However, the draft plan fails to provide confidence that Maryland is "on track" to achieve the goals of the GGRA. The emission reduction strategy described in the main body of the draft plan represents a "best-case scenario" for emission reductions that will succeed only if nearly all the policies envisioned in the plan are implemented faithfully and on-schedule, and if each policy delivers close to the maximum amount of potential emission reductions. Moreover, the draft plan, in its current form, fails to incorporate key changes that have significantly altered patterns of energy consumption since 2006, making it difficult to evaluate whether the proposed policies will achieve the intended results.

We urge that the draft plan be revised to present more realistic estimates of emission reductions from each policy, reflect up-to-date information, and better articulate what additional steps the state needs to take to achieve its goal.

With this information before them, elected officials, policymakers and the public will have the opportunity to consider what policy changes are needed to facilitate meeting Maryland's 2020 greenhouse gas reduction goals.

Environment Maryland Research & Policy Center has the following specific recommendations.

1. Present a more balanced appraisal of the emission reduction potential of various policies.

The draft plan should be revised to include a more balanced portrayal of the potential emission reductions from the policies.
The main body of the draft plan lays out estimated emission reductions resulting from each of the 65 policies and tallies the "potential" emission reductions from those policies, concluding that the programs "if implemented successfully" will achieve the 25 percent emission reduction goal. That conclusion, however, rests on an extremely optimistic view of the analysis presented in Appendix C of the plan, which provides a range of potential emission reductions for each policy. Whereas the main body of the report presents data suggesting that the policies will deliver emission reductions of 82 $MMTCO_2e$ (before accounting for overlap among policies), Appendix C presents a range of 45 to 82 $MMTCO_2e$ in expected emission reductions. Should Maryland achieve only the lower bound estimate of emission reductions, the state could fall far short of meeting the goals of the GGRA – even if action is taken in all 65 areas of policy described in the plan.

To ensure that the goals of the GGRA are met, Maryland's greenhouse gas plan must include realistic and balanced assumptions about both the likelihood that various policies will be fully implemented and the changes those policies will deliver in emission reductions.

At minimum, we recommend that MDE present the conservative, lower-bound estimate of emission reductions alongside the upper-bound estimate in the main body of the revised plan – a step that will accurately communicate to the public and decision-makers the need for strong action to reduce emissions in order to meet the goals of the GGRA. Ultimately, Maryland should plan for and adopt policies sufficient to ensure that goals of the GGRA are met even if all "potential" emission reductions fail to materialize.

2. Provide greater clarity on the impact of steps already taken and the need for additional policy action.

The current draft of the plan fails to distinguish clearly between expected reductions from existing policies and steps yet to be taken. This has the potential to create the misimpression that Maryland is farther along in its emission reduction efforts than is actually the case.

For example, the 17.7 $MMTCO_2e$ savings projected from the Regional Greenhouse Gas Initiative (RGGI) in the main body of the report is based on an assumption that the program will be improved to deliver additional emission reductions beyond those currently required. Nowhere in the main body of the report is this made clear; a reader must turn to Appendix C for clarification. The presentation of this "upper bound" estimate of savings from RGGI leaves the impression that Maryland will achieve 17.7 $MMTCO_2e$ in savings as a result of its current participation in the program when, in reality, strengthening of the RGGI emission cap will likely only occur as a result of vigorous and sustained advocacy by the state of Maryland in cooperation with other northeastern states.

Another instance in which the draft fails to distinguish between hoped-for emission savings and savings that are likely to be achieved regards EmPOWER Maryland. The draft plan assumes full compliance with the 2015 goals of EmPOWER Maryland, and expansion of the program after that. Not only is the assumed expansion of the program hardly referenced, but no mention is made of the fact that progress toward the existing EmPOWER Maryland goals is severely lagging. In calculating its estimate of savings from EmPOWER Maryland, SAIC assumes that the state has reduced per capita electricity consumption by 7 percent in 2012 (halfway to the 2015 goal), an assumption that is not supported by utilities' filings with the Public Service Commission or by data presented in Appendix C starting on p. 53.

Environment Maryland Research & Policy Center is encouraged by the inclusion of steps such as the expansion of RGGI and extension of EmPOWER Maryland in the draft plan. It is important, however, that the public understand that such steps are key components of any realistic plan to meet the state's greenhouse gas reduction goals.

3. Revise the business-as-usual scenario to reflect developments since 2006.

Since 2006, there have been significant shifts in energy consumption patterns in the United States, resulting from technological changes, government policies, the recent economic downturn, and shifting prices for fossil fuels. The draft plan submitted by MDE fails to reflect many of these important shifts. While we understand that the business-as-usual forecast of GHG emissions will be revised for the final plan, the importance of using up-to-date assumptions in evaluating the policies proposed in the plan cannot be overstated, for several reasons:

1. The use of up-to-date assumptions on energy use will enable creation of a more accurate baseline forecast against which to compare policies Maryland implements.
2. It will enable more accurate estimation of the emission reduction potential of various policies, providing the tools for decision-makers to prioritize policies based on their emission reduction potential.
3. It will enhance the credibility of the document and of Maryland's greenhouse gas reduction efforts more generally.

The two clearest examples of how the business-as-usual (BAU) scenario in the draft plan deviates from reality are in electricity generation and on-road travel. Emissions from in-state electricity generation since 2006 are very different than those described in the BAU scenario of the draft plan. In the draft plan, emissions from in-state generation are shown to rise from 2006 to 2010, with the biggest jump coming from coal-fired power plants with a 19 percent increase in emissions. However, this doesn't correspond to what happened in reality. From 2006 to 2010, carbon dioxide emissions from coal-fired power plants declined by 17 percent.[1] That change was much more the result of the economic downturn than any policies adopted by Maryland.

In addition, recent evidence suggests that the projected growth in vehicle miles of travel (VMT) of 1.8% from 2006 to 2020 is an overestimate, which will result in an overestimate of emissions from transportation in the BAU scenario. The use of historic VMT trends from 1990 to 2006 to forecast future VMT is likely to dramatically overstate travel as a result of a shift in driving patterns that has occurred nationwide and in Maryland since 2006 due to economic conditions, gasoline prices and other factors. The

[1] U.S. Department of Energy, Energy Information Administration, State Electricity Profiles 2010.

actual annual VMT growth rate in Maryland from 2006 to 2010 was slightly negative.[2] As a result, VMT would need to grow at a rate significantly greater than 1.8% per year from 2010 through 2020 to fulfill the BAU forecast. By way of comparison, the U.S. Energy Information Administration, in its latest *Annual Energy Outlook*, projects that light-duty VMT nationally will increase by an average of only 0.8% per year between 2010 and 2020. While there may be reasons why Maryland could be

expected to have a rate of VMT increase greater than the national average, there is little compelling reason to believe that VMT will grow at a rate significantly above 1.8% over the next decade.
Another input to the baseline that needs to be updated is population projections. Some of the population data current in the baseline are from 2007. These projections do not match the 2010 Census, or March 2012 projections from the Maryland Department of Planning.3
It is unclear whether the total effect of these revisions would be to increase or decrease the likelihood that the emission reduction policies in the draft plan will achieve the emission reduction goal of the GGRA. A credible plan, however, must include these significant changes in energy use in Maryland if it is to instill confidence that the anticipated emission reductions will actually materialize.

4. Update the overlap analysis.

Many of the policies in the draft plan overlap one another in their impacts on energy use. The current methodology in the draft plan for the overlap calculation is not clear, but a comparison between the main report and SAIC's analysis suggests the overlap estimate in the main report may be too low. SAIC assumes a 41 percent overlap for the residential, commercial, industrial and electric sector policies they modeled, compared to a 22 percent overlap of all policies in the main report. We understand that a revised overlap analysis will be completed for the final plan and hope that it will be robust.

5. Consider additional revisions.

1. The BAU scenario in the draft plan assumes a decrease in global warming emissions from natural gas production. That will hold true only if hydraulic fracturing does not become common in Maryland. Environment Maryland Research & Policy Center recommends that a **ban on natural gas fracking** be included as a specific policy step that the state should take to ensure it achieves its greenhouse gas emission reduction goals.

2. The plan should include a **margin of error** to account for policies that do not get implemented. Some of the policies that MDE has included in its plan, though they are sound policy ideas, have either moved slowly or not at all since the first discussions began in Maryland regarding options for reducing emissions. For example, there has been relatively little motion on policies related to pay-as-you-drive automobile insurance since 2008, and legal challenges have slowed

[2] U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information, Highway Statistics 2010.
[3] Maryland Department of Planning, Historical and Projected Household Population for Maryland's Jurisdictions (spreadsheet), 27 March 2012. Available at http://www.mdp.state.md.us/msdc/s3_projection.shtml.

development of a clean fuel standard. If a few policies are not implemented, including a margin of error in the analysis would nonetheless allow the state to achieve its emissions reduction target.
In summary, Environment Maryland Research & Policy Center applauds MDE and other state agencies and staff for the efforts made to reduce greenhouse gas emissions and to develop the draft plan. We support the policy vision laid out in the draft plan, which, if implemented, would not only reduce greenhouse gas emissions, but would also reduce Maryland's dependence on fossil fuels and improve the quality of our environment. However, the draft plan does not create a sense of

confidence that Maryland is "on track" to achieve the emission reduction goals of the GGRA. With so little time remaining to adopt policies that will have a meaningful impact on emissions prior to 2020, Maryland needs a plan based on realistic assumptions, up-to-date information, and a clear sense of the required tasks if we are to achieve the goals of the GGRA and do our share to protect our state from the worst impacts of global warming.

Sincerely,

Tommy Landers
Director

Response:

1) The final Plan has been updated to include a balanced appraisal of emission reductions. There will no longer be a range of expected emission reductions, but one final number for total emission reductions will be provided. This expected emission reduction amount is the State's best estimate of what greenhouse gas reductions will be in 2020.

2) The edits in Chapter 6 of the final Plan will include information on the steps already taken toward reducing greenhouse gas emissions. The programs included in the Plan are tools that can be used to reduce greenhouse gas emissions, and the greater extent to which these programs are implemented, the greater the reduction potential.

3) Business as usual scenario
   a) We have edited the Plan so that it now represents both the best case scenario of reductions as well as more conservative, lower-bound reduction estimates originally only in the Appendix. These updated estimates are in Chapter 6 of the Plan. Key changes have been made to the Plan's 2006 baseline emissions analysis mandated by GGRA (Greenhouse Gas Emissions Reduction Act of 2009). The 2020 business-as-usual (BAU) emissions estimate is being revised for the energy sector. The Plan is a living document and the 2020 BAU estimate will continue to be updated after 2012. The Plan will be reviewed and re-evaluated in the 2015 status report to the legislature as mandated by GGRA.
   b) A very standard growth rate for VMTs was used based on historical data of VMT growth. There will be no revised VMT estimates at this time, as the impact of 1% in only one year will not be as significant as the impacts over multiple years. To be clear, a reduction of over a billion VMTs would have to occur to show a significant change.

4) The overlap analysis has been updated accordingly and the SAIC analysis is included in the final plan as an appendix.

5) Additional Revisions Recommended
   a) In the final Plan, hydraulic fracturing or fracking is addressed in Chapter 6. A State Taskforce is currently evaluating fracking separately from the Greenhouse Gas Emissions Reduction Plan. While MDE is concerned about gas emissions from other states effecting Maryland, no programs concerning fracking will commence until the Taskforce has published their report. Further, given the limited quantity of shale gas located in Maryland, fracking is less unlikely to contribute as significantly to greenhouse gas emissions as compared to neighboring states.
   b) By including the overlap analysis, the updated Plan will adequately include the margin of error of how much greenhouse gas emissions will realistically be reduced. Maryland has been involved in a regional effort in the Northeast to develop a Clean Fuels Standard which considers the life cycle GHG impacts of transportation fuels. The direction and future of the program is currently being re-evaluated. The State has removed any Clean Fuel Credits from the Plan until the program is better defined. Conducting a full life cycle analysis of other programs in the Plan would present tremendous technical, methodological and resource challenges and, other than addressing natural gas benefits in the power sector, is not feasible to include in the Plan at this time.

Commenter: Katelyn Hasz

From: Katelyn Hasz <khasz1@students.towson.edu>
To: <climate@mde.state.md.us>
Date: 8/28/2012 12:29 PM
Subject: GGRA Revisions Needed

Dear Governor Martin O' Malley and Secretary Robert Summers,

Thank you for all your leadership in recent years in fighting climate change in Maryland by promoting clean, renewable energy.

Last month, per the Greenhouse Gas Emissions Reduction Act of 2009, the Maryland Department of the Environment released a draft plan for reducing carbon pollution statewide by 25 percent by 2020. The plan lays out an admirable framework of 65 programs for reducing emissions, involving efforts from many state agencies.

However, the plan has serious shortcomings. It makes unrealistic assumptions about certain pollution cuts. It projects overly rosy timelines for achievements. And - in several instances - it just gets the facts wrong. For example, the plan assumes the state’s clean electricity standard has the potential to reduce much more carbon pollution than is realistically possible.

By the end of 2012, MDE and each state agency responsible for implementing the plan must work together to ensure the final GGRA plan is complete with a clear path for implementing programs that will realistically achieve the General Assembly’s mandate. All state agencies must be held accountable for this goal.

Cutting carbon pollution will provide great economic benefits to the state if implemented effectively. Maryland's leadership will show our country and the world that climate progress is achievable and brings with it substantial benefits.

Sincerely,

Katelyn Hasz
lachlan Cr
baltimore, MD 21239

Response:

1) The final Plan has been revised to examine the true potential benefits of the programs expressed. The overlap analysis in the final Plan ensures that reduction numbers have not been the result of double counting, and has been updated accordingly. The SAIC analysis is also included in the final plan.

2) MDE has been working closely with the governor as well as other State agencies involved such as, MDoT, MEA, and MDP. The Governor's office is tracking implementation of the plan through the Governor's Delivery Unit (GDU) (https://data.maryland.gov/goals/greenhouse-gases). The Governor has been directly involved in development of the Plan. He has made the Plan into a "stat" process for the state of Maryland, called ClimateSTAT. The Plan itself is a living document that will be changed and edited as the implementation process occurs.

Commenter: Liz Feighner
August 16, 2012

Maryland Department of the Environment
climate@mde.state.md.us

Re: Maryland Greenhouse Gas Emissions Reduction Draft Plan

To Whom It May Concern:
I am writing about Maryland's Greenhouse Gas Emissions Reduction Plan and appreciate the opportunity to comment on this plan. While Maryland has taken climate change seriously by passing the2009 Greenhouse Gas Emissions Reduction Act, there are issues with the current plan that jeopardize the target goal to cut greenhouse gas (GHG) emissions 25 percent below 2006 levels by 2020.

I have several concerns that the plan relies too much on natural gas to meet these goals and does not factor in the negative impact of natural gas on the climate and our natural resources.
While it may look good on paper that burning natural gas instead of coal reduces GHG emissions in Maryland, the plan does not include the impact of drilling for natural gas through a process called hydraulic fracturing, also known as fracking. The methane emissions from fracking are a serious concern and should be factored into the plan even though these emissions occur in other states where fracking is allowed.

Since Maryland currently has a ban on this controversial process and rightly so, Maryland should include the impact of these detrimental emissions in the plan since the entire life cycle of natural gas needs to be considered. Maryland's reliance on natural gas harms states that allow the dangerous practice of fracking and, therefore, the Maryland plan should account for the significant GHG emissions that occur during the fracking process.

I am also concerned that the plan relies on energy sources that are considered Tier 1 renewable energy sources that are actually contributing to dangerous toxic emissions and adding to the GHG emissions. Trash incineration, black liquor and wood waste are not "clean" energy sources and should not be considered as Tier 1. Counting these dirty energy sources as Tier 1 is disingenuous and these sources should not get Renewable Energy Credit (REC) certification.

One of the requirements of the plan is that it must have a positive impact on Maryland's economy and jobs. Maryland developed the Genuine Progress Indicator (GPI) to measure how development activities impact long-term prosperity, both positively and negatively. Traditional indicators like the Gross Domestic/State Products address only economic transactions. They do not include the environmental and social costs or fully appreciate the significant contributions of our natural systems. To truly measure the positive impact that the Maryland's Greenhouse Gas Emissions Reduction Plan will have on Marylanders, the plan should utilize this innovative tool in its calculations.

Thank you for providing the public the opportunity to comment on the Maryland's Greenhouse Gas Emissions Reduction Plan. This is an important plan that needs strengthening in order to truly achieve a real reduction in GHG emissions. Seeing the economic and environmental devastation across the country caused by climate change makes it imperative that Maryland achieve the plan's targeted goals.

Sincerely,

Liz Feighner
10306 Champions Way
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liz.feighner@gmail.com

"We do not inherit the Earth from our Ancestors: we borrow it from our children." ~ Native American Proverb

Response:

1) In the final Plan, hydraulic fracturing or fracking is addressed in Chapter 6. A State Taskforce is currently evaluating fracking separately from the Greenhouse Gas Reduction Plan. While MDE is concerned about gas emissions from other states effecting Maryland, no programs concerning fracking will commence until the Taskforce has published their report. Further, given the limited quantity of shale gas located in Maryland, fracking is less unlikely to contribute as significantly to greenhouse gas emissions as compared to neighboring states.

2) We agree with this comment and as part of the clean fuel standard, we have looked at life cycle effects. Unfortunately, this program has suffered delays and controversy, because of which, we have eliminated any credits until the program is better defined. We hope to implement this program in the future. Life cycle effects could be added to every part of the Plan, but as of right now, this is a huge struggle to include due to conflicting views of different stakeholders. However, there are key areas where this program is becoming more prevalent, especially in clean fuel and natural gas benefits in the power sector.

3) Black liquor and wood waste is addressed in the final Plan. With modifications to RPS, there could be increased carbon savings. At this time, the Plan does not recommend changes to RPS, although we recognize that carbon emissions from RPS can directly increase or decrease carbon emissions in the State.

4) Genuine progress indicator (GPI)
   a) Gross Domestic Product (GDP) is a commonly used measure, and is a measure that most people understand. The GPI is a State specific measure. Maryland decided to use GDP as a metric to track economic benefit because of its familiarity in the economic world. GDP also provides a more conservative estimate of benefits from the programs. MDE is involved in the GPI process and will continue to work through it if GPI is incorporated in the State government process.

Commenter: Mary Wolfe

Dear Governor Martin O' Malley and Secretary Robert Summers,

Thank you for all your leadership in recent years in fighting climate change in Maryland by promoting clean, renewable energy.

Last month, per the Greenhouse Gas Emissions Reduction Act of 2009, the Maryland Department of the Environment released a draft plan for reducing carbon pollution statewide by 25 percent by 2020. The plan lays out an admirable framework of 65 programs for reducing emissions, involving efforts from many state agencies.

However, the plan has serious shortcomings. It makes unrealistic assumptions about certain pollution cuts. It projects overly rosy timelines for achievements. And – in several instances – it just gets the facts wrong. For example, the plan assumes the state's clean electricity standard has the potential to reduce much more carbon pollution than is realistically possible.

By the end of 2012, MDE and each state agency responsible for implementing the plan must work together to ensure the final GGRA plan is complete with a clear path for implementing programs that will realistically achieve the General Assembly's mandate. All state agencies must be held accountable for this goal.

Cutting carbon pollution will provide great economic benefits to the state if implemented effectively. Maryland's leadership will show our country and the world that climate progress is achievable and brings with it substantial benefits.

Sincerely,

Mary Wolfe
2 Oakridge Court
LuthervilleTimonium, MD 21093

Response:

1) The final Plan has been revised to examine the true potential benefits of the programs expressed. The overlap analysis in the final Plan ensures that reduction numbers have not been the result of double counting, and has been updated accordingly. The SAIC analysis is also included in the final plan.

2) MDE has been working closely with the governor as well as other State agencies involved such as, MDoT, MEA, and MDP. The Governor's office is tracking implementation of the plan through the Governor's Delivery Unit (GDU) (https://data.maryland.gov/goals/greenhouse-gases). The Governor has been directly involved in development of the Plan. He has made the Plan into a "stat" process for the state of Maryland, called ClimateSTAT. The Plan itself is a living document that will be changed and edited as the implementation process occurs.

Commenter: Maryland Association of Counties

MARYLAND ASSOCIATION OF COUNTIES, INC.

August 17, 2012

The Maryland Association of Counties (MACo) submits the following comments to the Maryland Department of the Environment (MDE) regarding the draft version of Maryland's Plan to Reduce Greenhouse Gas Emissions (Plan). MACo recognizes that climate change could pose significant challenges to Maryland and its counties and wishes to acknowledge the significant work and effort of agency staff in the creation of the Plan.

However, MACo is concerned with the lack of specificity and feasibility of several areas of the Plan. MACo's comments fall within four general categories: (1) comments regarding the estimated costs, economic benefits, and results of implementing the strategies proposed in the Plan; (2) specific greenhouse gas (GHG) reduction strategies outlined in Chapter 6 of the Plan that would significantly affect local governments; (3) adaptation strategies outlined in Chapter 8 of the Plan that would significantly affect local governments; and (4) the process that will be used to finalize and potentially implement the Plan.

Cost, Benefits and Results

- *The Plan should estimate the implementation costs of each reduction strategy for the State, local governments, and other key stakeholders.*

The cost of implementing the 65 proposed reduction strategies in Chapter 6 and Appendix C of the Plan is estimated to be $3 billion. While the potential job and economic benefits of the reduction strategies are discussed, the implementation costs that would be borne by the State, local governments, and other stakeholders are not. Just as the Plan estimates the potential economic benefits of each strategy, the Plan should also estimate each strategy's implementation costs.

County governments are already facing significant costs to comply with the federal Chesapeake Bay Total Maximum Daily Load requirements and various state mandates, such as new septic system growth tiers, PlanMaryland planning areas, and stormwater management requirements.

- *The Plan should provide greater cost information for each adaptation strategy for the State, local governments, and other key stakeholders.*

Little cost information for the adaptation strategies discussed in Chapter 8 of the Plan except to assign generic such as "high," "low," and "to-be-determined." As noted in the first bullet, the costs that would be borne by the State, local governments, and other stakeholders should be estimated to the extent feasible before a commitment is made to implement the adaptation strategy.

- *The Plan should address how the reduction strategies will affect climate change in Maryland.*

The Plan highlights climate change as the chief reason to reduce GHGs and Chapter 4 of the Plan highlights the “cost of inaction” if climate change is not addressed. Chapter 5 of the Plan discusses ancillary benefits of reducing GHGs, including improvements to the health of the Chesapeake Bay, public health, and air quality. However, the Plan does not quantify how the reduction strategies will actually affect climate change.

- *Further analysis of the potential economic and job impacts of the reduction strategies should be undertaken.*

A preliminary economic analysis conducted by Towson University’s Regional Economic Studies Institute (RESI) estimates that if all 65 of the Plan’s proposed reduction strategies are implemented the result will be the creation of approximately 36,000 jobs, $6.1 billion in additional economic output, and $2.1 billion in additional wages. According to RESI, for every $1 million invested in the reduction strategies, 15 jobs will be created with an economic output of $1.8 million and $0.6 million in wages.

While acknowledging that the findings are preliminary, the Plan dedicates an entire chapter (Chapter 7) to the RESI study. Based on the prominence given to the RESI study, further analysis of the potential job and economic development impacts should be undertaken. If feasible, economic impacts and benefits should be mapped to a regional or county level.

GHG Reduction Strategies

MACo’s initial comments regarding the 65 proposed reduction strategies will focus on three specific strategies. Ultimately, MACo may have additional concerns regarding other potential strategies as further detail is provided.

- *The economic feasibility of increasing recycling goals, especially for rural counties, should be examined before setting new recycling goals for county governments under the Recycling – 1 strategy.*

The Recycling – 1 strategy discusses recycling and source reduction and contemplates increased recycling rates for county governments. While a robust and economically viable recycling program can result in many benefits, including GHG reduction, recycling is heavily dependent on raw material costs and population density in order to be profitable. For most Maryland counties, recycling does not generate a net profit and instead constitutes an unfunded state mandate. Rural counties, with smaller populations and longer travel distances, are particularly challenged as the lack of a viable market precludes interest from most recycling vendors. MDE should consider the economic feasibility of any proposed recycling goal increases and identify funding sources necessary to hold counties where recycling is unprofitable harmless.

- *County governments should not be subject to a vehicle miles traveled (VMT) target under Land Use – 1 strategy.*

The Land Use – 1 strategy would require local governments to use their land use planning and zoning authority to "require a significant adjustment of land use patterns away from automobile-oriented development." Furthermore, "[the Maryland Department of Planning (MDP) and sister agencies will investigate the feasibility in Maryland of implementing California's Senate Bill 375 bill and will develop sustainability criteria (e.g., a decrease or no net increase in VMTs) that local transportation plans and projects must achieve in order to receive State transportation funds." (Both quotes from page 253 of the Plan.)

MACo opposes VMT targets for county governments. There are many reasons behind where people choose to live and work and how they travel, including attachment to a particular geographic area or lifestyle, family location, housing affordability, and job location. The ability of a county government to influence these choices through the comprehensive planning and zoning process is limited and the Land Use – 1 strategy should be removed from the Plan.

Mass transit options are not (and realistically will not be) available in many regions of the state. Additionally, counties have little ability to control "pass through" traffic that travels through a particular jurisdiction in order to reach a destination outside of the jurisdiction.

In addition, the Maryland Department of Transportation (MDOT) has long been the primary state agency associated with transportation planning. Yet the Land Use – 1 strategy casts MDP as the lead agency. MACo questions why the transfer of a longstanding MDOT responsibility to an agency that has not previously held a major transportation oversight role is necessary.

- *County governments and metropolitan planning organizations (MPOs) should not be subject to GHG targets under the Land Use – 2 strategy.*

The Land Use – 2 strategy would establish GHG transportation and land use planning goals for local governments and metropolitan planning agencies. While initially voluntary, such goals could easily become mandatory. MDE is in the process of vetting regulations to assign GHG emission targets and reporting requirements for certain MPOs. Both the Baltimore Regional Transportation Board and the National Capital Transportation Planning Board, along with county transportation and MDOT officials have expressed concerns over the propriety and feasibility of the regulations. Unless current MPO and county concerns can be addressed, the Land Use – 2 strategy should be removed from the Plan.

Adaptation Strategies

- *The Plan should more clearly highlight the potential responsibilities that will be placed on county governments under the proposed adaptation strategies.*

Chapter 8 of the Plan states that Maryland is already experiencing the effects of climate change and that a series of adaptation strategies should be implemented to offset its future effects. Some of the strategies would clearly require significant county government commitment and resources but lack necessary specificity. Other strategies, however, are so vague that the effect on county governments cannot even be estimated.

For example, a recommendation under the section on sea-level rise would require the integration of sea-level rise adaptation and response planning strategies into existing local policies and programs, including modifications to building codes and construction techniques. A recommendation under the human health section would require the local planning practices to improve health response capacity through the development of new or expanded programs. While clearly indicating some level of county government funding and programmatic changes, more information is needed before counties can truly comment on their costs and impacts.

Other key recommendations involve potentially significant changes to water resource, infrastructure, and population management. However, many of these recommendations are vague and lack specificity. For example, MDE proposes to "manage water through the lens of future climate and population." MDP proposes to "explore incentives to promote sound planning practices." Without having a better understanding of the impacts of the proposed adaptation strategies on county governments, it is difficult to comment on the strategies in a meaningful way.

Process

- *The ongoing process to develop reduction and adaptation strategies should be open and collaborative and proactively include county governments and other key stakeholders.*

The Plan states that Maryland's response to climate change "must be a highly integrated process that occurs on a continuum, across all levels of government, involving many internal and external partners and individual actions…" (Pages 315 and 317.) Many of the proposed strategies in the Plan will require significant policy changes and resource investment by local governments and other stakeholders but were developed without their participation and input.

Such participation needs to go beyond simply commenting on a series of strategies developed exclusively by the State. Stakeholders should be part of an ongoing process to develop, refine, and accept or reject both reduction and adaptation strategies. Funding sources should also be identified where the strategies envision new county government spending. Otherwise, the Plan will face the same unresolved challenges as the Chesapeake Bay TMDL process. A realistic timeframe for consideration and implementation of the strategies should also be established.

Conclusion

MACo appreciates the opportunity to comment on the Plan and hopes that the concerns of MACo and other comments submitted by the counties are addressed prior to the final adoption of the Plan. Given the complexity and potential consequences of climate change, time should be allowed for stakeholders to fully debate and review the Plan before it is finalized. Additionally, amendments to the he draft Plan should be developed as part of a collaborative process and not be driven by a top-down "one-size-fits-all" approach.

For further information regarding MACo's comments on the Plan, please contact Legal and Policy Counsel Les Knapp at 410.269.0043 or lknapp@mdcounties.org.

Response:

1) Costs, Benefits and Results
   a) The final Plan will include significant updates to the implementation costs, particularly in RESI's economic analysis in Chapter 7 and the Appendix. Transportation sector implementation costs can also be found in the transportation policy summaries in Chapter 6. Implementation costs developed by RESI and MDOT are estimates only. The Plan itself does not begin the implementation of the various programs. Actual implementation of the Plan will occur over the next eight years, so costs will be variable. Costs for the State as a whole will be expressed, but are not estimated down to the local government level. The RESI analysis does not examine where funding for the programs will come from; it solely looks at how much money is needed for the programs. MDOT's project emission reduction levels which can be accomplished with available funds are indicated, as well as additional funding needed if the ultimate GHG reduction projects are to be implemented. The Plan provides positive net economic benefits. There may be some costs associated with specific programs, but as a whole the Plan has greater benefits to the State of Maryland.

2) Climate Change
   a) Climate scale modeling is conducted on an international level, not a state by state level. The final Plan includes edits to Chapter 2 focusing on climate change science and the immediate impacts the international models of climate change have on Maryland. The Governor's Climate Action Plan includes a report which directly adapts climate models to Maryland, called Global Warming and the Free State. This report is referred to in the Plan and the Plan describes how reduction strategies will affect climate change.

3) Job Creation and Benefits
   a) Working directly with RESI, MDE has facilitated further analysis of potential job and economic development benefits. The final economic analysis has been updated within the Plan as well as Chapter 7.

4) GHG Reduction Strategies
   a) Recycling-1
      i) There are already State mandated recycling goals which were not created specifically for GHG reductions. Although recycling may by itself have a negative economic impact in some areas of the State, the law requires that the overall plan with all of the programs included to have a positive economic benefit to the State. The Plan is clearly economically beneficial to the State of Maryland.

ii) The Plan is not required to identify funding sources for any unfunded programs recommended to reduce GHG emissions. The programs within the Plan are proposed tools to use to reduce GHG emissions, but are not automatically implemented with the finalization of the Plan.

b) Land Use-1

i) Under the Plan, MDP and sister agencies will investigate the possibility of a local or regional collaboration to perform a Vehicle Miles Traveled (VMT) Fee Pilot Project Study in Maryland. In addition, MDP and sister agencies will investigate the feasibility of implementing Rule 9510 of the San Joaquin Valley Air Pollution Control District in Maryland, which requires mitigation for air emissions associated with development projects, including those from VMT. MDP is not requiring a fee to be charged for VMTs as a part of the Plan. We recognize that such a fee is objected to, but the fee is not a commitment at this time, only a potential source of funding.

ii) MDP understands the concerns in regard to impacts on rural areas and on local governments. Any policies developed will include the opportunity for input by local governments and counties. Making a difference now, rather than later, is important to prevent increases in greenhouse gas emissions by promoting efficient development and land use. The longer efforts to reduce greenhouse gases are stalled, the more expensive and difficult achieving reductions becomes.

iii) The proposed VMT Fee Pilot Project study in Maryland is an idea put forward as a way to reduce greenhouse gas emissions, but the state understands that there might be negative issues with this program. If this program were to be implemented, it would be a partnership with an interested local or regional government, and would be a pilot to study both negative and positive outcomes.

c) Land Use-2

i) This Plan is an idea and guide on how to reach the goals and how to implement mechanisms for reductions. Regulations are implementation mechanisms that can possibly be put in place to reduce greenhouse gas emissions but are not part of the Plan itself. The state has already asked for other mechanisms rather than regulations, to implement policies.

ii) MDE staff has been coordinating with local, regional, and state agencies throughout the drafting of the Plan. Coordination with various agencies has occurred through a number of meetings. Individual meeting with local governments have also occurred when requested. Some of the groups present and active in the planning process have been Maryland Department of Transportation, the Baltimore Metropolitan Council, the Washington Metropolitan Area Transit Authority, Maryland Association of Counties, as well as individual counties and specific environmental groups.

5) Adaptation Strategies

a) Chapter 8 Adaptation is an update of currently occurring programs at different state agencies. Chapter 6 focuses on the programs that need to change to reduce greenhouse gases (e.g., mitigation), and which comments on costs can be addressed. Chapter 8 is just an update on climate change adaptation that the State of Maryland is already working on. Since adaptation and mitigation go hand-in-hand, a chapter in the GGRP is dedicated to adaptation, to show that mitigation is not enough. Contractual assistance was not made available to examine the adaptation programs outlined in Chapter 8. The Plan itself does not address the adaptation strategies of the various programs. Current laws do not require net benefits of the adaptation programs to be analyzed or provided.

b) State governments, such as the Department of Natural Resources, are already working with local governments on their adaptation strategies, specifically with local planning departments to incorporate climate change adaptation into their development plans. Some strategies still need to be developed, particularly the implementation of these strategies, and therefore they are left deliberately vague.

c) Adaptation strategies are incorporated into so many different aspects of state and local government planning, that it is hard to address each topic here. For that reason, the state of Maryland published two reports directly about adaptation:
   i) http://ian.umces.edu/press/reports/publication/299/comprehensive_strategy_for_reducing_maryland_s_vulnerability_to_climate_change_phase_ii_building_societal_economic_and_ecological_resilience_2011-01-24/
   ii) http://ian.umces.edu/press/reports/publication/197/comprehensive_strategy_for_reducing_maryland_s_vulnerability_to_climate_change_phase_1_sea_level_rise_and_coastal_storms_2008-09-12/

d) The adaptation strategies contained in Chapter 8 are currently being used to guide and prioritize state-level action. While local governments clearly have a role in responding to the impacts of climate change, there are no specific mandates contained within Chapter 8 for action at the local level. That said, through the implementation of adaptation efforts at the state-level, the State of Maryland is hoping to catalyze similar action at the local level. Additionally, through some of the various state programs and adaptation initiatives that are underway, there are some opportunities for local government funding and technical assistance for climate change planning efforts. One such program is DNR's Coast-Smart Communities Initiative which provides financial and technical assistance to local governments looking to reduce their vulnerability to the effects of coastal hazards and sea level rise through planning and permitting activities. Grants of up to $75,000, drawn from the state's federal Coastal Zone Management Act funds, are awarded on an annual basis and may be renewed for up to three additional years. For more information, visit http://www.dnr.maryland.gov/coastsmart/.

Comment: Maryland Association of Realtors

August 17, 2012

To Whom it May Concern:

The Maryland Association of REALTORS® (MAR) offers the following comments regarding Maryland's Plan to Reduce Greenhouse Gas Emissions (hereinafter referred to as the "Plan").

As a trade association representing 22,000 REALTORS® throughout Maryland, our comments are focused on the Plan's provisions affecting housing and growth. While MAR recognizes that there are some benefits to compact development, MAR is concerned that some of the measures contemplated by the Plan will result in significant growth restrictions. In fact, numerous policies (Chesapeake Bay Nitrogen Reduction Act of 2009, Plan Maryland, WIP plans, and the Sustainable Growth and Agricultural Preservation Act of 2012) have already been implemented in the last 2-3 years that will result in more compact development. And yet, before the impact of these policies can be quantified, further growth restrictions are now being considered.

Additionally, MAR is concerned that some of the economic benefits of compact development are overstated because it is not clear that the Plan's analysis includes the true costs of redevelopment.

And finally, MAR is concerned that the overall effort to reduce Greenhouse Gas (GHG) emissions does not adequately factor in market changes that also achieve reductions in GHG like the increasing use of natural gas instead of coal in energy production.

Transportation 13: GHG Emissions Impacts from Major New Projects and Plans One of the implementation recommendations in this section of the plan recommends that a GHG analysis be conducted in conjunction with any major capital project. In fact, the Plan suggests an analysis be required anytime an Environmental Assessment is conducted. MAR is concerned that such an analysis should not be used as a required step in receiving approval. Already major development projects are delayed for years as opponents litigate every step of the approval process. Significant litigation occurs as a result of many environmental assessments, and it would be counterproductive to further empower such delay tactics. MAR believes if such analysis is conducted it should be informational only with clear time restrictions so the cost of development is not inflated.

Land Use 1: Smart Growth and Land Use/Location Efficiency
MAR strongly opposes emission caps for transportation implemented through development and land-use decisions. Over the last 15 years, Maryland has passed numerous growth laws that will have the effect of creating more compact development which is closer to population and job centers. The original Smart Growth Law of 1997, the Brownfield's Law, the Critical Areas and Coastal Bays Act of 2008, the Chesapeake Bay Nitrogen Reduction Act of 2009, the Planning Visions Act of 2009, the Smart Growth Indicators Act of 2009, the Smart Growth Act of 2009, PlanMaryland, WIP Plans and Offsets, the Sustainable Growth and Agricultural

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Preservation Act of 2012 are examples of many but not all of the laws and regulations that will result in more compact development in Maryland. Many of these laws are so new that it is impossible to quantify their impacts on growth. However, adding m1other step in the development process by requiring compliance with GHG goals will surely create a hurdle for development projects and will result in diminishing Maryland's capacity to meet future growth needs. While reduction of GHG is an important societal goal, so is the protection and creation of affordable housing. Until the impacts of WIP Plan offsets, PlanMaryland and the Sustainable Growth Act are quantified, it would be irresponsible to impose additional mandates to further a goal that Maryland may already be on the path to meet.

Land Use 2: GHG Targets for Local Government's Transportation and Land Use Planning

MAR shares the same concerns with the previous section over this section's recommendation that Maryland consider regional transportation caps similar to California's legislation, Senate Bill375. Without knowing the impact of all of the other legislation that will impact more compact development in Maryland, it would be at best premature to consider regional GHG emission caps linked to development, and, at worst, it would reduce Maryland's growth capacity and affordable housing.

Land Use 3: Funding Mechanisms for Smart Growth

This section of the plan calls for consideration of new funding measures. In so doing, this section lends credibility to MAR's concern about whether the costs of redevelopment are adequately reflected in the "cost savings" touted by the report for more compact development. MAR is concerned that local government is already unable to pay for WIP compliance and offsets, and that a recommendation to identify additional resources on top of WIP compliance will result in even more significant costs bom by property owners.

Land-Use 4: GHG Benefits from Priority Funding Areas or Other Growth Boundaries

Fundamentally, MAR believes that growth should remain a local government function, and MAR is concerned with any potential calls for strengthening PlanMaryland's ability to control growth boundaries. MAR believes that Maryland has adequately provided direction to local government over the last three years in terms of where and how growth can occur.

Economic Impact

MAR has a number of concerns and questions regarding the economic impact of the Plan. When the Plan cites economic data showing the savings that result when roads and other infrastructure are not extended to undeveloped areas, does it calculate the significant costs that can be associated with redevelopment? Government costs such as increased sewer capacity and upgrades, road improvements, parking garages and increasing school capacity should be part of that calculation. Interestingly, the Plan cites some data showing the average cost of building a home will be $16,000 cheaper under a more compact development scheme while acknowledging in almost the same paragraph that

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high density development will also lead to increased "residential property values." Land acquisition is clearly an expensive part of home building, and it is unclear whether the $16,000 savings cited in the Plan also accounts for the increased land acquisition costs.

Additionally, as other policies such as WlP plans and the Sustainable Growth and Agricultural Preservation Act take effect currently buildable lots will be off limits to development which will certainly increase the price of the remaining lots that can be built out. When costs such as these rise too much, the development that often occurs is targeted to higher income purchasers who can afford it. This is particularly true of many mixed-use developments that need a higher average disposable income to justify the creation of retail establishments adjoining the housing.

MAR is also concerned that the financial impact does not include another important factor for redevelopment: community opposition. Many redevelopment projects can take years to move from planning to construction because most communities react badly to development that they fear will bring more traffic congestion, loss of open space, and overcrowded schools. The Adequate Public Facility Ordinances (APFO) that the Plan cites as potential roadblocks to smart growth did not occur by chance. There was significant public support for those laws in response to increased development. If local governments do not recover significant cost savings from denser development, it is unlikely that local government will be able to pay for the infrastructure costs to mitigate community concerns. Local government is already struggling to figure out how to pay for WlP compliance. Expecting that local government will now have the resources for the costs that will make redevelopment feasible appears unrealistic.

Even worse, if removing APFO laws becomes politically impossible, any further restriction of growth areas outside of population centers can easily stop all growth. As more rural lots are removed from the development envelope and APFO ordinances shut down development in more suburban and urban areas, there will be no growth opportunities.

MAR is also concerned about the basis for other cost savings cited in the Plan. For example, the Plan cites the cost savings from compact development that result from increased use of mass transportation. One study cited in the Plan from Montgomery County estimated a 35-40% monthly transportation savings for areas along the Metro Redline, compared with areas not nearby. While those savings are significant, there are many more locations too far removed from Metro to make such savings available to most residents. Moreover, the start-up costs of extending similar mass transit options can be overwhelming both financially and politically.

Market Factors Affecting GHG

Recent data indicate that the release of carbon dioxide from U.S. sources is lower now than at any other point in the last 20 years. Much of that reduction is thought to result from the utility industry substituting natural gas for coal as an energy source. That substitution resulted because the market for natural gas became much more attractive to utilities. Given that the reduction in GHG is measurable, MAR wonders what other market forces are already at work that should also be part of the calculation used to measure attainment of GHG reductions in Maryland.

Finally, MAR understands the interest in reducing GHG through encouraging and mandating more compact development. However, MAR believes that Maryland has already passed numerous policies to achieve that goal, and fears that the land use provisions in this Plan will only hurt Maryland's ability to meet future growth demands and housing affordability.

Sincerely,

William Castelli
V.P of Government Affairs

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Response:

5) Transportation 13
   a) MDOT is only requiring greenhouse gas (GHG) emissions to be evaluated, on a case by case basis, in environmental studies for large transportation projects in the Plan. It will not require counties to do so. The Plan outlines several potential strategies under the Transportation – 13 Program, but does not immediately put these strategies into effect. These potential strategies are tools that could possibly be used to reduce GHG emissions in the transportation sector. The National Environmental Planning Act already requires environmental studies to be conducted on large projects. Adding a GHG emissions evaluation to these environmental studies would not significantly increase the costs or time of the evaluation. This additional work could possibly result in changes that increase the cost of the project and/or time to construct transportation projects but will not target urban areas exclusively; both rural and urban areas will be equally impacted. As far as mitigation for GHG emissions, this is currently not required. The Plan does not require mitigation, and MDOT has not determined if mitigation would even occur at all.
   b) The state will continue to pursue its regulation to establish long range GHG targets for transportation planning (COMAR 26.11.37), but will not require any additional work on the part of local governments in light of the federal conformity process. This is a separate process from the development of the GGRA Plan.

6) Land Use 1 - 4
   a) MDP understands that there are existing programs and policies in Maryland that strive to promote Smart Growth practices. The Plan includes a goal of 75% compact development that it strives to achieve. Since this goal is not a requirement of the plan, just a target to aim for, it will be used to direct the state on whether additional or different programs and policies are needed from the ones already in place.
   b) The Plan itself does not impose any mandates upon the state of Maryland. This Plan is an idea and guide on how to reach the goals and how to implement mechanisms for reductions. Regulations are implementation mechanisms that can possibly be put in place to reduce greenhouse gas emissions but are not part of the Plan itself. The state has already asked for other mechanisms rather than regulations, to implement policies.
   c) The state will continue to work with interested parties on implementation, and as required by the law, we will complete a 2015 report about what's working, what's not working, and what we need to change. Although no comments will be accepted on the final plan, the plan itself and implementation of programs will be a continuing process. Progress in achieving goals laid out in the Plan will be tracked between now and 2020 and this ongoing review will inform any changes to programs and policies.
   d) MDP understands the concerns in regard to impacts on rural areas and on local governments. Any policies developed will include the opportunity for input by local governments and counties. Making a difference now, rather than later, is important to prevent increases in greenhouse gas emissions by promoting efficient development and land use. The longer efforts to reduce greenhouse gases are stalled, the more expensive and difficult achieving reductions becomes.
   e) The state of Maryland recognizes the need for affordable housing. Any proposed policies will work to address affordable housing and Maryland's growth capacity with the appropriate stakeholders.
   f) The updated and edited RESI analysis shows an overall net job creation and economic benefit. Both job loss and increased costs were included in the analysis, but the net outcome was still job creation and benefits. While some specific programs will have benefits and some will have costs, the Plan must show a net economic benefit of all programs. This net benefit is described in the updated final Plan. The Plan is not required to identify funding sources for any unfunded programs recommended to reduce GHG emissions. The programs within the Plan are proposed tools to use to reduce GHG emissions, but are not automatically implemented with the finalization of the Plan. Maryland state agencies will work with local governments and counties to determine how to implement programs while limiting costs.

3) PlanMaryland
   a) PlanMaryland is a separate program within the state which has already been approved by the Governor and could result in proposals for procedural, legislative or regulatory change to meet the goals of PlanMaryland. PlanMaryland is referenced in the Greenhouse Gas Reduction Plan, since future PlanMaryland implementation mechanisms might prevent future greenhouse gas emissions.

4) Economic Impact
   a) RESI worked with the responsible agencies for implementing each policy to obtain cost data. The data in the model reflects best estimates given the available information at the time. The responsible agency provided the all the expected costs as a result of a program.
   b) In the economic analysis, the total cost of redevelopment using both the Business As Usual model and the Greenhouse Gas Reduction strategy is taken and the GGR strategy ends out being less expensive. Regardless of what model you use, sprawl or more compact development, you will have increased sewer capacity, upgrades, and road improvements, etc. But the costs of sewer capacity, upgrades, and road improvements, are $16,000 less expensive under the more compact development scheme.
   c) Community Opposition
      i) The Plan is not required to identify funding sources for any unfunded programs recommended to reduce GHG emissions. The programs within the Plan are proposed tools to use to reduce GHG emissions, but are not automatically implemented with the finalization of the Plan. The Plan provides positive net economic benefits. There may be some costs associated with specific programs, but as a whole the Plan has greater benefits to State of Maryland. The Plan does not start the implementation process. Regulations are implementation mechanisms that can possibly be put in place to reduce greenhouse gas emissions but are not part of the Plan itself. The State has already asked for other mechanisms rather than regulations, to implement policies. The State recognizes that local governments already have large economic burdens.
   d) Mass transportation
      i) It is true that the rural areas of counties are at a disadvantage concerning mass transportation. The Plan does show a net benefit from mass transportation programs to the entire State of Maryland. This benefit does not distinguish between urban and rural communities. The State receives a benefit, but the model does not analyze the benefits for individual counties. The State recognizes that it would not be advisable to extend mass transit to all counties.

Comment: Maryland Conservation Council

Maryland Conservation Council

Protecting Maryland's Natural Heritage Since 1969

Comments on, and Suggestions for the Maryland Department of the Environment's 2011 GGRA Draft Plan

The Greenhouse Gas Reduction Act Draft Plan is a well intentioned attempt to correct what is perhaps the most serious global environmental threat facing the planet: climate change caused by human greenhouse gas (GHG) production. The Draft Plan presents 65 programs intended to reduce Maryland's GHG emissions by 25% by the year 2020. Some of these programs promise to be effective, but the draft plan does not acknowledge that this effort is just the beginning. Thus, one of the shortcomings of the Draft Plan is that it does not mention the more stringent policies necessary for ending GHG emissions and their deleterious effect on global climate change in a timely way. This might lead the average reader to think that a 25% reduction is all that is needed. A much more thorough picture of the climate change threat and the measures required for its elimination is laid out in a five volume work, *America's Climate Choices* (ACC) (references 1-5) from the National Research Council (NRC), the research arm of the National Academies of Science (NAS). The NAS is one of the world's most prestigious scientific bodies, founded during the Civil War by Abraham Lincoln to advise the government on scientific matters (www.nationalacademies.org). Another major work from the NAS/NRC, which is very relevant to this discussion, is *America's Energy Future* (AEF) (references 6-9).

Prior to anthropogenic emissions, atmospheric CO_2 concentration was about 280 ppm (parts per million). One of the findings in ACC is that to hold atmospheric carbon dioxide levels to 450 ppm, almost all (>80%) of emissions as of 2000 must end by 2050. Even though 450 ppm carbon dioxide seems to be the lowest atmospheric concentration that is practicable to achieve, this concentration may still have severe effects on the earth's climate; and even if that goal is achieved, the GHG's already in the atmosphere will continue to alter global climate. ACC also states that there is no clear indication about how fast climate change will occur, making it prudent to end emissions as quickly as practicable. Ultimately *all* GHG emissions must stop, because over the very long-term, even small emissions will accumulate to damaging levels, especially the atmospherically more stable gases such as CO_2 .

> **The Final Plan should state clearly that a 25% reduction is just an initial target and that reduction must reach at least 80% by 2050 and 100% as quickly as practicable.**

Wind is known as an “intermittent” source of energy because it is unpredictable. The most ambitious study of the integration of wind power into the American electricity mix is *Wind Power in America’s Future* (10), a study focused on the goal of providing 20% of America’s *electricity* (not total energy) by 2030. It states clearly (pages 11, 154-155) that fossil fuel backup will be necessary to supply electricity when wind fails, and that 20% is as large a proportion of electricity demand that intermittent sources can supply with present technology, even with backup. Similar statements are made throughout references 1-9. The road to GHG-free energy is not as simple as renewables advocates imply.

> **The Final Plan should mention that industrial-scale renewables cannot be utilized without fossil fuel backup.**

We believe that the Draft Plan has several other shortcomings. Even though ACC and AEF include nuclear power as a critical method for generating electricity without making carbon dioxide (1, page 68; 2, page 65; 6 pages 114, Chapter 8), nuclear power is ignored in the GHG Emissions Control Act, and also is not mentioned in this Draft Plan . The Governor, commendably, supports the construction of the new reactor at Calvert Cliffs.

> **The Final Plan should mention the benefits in reducing carbon dioxide emissions that nuclear power will provide; and that the Calvert Cliffs 3 project, if compared to coal plants of the same capacity, will offset about 12 million tons of carbon dioxide per year; six million if compared to natural gas.**

The Draft Plan is somewhat misleading about the economic benefits available from “green” energy programs (jobs, salaries, and business revenues) because it states only the gross, not the net, effects. Once again ACC states that the net positive economic impacts of “green” technologies are probably going to be small because business activity will be lost as well as created (2, page 183). For example, when a portion of the fossil fuel industry's business is replaced by renewable energy, jobs and income will be lost in the fossil fuel industry. Estimating the number of jobs lost is very difficult, but the statements about economic impact should mention what will inevitably happen.

> **The Final Plan should mention that the employment and other economic figures given are gross numbers and that they are likely to be reduced by losses in other business sectors.**

To the biologist, a very disturbing proposal in the Draft Plan (repeating the MDCCC’s 2008 report) is the use of massive amounts of biological material to co-fire boilers. The MDCCC’s report calls for the use of forest slash for this purpose. The clear cutting of forests is bad enough from the standpoint of impacts on forest stability and biological diversity; removing material that will help maintain the fertility of the degraded forest adds another insult. Despite the claims of professional forest managers that their practices increase the health of forests, one must consider that these practices have been used for only about 100 years, yet we know that there have been trees for about 385,000,000 years. Thus, natural, un-managed forests have needed no help in maintaining their viability; this new assault on them is likely to diminish their biological sustainability. Removing the slash is almost certain to lead to shorter rotation times in forest management. In addition, the effects of the recent drought on crops should be warning enough that using agricultural products to make energy is inadvisable, especially because "energy" crops will compete with food crops for land. Less well understood is the fact that burning biological material produces and releases halogenated organic compounds (11), some of which, like dioxins, are presumed toxic. As an illustration of how utterly ineffective this activity will be in meeting our electricity needs (let alone total energy demand), it would require biomass grown on over 2,500 square miles of land (calculated using average crop yields) to produce as much electricity as a large nuclear power plant occupying only about1/2 square mile.

The use of forest slash should be eliminated from the Final Plan out of concern for the sustainability of the forest itself and out of mercy for the creatures that live in it. And the use of plant materials (like switch grass) grown specifically to co-fire boilers should be eliminated from the Final Plan to acknowledge that the climate of the planet is becoming increasingly unpredictable, and also out of mercy for creatures that will no longer be able to thrive in what will become an industrial monoculture.

We repeat that there is an urgent need to end the emission of GHGs. The literature on this topic is replete, however, with technological advances that must be made before many of the candidate renewable technologies become commercially viable. Large scale implementation of wind and solar power require the development of a “smart grid” and a method to store large quantities of electrical energy, in addition to reduction in overnight construction costs. These advances in technology are usually called “breakthroughs,” meaning that their successful effectuation is not assured. Although increases in energy efficiency are highly desirable, much remains to be developed before efficiency can reach its maximum potential. For instance, in considering the energy efficiency of buildings, it must be remembered that the working life of existing homes and commercial structures is close to a century; retrofitting is slow and very expensive. The major reports from the NAS and DOE (references 1-4,6-10) repeatedly state that the intermittent renewables (wind and solar power) cannot be implemented on a larger scale than they are today without the use of fast-responding natural gas combustion turbines. This fact alone limits their capability of ending GHG emissions.

A recent document from a group supporting renewable energy (12) warns that three major components of the renewable energy strategy (RGGI. EmPower Maryland, and the RPS) are not going to reduce GHG emissions from electricity production by 2020 by as much as had been anticipated. Keep in mind the RPS applies to only 8% of CO_2 emissions from all human activity because electricity production is responsible for only 40% of our CO_2 emissions, and the RPS *might* eliminate only 20% of that 40%. In stark contrast, the nuclear reactors built 40 years ago are reliable, economical, and safe. Newer designs should be even more so, but this is not necessary for reactors to be able to supply all of our electricity; witness the case of France. To supply our electricity needs, industrial-scale renewables require both unassured critical technological advances and face significant socio-economic hurdles, whereas nuclear power faces only the latter. An understanding of some elementary chemistry and physics leads to the conclusion that reactor designs now in development can supply heat for buildings and for industrial processes. Beyond that, it is certain that these new designs could be used to make methane, which is an effective liquid transportation fuel, thereby eliminating the urgency to develop electric vehicles which, although very desirable, have many hurdles to overcome. Thus nuclear power could effectively supply ALL of our energy needs without the production of GHG.

Had the anti-nuclear movement not succeeded in keeping the industry crippled for the past 30 years, there would have been no economic or rational reason to have built fossil fuel plants, especially not coal plants, since about 1980. The world's existing nuclear reactors have lessened the emission of carbon dioxide by about 18% of what it would have been without them; had more been built there would be much less carbon dioxide in the atmosphere today. Perhaps the heat waves and hurricanes that have killed tens of thousands of people would not have been as severe. It is frustrating that the technology best suited to eliminate ALL GHG emissions has been totally overlooked in this document.

> **The Final Plan should propose the increase of the proportion of carbon dioxide-free electricity sales in Maryland to 30% of total sales, and stipulate that the added 10% come from either new reactors or uprates of existing reactors. The amended law should be called a Clean Energy Portfolio Standard rather than an RPS.**

We thank the MDE for the opportunity to comment on the GGRA Draft Plan.

Sincerely,
Norman D. Meadow, Ph.D.

First Vice President, Maryland Conservation Council

Principal Research Scientist, Retired
Department of Biology
The Johns Hopkins University

2304 South Road, Baltimore, MD 21209
410-664-7196

REFERENCES

1. *America's Climate Choices*, 2011, National Academies Press, Washington D.C.

2. *America's Climate Choices, Limiting the Magnitude of Future Climate Change*, 2010, National Academies Press, Washington D.C.

3. *America's Climate Choices, Informing Effective Response to Climate Change*, 2010, National Academies Press, Washington D.C.

4. *America's Climate Choices, Advancing the Science of Climate Change*, 2010, National Academies Press, Washington D.C.

5. *America's Climate Choices, Adapting to the Impacts of Climate Change*, 2010, National Academies Press, Washington D.C.

6. *America's Energy Future: Technology and Transformation*, 2009, National Academies Press, Washington D.C.

7. *America's Energy Future, Electricity from Renewable Resources*, 2010, National Academies Press, Washington D.C.

8. *America's Energy Future, Real Prospects for Energy Efficiency in the United States*, 2010, National Academies Press, Washington D.C.

9. *America's Energy Future, Liquid Transportation Fuels from Coal and Biomass*, 2009, National Academies Press, Washington D.C.

10. *Wind Power in America's Future: 20% Wind Energy by 2030*, 2008, US DOE, Dover Publications, Mineola, N.Y.

11, Gribble, G.W., 2004, *American Scientist,* 92:342

12. http://www.chesapeakeclimate.org/take-action/maryland/tell-gov-omalley-strengthen-mds-global-warming-plan

Response:

1) The updated science chapter of the Plan (Chapter 2) adequately addresses the need for aggressive CO2 reductions for the Plan to be successful. Maryland state law also requires a 2015 status report in which the General Assembly reviews the Plan. At this time the goal may or may not be revised based on changes in science and management.

2) Wind Power
   a) There have been numerous studies on integration of wind power into the electricity grid. In general, the integration challenges and cost are minimal until a substantial plurality of peak demand is met through intermitted resources. Maryland is located in PJM, which has many beneficial characteristics with respect to wind power integration. PJM is geographically expansive, contains over 60 million customers, and dispatches over 160,000 MW of installed capacity. Additionally, PJM dispatches energy in 5 minute increments, requires wind producers to forecast sub-hourly output, and runs a competitive frequency regulation market to handle sub-5 minute fluctuations. As a result, variations in the output of a single wind turbine or project are routinely handled through standard business practices and do not require incremental "firming" capacity.

3) Nuclear power
   a) The state of Maryland has a deregulated energy market. Therefore, MDE and the State have very limited control to order new generation. Currently, the Public Service Commission can only order new generation if it deems there is a sufficient risk to

reliability, but it also must strive to minimize costs to ratepayers. Nuclear facilities are unlikely to be a selected technology to meet reliability requirements given their size, lack of operational flexibility, and cost. In normal day-to-day circumstances, the State has no control over which energy generating facilities are constructed.

b) It is implicit that nuclear power does not have any carbon emissions. The Plan does not address that nuclear energy does not add carbon to the atmosphere. While Maryland recognizes that replacing fossil fuel power generation facilities with nuclear energy facilities will reduce greenhouse gas emissions, the state does not determine what facilities are built.

4) Maryland has an RPS which the Governor has currently implemented. RGGI, a cap and trade program, is also aimed at reducing carbon from the electricity sector.

5) Economics
   a) The Plan includes an updated RESI analysis based on agency provided and best available data. The analysis clearly describes the assumptions made, and the State recognizes that other studies available may come to different conclusions.
   b) The 2012 analysis provided by RESI relies on the REMI modeling software. This model is well accepted as being able to predict economic outcomes and more information can be found on the REMI website. www.remi.com
   c) The final Plan includes employment and economic figures that are net positive benefits, not gross values. Costs and losses in other business sectors are already included in the information provided. The appendices give more detailed data and will be available at a future date.

6) Forest Slash
   a) Clearcutting is a long proven silvicultural technique used to regenerate forests comprised of species requiring full sunlight to grow. Removing the mature overstory of a forest is a management technique practiced by the original inhabitants of North America for thousands of years, except that they used fire as their tool for removal. Some mature forests, but not all, do exhibit high diversity of physical structural and support species dependent upon that structural diversity. It is also important to recognize that a young regenerating forest is actually far more diverse in species richness than most fully mature forests, and young forests are actually becoming scarce in Maryland as more and more land is reserved from the working landscape. The many species of associated plants and wildlife species reliant upon the species diversity, density, and structural make-up of young forests are declining in parallel with the loss of young forests.
   b) The proposed plan does not specifically call for increasing clearcutting forests. In fact, the recommendations are based upon simply using the available wood already produced but not utilized by existing on-going activities. Utilizing a portion of forest slash generated during a timber harvest for fuel is one such example. Keep in mind that the economics of fuel wood do not, nor are they likely to, support the economic costs of harvesting a forest simply for its fuel value. In other words, because wood fuel is such a

low value forest product, its production will be simply a by-product of the timber harvests occurring for the higher value products.

c) Forest managers are often frustrated by their inability to reduce the density or remove unwanted species from their forests simply due to a lack of markets that would defray the high costs of those operations. A fuel market could create an opportunity to do so, and thus allow forest managers to enhance the outcomes of their management actions.

d) Removing slash from the forest also removes nutrients. Fortunately, the vast majority of soils in Maryland are highly resilient and the normal photosynthesis activity of the forest quickly recaptures and replenishes the minimal loss of nutrients. In cooperation with the Pinchot Institute for Conservation, the Maryland DNR Forest Service developed an extensive suite of "Best Management Practices" for use in planning and conducting forest harvests that will also utilize slash. A principal protocol of these BMPs includes retaining a significant portion of the slash on-site, albeit this is in consideration of wildlife habitat than from a concern of nutrient depletion.

e) Using forest slash has no impact at all on rotation lengths. The plan does not call for establishing monocultures as is suggested by the commenter. The recommendations remain specific to the opportunity for using wood, from both rural and urban sources, and make no mention of using crops. Envisioned is simply using the woody materials already generated through on-going existing activities but left unutilized (e.g., arborist trimmings). Also, the commenter assumes the energy produced would be electricity; however, the recommendations stress the opportunity present is to use our abundance of unutilized wood resources as an economical and environmental smart alternative to fossil fuels for meeting our thermal energy needs.

Comment: Maryland State Builders Association

MARYLAND STATE BUILDERS ASSOCIATION
121 Cathedral Street Suite 2A, Office 2
Annapolis, Maryland 21401

(410) 263-0070 phone
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August 17, 2012

Mr. Tad Aburn, Director
Air and Radiation Management Administration
Maryland Department of the Environment
1800 Washington Blvd.
Baltimore, MD 21230

ATTN: climate@mde.state.md.us

Dear Mr. Aburn:

On behalf of the Maryland State Builders Association (MSBA), thank you for the opportunity to provide comments on the Maryland Department of Environment (MDE) 2011 Greenhouse Gas Emissions Reduction Act of 2009 (GRRA) Draft Plan. I understand that this draft Plan fulfills the law's requirement for the Department to submit a draft of the GGRA Plan to the Governor and General Assembly in advance of the final Plan and that the Plan must demonstrate that implementation will result in the creation of jobs and improvement in the state's economy.

MSBA strongly supports the goal of reducing greenhouse gas emissions and acknowledges the importance of reducing pollution from air sources as an important component of the Chesapeake Bay Cleanup effort. Generally, we are concerned about the probability of success of this reduction plan given the potential migration of emissions from neighboring states and other natural climate conditions. Of the 65 control measures that comprise the Plan, almost 20 have a direct or indirect impact on residential development based on our initial assessment of the draft Plan. The Building Sector measures outlined on pages 244-248 and the Land Use Sector measures outlined on pages 251-258 have the potential to greatly impact the volume, cost and location of future growth.   In terms of building code actions, investing in retrofit of existing building and housing stocks using an existing program like Smart Codes, would be more cost effective in reducing emissions than spending more money on new construction. In Maryland, new buildings now make up approximately one percent of the building stock and must be thirty percent more energy efficient than a comparable building constructed to the 2006 code. We also believe that some of the proposed transportation actions will have an indirect impact on housing availability and affordability in rural areas. The job creation and economic benefits cited in these sections do not appear to account for job losses and increased costs of development in urban, suburban or rural areas of the state.

In a healthy economic climate the construction industry represents almost 20 percent of the jobs and GDP in Maryland. We are keenly interested in the economic development component of the plan. We have reviewed RESI's estimates that the Plan, when fully implemented, will result in annual benefits that include the creation of approximately 36,000 jobs, $6.1 billion in additional economic output, and $2.1 billion in additional wages. However, our analysis of this preliminary economic study identified significant flaws to the concept of improving the State's economy. It appears that the analysis counts revenue received by business or government as a positive benefit without accounting for the impact of these regulations on business and consumers. The economic output and job creation may be grossly exaggerated by not reducing positive impact due to additional regulation.

Because of the importance of the economic assessment of implementing the GRRA Plan, we requested our national staff at the National Association of Homebuilders (NAHB) to review the 700 page report and provide an assessment of the conclusions reached by RESI. They pointed to a number of assumptions that may be flawed. I have attached their memorandum for your review. Confirming the accuracy of the economic analysis is critical to the future of the Plan and the viability of the residential development and construction industry.

On behalf of MSBA, I respectfully request that you consider withholding the measures outlined in the Building and Land Use Sector until the Advisory Committee has more time to gain consensus on these actions and other interested stakeholders can better understand the implications of these actions and the clear economic benefit or detriment that could result.

Thank you for your consideration of these comments.

Sincerely,

Eliot Powell
President

Attachment

Response:

1) Land Use Strategies
    a. MDP understands the concerns in regard to impacts on rural areas and on local governments. Any policies developed will include the opportunity for input by local governments and counties. Making a difference now, rather than later, is important to prevent increases in greenhouse gas emissions by promoting efficient development and land use. The longer efforts to reduce greenhouse gases are stalled, the more expensive and difficult achieving reductions becomes.

b. This Plan is an idea and guide on how to reach the goals and how to implement mechanisms for reductions. Regulations are implementation mechanisms that can possibly be put in place to reduce greenhouse gas emissions but are not part of the Plan itself. The state has already asked for other mechanisms rather than regulations, to implement policies.

2) Economics
   a. The updated and edited RESI analysis shows an overall net job creation and economic benefit. While some specific programs will have benefits and some will have costs, the Plan must show a positive net economic benefit and job creation of all programs when aggregated. This net benefit is described in the updated final Plan.
   b. The RESI analysis makes every effort to collect data when available and clearly expresses any assumptions that were used in the calculations. The analysis has been updated and is based on the agency provided and best available data. The assumptions used within the model do not exaggerate job creation or economic benefits from the programs in the Plan.

Commenter: MD National Capital Building Industry Association

Comments on 2011 GGRA Draft Plan

Since there are huge electricity losses during the generation, transmission and distribution of electricity, programs to reduce such losses would also reduce Greenhouse Gas Emissions. Programs such as the Combined Heat and Power should be a priority. The State should look at what else can be done to reduce these losses.

Ref. :MEA's "Maryland Energy Outlook 2010" which says, "Note that electricity losses (losses during the generation, transmission and distribution of electricity) are 31% of overall energy consumption…."

Maryland Energy Outlook 2010 link on webpage
http://energy.maryland.gov/energy101/index.html

Annette
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Response:

1) The state of Maryland has already enacted a utilities structure which provides incentives for lower energy consumption, also called decoupling. EmPOWER Maryland is the program currently in place that reduces energy consumption. The final Plan includes the EmPOWER Maryland program to reduce the electricity lost during transportation.

2) Currently, EmPOWER Maryland is examining ways to reduce energy losses at the distribution level to become more efficient. Technological changes to the distribution grid are also being examined to reduce energy losses.

Comment: National Association of Home Builders

National Association of Home Builders
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July 9, 2012

Tom Farasy
Terra Verde Communities, LLC
301.704.1495
www.terraverdecommunities.com

Re: Economic Impact Analysis for the Greenhouse Gas Emissions Reduction Act 2012.

Dear Tom,

This letter provides some comments on the above-referenced *Impact Analysis* produced by the Towson University Regional Economics Studies Institute (RESI), and dated December 2011.

The *Impact Analysis* is a 972 page report, including five appendices. A large proportion of the report is devoted to tables reproducing results from the IMPLAN model. IMPLAN is a well established and generally non-controversial technique for generating income, wage, and employment outputs from particular inputs; so, the primary questions about the Impact Analysis involve how the inputs are generated and what they really mean.

The *Impact Analysis* applies the IMPLAN model one at a time to each of 65 separate strategies for reducing greenhouse gas (GHG) emissions. The analysis produces two distinct types of impacts: those during the initial investment phase, and ongoing impacts during the operational phase of the strategy.

INVESTMENT PHASE IMPACTS

The investment phase impacts are one-time impacts that occur while a particular GHG strategy is being implemented. The inputs into IMPLAN are dollars spent by some entity in the process of implementing the strategy. In general, the report doesn't distinguish who is spending the money and doing the investing. It may be a government, business, or some other entity.

The report also fails to address how the money will be generated, and if it is reasonable to expect that it can be generated that way. Will it require governments to raise taxes or fees? Will businesses have to reduce investment in some other areas to spend it on GHG reductions? Either of these would lead to offsetting

reductions in employment that should be discussed if not estimated.
The report sidesteps some of the complications that arise in the investment phase by attempting to estimate not actual impacts associated with implementing a strategy, but impacts of a hypothetical $1 million investment. The reason given is uncertainties about implementation costs.

Because the investment phase impacts in the study are hypothetical in nature, with no pretense that they can or will actually be realized, the rest of these comments will focus on the second category of impacts estimated in the study: those that occur during the operation phase and are used to produce the aggregate figures, such as $6.1 billion in economic output or 36,000 jobs.

OPERATION PHASE IMPACTS

The operation phase impacts are described as ongoing, annual impacts that occur after a strategy has been fully implemented and is generating benefits. The inputs into IMPLAN vary depending on the strategy. In some cases, they are cost savings for households who use the savings to buy goods and services produced in Maryland. In other cases, the ongoing impacts are driven by revenue for particular types of businesses or government.

Summed over all GHG strategies, the operation phase impacts reported in Impact Analysis are roughly $6.1 billion in economic output, $2.1 billion in wages, and 36,000 jobs.

At first blush, it may seem peculiar that RESI resorts to a hypothetical case for the investment phase impacts, yet is able to estimate actual impacts during operation. However, it is possible that better information is available for the expected benefits of a strategy than the costs of implementing it. This needs to be evaluated on a case by case basis.

Unfortunately, in many cases, the assumptions adopted for the operation phase and input into IMPLAN are flawed, resulting in inflated output and jobs estimates that are not credible. This is particularly true of some strategies that are estimated to support a relatively large number of jobs. Below are some examples:

Strategy 3.2.9: Pricing Initiatives

> This strategy is a combination of existing programs and programs under development, including electronic toll collection, development of HOT lanes, congestion pricing, parking fees, and incentives for employers.
>
> It is estimated to support 7,635 jobs during its operation phase, 2,807 in public administration (i.e., government).
>
> The inputs into IMPLAN are a combination of savings to consumers who need

to buy less gasoline—due either to reduced vehicle miles traveled (VMT) or less

time spent idling—and revenue for governments due to the increased fees. The largest input is $100.5 million in parking fee revenue for the City of Baltimore, which is responsible for a substantial share of the public sector jobs supported.

Spending less on gasoline would, in fact, leave more money in the pockets of Maryland consumers. Inputting this into IMPLAN produces reasonable estimates of jobs generated within the state in businesses supported by consumer spending (such as health services and retail trade).

However, requiring consumers to pay parking and VMT fees clearly leaves less money in their pockets to buy goods and services produced in Maryland. This negative effect could easily be input into the IMPLAN model to show the jobs destroyed in consumer-supported industries, but isn't.

The job creation reported in this section of the report is not credible, due to this inconsistent treatment of household income (i.e., counting it when the effect is positive, but ignoring it when negative).

Strategy 3.3.2: Creating Ecosystem Markets to Encourage GHG Emissions Reductions

This strategy consists of various requirements for mitigating for impacts during development, and trading pollution credits.

It is estimated to support 4,709 jobs during its operation phase, 1,851 in management of companies and enterprises.

The inputs into IMPLAN include estimated value of preserved environmental amenities, and the estimated or actual value of transactions in ecosystem markets. In most cases this is input directly into the "management of companies and enterprises" sector, resulting in jobs for accountants, managers, and supervisors of office workers. The largest inputs are an estimated $44 million value of nutrient credits traded per year, and $42 million average value of CO_2 credits sold per year by the state in cap-and-trade auctions.

In both cases, costs are imposed on particular businesses. Nutrient trading would involve primarily urban entities buying credits from agricultural businesses. The CO_2 auctions are primarily power companies transferring money to the state government. Because buying the credits imposes additional costs on particular businesses, it should reduce investment and employment in those businesses, but the report ignores these negative effects.

It is also unclear why 100 percent of the proceeds of every transaction would be used to buy additional accounting and managerial services. The report's explanation, "the expectation that a wide variety of business types will be motivated by market compliance to engage in best practices which benefit both the environment and their bottom line," is not persuasive.

Strategy 3.3.3: Increasing Urban Trees to Capture Carbon

This is a program run by DNR in conjunction with state and local agencies that has averaged about 68,000 trees planted per year.

It is estimated to support 2,953 jobs during its operation phase, 1,276 in management of companies and enterprises.

The input into IMPLAN is roughly $4,000 per tree estimated annual contribution to retail trade input into the "management of companies and enterprises" sector.

It is logical that a program for buying and planting trees would support jobs in the state. However, $4,000 per tree seems unrealistically high. It follows from an unsubstantiated assumption that 600,000 urban trees account for 10.5 percent of all direct retail GDP in the state, which seems unlikely. It is also unclear why this is fed into "management of companies and enterprises" rather than into retail or wholesale trade, or "greenhouse, nursery, and floriculture production"—i.e., into businesses that normally sell and produce trees.

Strategy 3.3.8: Conservation of Agricultural Land for GHG Benefits

This is a single program, estimated to support 3,374 jobs during its operation phase, largely in industries supported by consumer spending (such as health services and retail trade).

The input into IMPLAN is roughly $490 million for the value of farmland preserved year, treated as savings to consumers, who then spend money on goods and services produced in the state.

The major premises of this section are faulty. First, preserving agricultural land is not a GHG strategy. In describing this section, the report states, "The benefits associated with the creation of protected lands and open space encourage the growth of natural wildlife habitats and reduce sediment and nutrient loss." But these are benefits from other types of preserved areas, not agricultural land. Agricultural land is not a natural wildlife habitat and is the largest source of sediment and nutrient pollutants. Nor are any of these environmental related in any obvious or direct way to GHG emissions.

Second, preserving agricultural land does not put money into the pockets of consumers, so it is not a valid input into this part of the IMPLAN model.

Strategy 3.3.9: Buy Local for GHG benefits

This strategy helps agricultural producers market their products to wholesalers within the state.

It is estimated to support 2,827 jobs during its operation phase, 1,386 in wholesale trade.

The input into IMPLAN is an additional $5 spent on average by every household in Maryland every other week for locally grown produce, input into wholesale trade businesses.

An important unanswered question is why encouraging wholesalers to buy from particular farms would cause consumers in Maryland to buy more produce? It is understandable that the program would cause wholesalers to buy a greater share of produce within the state and increase business for Maryland farmers, but why would this increase business volume for the wholesalers themselves? Without an explanation, the estimate of wholesale trade jobs supported in this section is not credible. GHG Economic Impact Analysis July 9, 2012 Page 5

In summary, the IMPLAN model is a standard and accepted tool for estimating the economic impacts of policies such as GHG reduction, but the model's output is only as good as the inputs fed into it, and there are problems with the inputs used in several sections of the *Impact Analysis.* The problems include counting revenue received by businesses or government as a positive benefit while ignoring obvious costs imposed on other businesses or consumers, assuming that a particular strategy puts extra money in the pockets of consumers when there is no reason to suspect this is the case, and inputting revenue into what appears to be the wrong industry without explanation. Due to the severity and magnitude of these problems, summary statistics reported in the analysis—such as the $6.1 billion in economic output and 36,000 jobs supported during the operation phase—lack credibility.

I hope you find these comments helpful. Please feel free to contact me if you have any questions about them, or if you need anything else.

Best regards,

Paul Emrath
Vice President
Survey and Housing Policy Research

Response:

1) Investment Phase Impacts
   a) The Plan is not required to identify funding sources for any unfunded programs recommended to reduce GHG emissions. The programs within the Plan are proposed tools to reduce GHG emissions, but are not automatically implemented with the finalization of the Plan.

2) Operation Phase Impacts
   a) Although the RESI analysis is not perfectly comprehensive, it clearly expresses the assumptions used in the calculations. The analysis has been updated and is based on the agency provided and best available data. The assumptions used within the model do not

exaggerate job creation or economic benefits from the programs in the Plan. The analysis is transparent, and the Plan is a living document which will continue to be updated as the plan moves forward to the implementation phase. The State will continue to work with interested parties on implementation, and as required by the law, the State will be doing a 2015 report about what is working, what is not working, and what needs to change.

b) RESI worked directly with State agencies to make certain the agencies were comfortable with assumptions made in the analysis.

Commenter: Susan Jacobson

From: Susan Jacobson <suejacobson2@gmail.com>
To: <bhug@mde.state.md.us>
Date: 5/8/2012 4:49 PM
Subject: GGRA Revisions Needed

Dear Governor Martin O' Malley and Secretary Robert Summers,

Thank you for all your leadership in recent years in fighting climate change in Maryland by promoting clean, renewable energy.

Last month, per the Greenhouse Gas Emissions Reduction Act of 2009, the Maryland Department of the Environment released a draft plan for reducing carbon pollution statewide by 25 percent by 2020. The plan lays out an admirable framework of 65 programs for reducing emissions, involving efforts from many state agencies.

However, the plan has serious shortcomings. It makes unrealistic assumptions about certain pollution cuts. It projects overly rosy timelines for achievements. And – in several instances – it just gets the facts wrong. For example, the plan assumes the state's clean electricity standard has the potential to reduce much more carbon pollution than is realistically possible.

By the end of 2012, MDE and each state agency responsible for implementing the plan must work together to ensure the final GGRA plan is complete with a clear path for implementing programs that will realistically achieve the General Assembly's mandate. All state agencies must be held accountable for this goal.

Cutting carbon pollution will provide great economic benefits to the state if implemented effectively. Maryland's leadership will show our country and the world that climate progress is achievable and brings with it substantial benefits.

Sincerely,

Susan Jacobson
8 Lodge Pl
Rockville, MD 20850

Response:

1) The final Plan has been revised to examine the true potential benefits of the programs expressed. The overlap analysis in the final Plan ensures that reduction numbers have not been the result of double counting, and has been updated accordingly. The SAIC analysis is also included in the final plan.

2) MDE has been working closely with the governor as well as other State agencies involved such as, MDoT, MEA, and MDP. The Governor's office is tracking implementation of the plan

through the Governor's Delivery Unit (GDU) (https://data.maryland.gov/goals/greenhouse-gases). The Governor has been directly involved in development of the Plan. He has made the Plan into a "stat" process for the state of Maryland, called ClimateSTAT. The Plan itself is a living document that will be changed and edited as the implementation process occurs.