# 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.**

## Appendix B – Public Comments

The Education, Communication, and Outreach Working Group of the Maryland Commission on Climate Change (MCCC) held a series of five public meetings across Maryland between July and August of 2015. The purpose of these meetings was to inform the public of the mission and actions of the MCCC, the purpose of the Greenhouse Gas Emissions Reduction Act of 2009 (GGRA) and the content of the *2015 GGRA Plan Update*, and to take public comment on relevant issues of concern regarding climate change in Maryland. These meetings were held at the following locations:

1. July 14, 2015 – Patterson Park Branch Library, 158 N. Linwood Ave, Baltimore, MD
2. July 16, 2015 – The Eastern Shore Higher Education Center at Chesapeake Community College, 1000 College Cir, Wye Mills, MD 21679
3. July 28, 2015 – UMCES Appalachian Laboratory, 301 Midlothian Rd, Frostburg, MD 21532 – IVN room
4. August 4, 2015 – All Saints Parish, 100 Lower Marlboro Rd, Sunderland, MD 20689
5. August 6, 2015 – Prince George's County Department of Environment Resources headquarters building, 1801 McCormick Drive, Largo, MD 20774

Time was allotted during each meeting for willing attendees to address the present members of the MCCC with comments, and written comments were collected at the conclusion of each meeting. While these comments addressed a wide range of topics related to climate change, comments addressing the dangers of climate change and Maryland's vulnerability, the Cove Point natural gas facility, fracking in Maryland, amending Maryland's Renewable Portfolio Standard (RPS) and the renewal of the GGRA occurred with the greatest frequency. Response to these comments can be found in the designated areas of the *2015 GGRA Plan Update* outlined below:

- Dangers of climate change and Maryland's vulnerability
    - See Chapter 3: Climate Change and the Cost of Inaction in Maryland
- The Cove Point natural gas facility
    - See Chapter 5: Inventory and Forecast
- Fracking in Maryland
    - See Chapter 5: Inventory and Forecast
- Amending Maryland's Renewable Portfolio Standard (RPS)
    - See Chapter 6: Summary of Reduction Programs
- Renewal of the GGRA
    - See Chapter 12: Emerging Issues and Legislative Priorities

The full collection of both verbal and written comments received at the MCCC public meetings are contained within this appendix.

MARYLAND

[redacted]

# Fwd: Greenhouse gas plan

**CLIMATE CHANGE -MDE-** <climate.change@maryland.gov> Mon, Jul 27, 2015 at 7:39 AM
[redacted]

---------- Forwarded message ----------
From: **Andrea de urquiza** <adeurquiza@yahoo.com>
Date: Fri, Jul 17, 2015 at 12:58 PM
Subject: Greenhouse gas plan
To: "climate.change@maryland.gov" <climate.change@maryland.gov>

I was unable to attend your meeting in Baltimore but I want to express my support for any efforts to reduce human impacts on the climate. I am a registered voter and old enough to remember the world before climate change.

# Baltimore City Public Meeting Comments

## Tuesday, July 14, 2015

#1, Jim Kraft: Looking at science wastes time. Remove as much from the waste stream - bottle bill/bag bill at state level. Building codes - ground level should not be habitable. $2 billion on roads is ridiculous and we should invest in getting people off the roads, cities are for people not cars. Healthy harbor program by 2020 - vacations in Baltimore city

#2, Betsy Singer: as a League of women voters representative: more aggressive RPS and low income folks pay more

#3, Gwen Dubois: Tier 1 programs incineration, we have to make it again. Waste to energy incentives are promoting bad policy. Environmental justice component of climate justice and think about the energy of trucks that transport the energy.

#4, Andy Galli: clean water action. Climate change impacts our water resources tremendously. 1. Incineration, waste to energy as bio energy should be pulled and not considered. 2. Nonconventional gas extraction isn't necessary and we need a state ban 3. Transportation - more of it

#5, Seth Bush: Sierra club/sustainability commission and speaking on behalf of Earl ______. Paying attention to infrastructure development and especially in locations where mold, roofs are leaking and it needs to be a racial concern

#6, Fred Weimert: pastor and ecumenical leaders. More aggressive RPS, 230 religious leaders are working to increase solar use in churches and communities

#7, Michael Leonard: Julie (food and water watch) speaking on behalf of Michael Leonard. #1 kill manure to energy before it hatches, don't burn poop because of higher levels of GHG than coal power plants. #2 eliminate pollution trading as an option to get rid of GHG it creates incentives for polluters. #3 ban hydrofracking and extracting natural gas - proof that there are no impacts on anyone

#8, Amy Sens: pastor: keep doing what we are doing and do more. Think about the EJ issues of the climate issues - jobs, energy efficiency, and transportation. Also subsidizes people who aren't able to pay

#9, Martin Rusman: retired physician. We need to do more. 1. Mandatory changes and more engagement of the public. Crowd sourcing in a volunteer corp. 2. stop wasting time on fracking no need to develop any regulations and look at a 20 year time frame. 3. Think about looking at the sequestration ability of soil- get pesticides out of the stream

#10, Martin Rusman: Agreed with all and gave time back to the floor

#11, Stan Boyd: are we going at a sat enough rate to reach 90% by 2050. Clean up the RPS and raise standard. Close coal plants and emphasize renewable energy. Fracked gas out of Maryland and not even through the state. Promote empower

#12, Jamie Demarco: inner harbor will be flooded by the end of the century and seeing the places he grew up disappear. Stories about why asthma is like for a baltimore woman. Renew GGRA and increase RPS 25% by 2020

#13, Giruwe Ashenafi: local 1199 SIEU healthcare workers. Healthcare workers see the impacts of climate change all the time through asthma rates and it becomes an issue of social justice. We need to better. Increase the RPS

#14, Richard Reis : energy committee of Sierra club. We are responding to the slow disaster that is climate change and the pollutants impact people immediately and cause a disproportionate impact on income distressed communities. Increase RPS and remove incentives for tier 1. Emphasize new technology like lighting.

#15, Bill Freedman: No Comments

#16, Ruth Ann White: No fracking and we need to invest in renewable energy. Recommend the rapid switching to renewables and not follow old science for switching from oil to gas

#17, Cheryl Arney: brought a picture of her granddaughter Julianna. Her son, 45, is her inspiration for living in a sustainable manner. Hopes for the will to take the measures. Maryland is in big trouble. BGE sends the energy sources for our electricity, 4% from renewables so we need to reauthorize and go further.

#18, Russell Donnelly: environmental analyst. 1. 50% in forestation and 50% reduction in cutting. 2. No fracking. 3. Renew the act and add bigger teeth. 4. If incinerating, transition to glass plasma regulators - no compounds or pollutants coming out or stop making waste. 5. Baltimore on the map to install a railroad and don't dig underground...use monorails

#19, Claude Guillemend: grateful for the opportunity to speak to community. Believes in a fossil fuel free future and has put solar panels on her house she sold and her new house. There are people who are begging for the state to pass laws because there is only south individuals can do

#20, Richard Doran: fuel fund of Maryland. Bills keep going up for fossil fuel use in the city. There are health effects and low income residents are investing more than any other people because of the higher costs and the issues of pollution. Weatherization is one of the ways to really transform communities: e2e website on 30,000 homes in Michigan - could reinvest that money back into the communities for solar farms and such. The GGRA needs to be stronger and we need to think about more technology.

#21, Allison Rich: Vulnerable populations included in the plans especially children. Older adults with preexisting conditions are at risk. Schools included in inclusion of educating people in GGRA emissions.

Baltimore Public Mtg

Climate Change
Maryland

mde.maryland.gov

## Public Meeting Comment Sheet

*Discussion on the Greenhouse Gas Reduction Act Plan*

Tuesday, July 14, 2015, 5:30 p.m.
Baltimore, MD

**Instructions:**

Please use this form to provide any comments you have on the state's progress on addressing climate change and Greenhouse Gas Reduction Act Plan that will be up for renewal in 2016. Once you have completed the sheet, please place in the comment box or mail or email to:

Mr. Brian Hug
Maryland Department of the Environment
1800 Washington Blvd
Baltimore, MD 21230
Email: climate.change@maryland.gov

**Please submit comments by Friday, August 28, 2015**

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Comments Submitted By:

Name: Rev. Amy Sens

Representing: United Church of Christ

Address: 2002 Grinnalds Ave

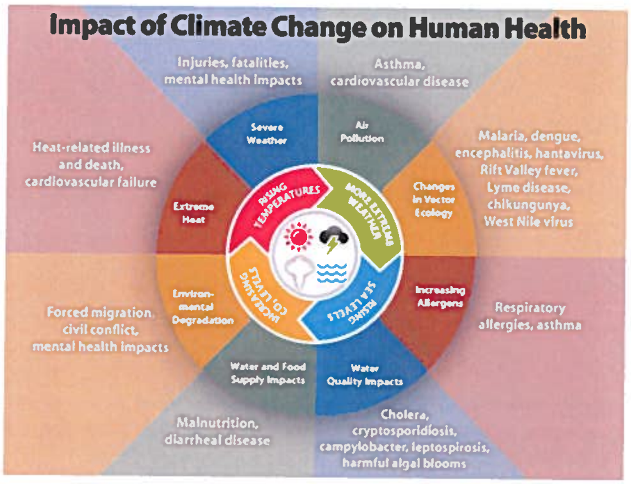
Comments: Climate change is a huge challenge and threat to Maryland. I would like to see continued support for current projects, and stronger RPS standards. In addition, projects that add to quality of life for poor & disadvantaged people - public transportation, energy efficiency in homes, →

*(Please use an additional sheet or back of this form for comments if additional space is needed)*

subsidies for people who can't afford more money for clean energy, and initiatives that make for cleaner air.

# Considerations: Health & Climate Change

July 2015 - Prepared by Allison Rich - Maryland Environmental Health Network www.MdEHN.org




**Threat**: "Climate change – caused by carbon pollution – is one of the most significant public health threats of our time," EPA Administrator Gina McCarthy, 09/20/2013

**Opportunity**: Through common-sense measures to cut carbon pollution, we can protect the health of our Nation, while stimulating the economy and helping to prevent the worst impacts of climate change. [i] Renewing the Greenhouse Gas Reduction Act is one such common-sense measure.

## Vulnerable Populations will suffer the greatest health burdens

### Children, the elderly, and people already suffering illness in Maryland

- Climate change will put vulnerable populations at greater risk – including:
  - Children, who breathe more air relative to their size than adults, are at higher risk of worsened asthma and respiratory symptoms from air pollution and severe weather or illness following severe weather
  - Older adults, especially those with pre-existing health conditions, are at a high risk of cardiac and respiratory impacts of air pollution or illness following serve weather
  - People already suffering from allergies, asthma, weak immune systems, and other illnesses are more susceptible to experiencing health impacts related to climate change
  - Communities burdened with higher rates of diabetes, obesity, or asthma may be at greater risk of climate-related health impacts

## Air pollution caused by greenhouse gas emissions are hazardous to health

### Ground-Level Ozone

- Tropospheric, or ground-level ozone, is formed by chemical reactions between greenhouse gases in the presence of sunlight. (This is not to be confused with stratospheric ozone, which protects us from harmful UV rays from the sun.)
- Exposure to ground-level ozone inhibits lung function and is anticipated to cause:
  - 1,000 to 4,300 additional premature deaths nationally per year by 2050 [ii]
  - 2.8 million more instances of acute respiratory symptoms such as asthma attacks, shortness of breath, coughing, wheezing, and chest tightness, by 2020
  - 24,000 more seniors and 5,700 more infants hospitalized for respiratory related problems, by 2050 [iii]

## Severe weather will increase the need for and disrupt health care services

### Extreme Heat Events

- Extreme heat events are expected to become more frequent and severe due to climate change and will have implications for health care services including:

- Health services utilization, disruption to the healthcare delivery system, and quality of patient care during disasters [i]
    - Increase in hospital visits for cardiovascular, respiratory, cerebrovascular diseases, mental health problems, mortality, injury, and illness
- Extreme heat exposure from climate change can be deadly:
    - During June 30–July 13, 2012, maximum daily temperatures in Maryland, Ohio, Virginia, and West Virginia averaged is 9.5°F warmer than normal. 12 Maryland residents died during this period due to excessive heat exposure [v]
    - Severe weather will also include flooding, droughts, storms, and fires that impact healthcare services as well as long term health concerns

## Population health status does not return after severe weather events:

- A study of Hurricane Katrina measured health impacts a year after the hurricane and found an increase in disease prevalence, increased health burden directly associated with disruption from Hurricane Katrina, and the adverse effect on morbidity was strongest for nonwhite subjects[vi]

## Sea level rise, heavy rainfall, and storm surges will increase will disrupt communities and increase water borne disease and disrupt communities

- ### Sea Level Rise
    - Rising seas and eroding shorelines displace coastal communities
    - Sea level rise and storm surge threatens drinking water supplies and agricultural fields with salt-water intrusion
    - Potential changes in exposure to diseases

- ### Flooding and Heavy Rainfall

The frequency of heavy precipitation events has already increased for the nation as a whole (75% increase for the Northeast), and is projected to continue increasing. With nearly 3,000 miles in coastline, Maryland is vulnerable to health concerns from flooding including:

- Failure of septic systems - Waterborne diseases contaminating drinking water
- Sewage back-up in plumbing or basements
- Floodwater containing toxins, bacteria, and sewage, can contaminate drinking water, vegetables growing in fields or gardens, and recreational water sources
- Water intrusion in buildings, worsening indoor air quality and/or causing toxic mold to grow in ceilings, walls, or insulation [vii]

- Between 2007-2013, Baltimore had on average 13.1 nuisance flood days per year, while Annapolis had 39. Annapolis and Baltimore have the highest increase in number of flood days in the nation [viii]

## Allergens related to pollen will increase:

- The length of the ragweed pollen season has increased in parts of the US by 11-27 days because of rising temperatures. As the climate warms more pollen is produced and pollen season lengthens, there will be an increase in health problems related to allergens:
    - Increases in the symptoms of seasonal allergies
    - Pollen triggers asthma attacks, leading to more ER and hospital visits

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[i] The Health Impacts of Climate Change on Americans The White House, 6 / 2014
[ii] "Climate Effects on Health – Air Pollution" Centers for Disease Control, 12/11/2014
[iii] Climate Change and Your Health, Rising Temperatures, Worsening Ozone Pollution Union of Concerned Scientists, 2011
[iv] "Heat-Related Deaths After an Extreme Heat Event — Four States" Centers for Disease Control, 2013
[v] Health of Medicare Advantage Plan Enrollees at 1 Year After Hurricane Katrina, Burton, et all., The American Journal of Managed Care Vol. 15 No. 1, 01/ 2009
[vi] Climate Change Impacts in the United States U.S. Global Change Research Program, 2014
[vii] Sea Level Rise and Nuisance Flood Frequency Changes around the United States, National Oceanic and Atmospheric Association, July 2014

LEAGUE OF WOMEN VOTERS OF MARYLAND, INC.
111 Cathedral Street, Suite 201, Annapolis, MD 21401

Testimony to Maryland Climate Commission
July 14, 2015, Baltimore, MD

Members of the League of Women Voters of Maryland and the national League have repeatedly expressed our concerns about global climate change and its impacts on our environment, our communities, our health, our economy and our very future.

We have reached a critical junction in Maryland. Our 3,000 miles of tidal shoreline make us one of the most vulnerable states in the nation when it comes to sea level rise. The Annapolis and Baltimore waterfronts and Ocean City face frequent flooding today. Baltimore set a record last month for the wettest June with over 13 inches of rainfall. We recently organized an educational Forum at Chesapeake College in Wye Mills on the eastern shore. "The Future is Now: Dealing with Rising Seas on Maryland's Shores" was well-attended and highlighted action to protect the people in Eastern shore communities that face eroding coastlines and flooded farmland.

We support the work of the Maryland Climate Commission to identify and seek solutions for the potentially catastrophic disruptions we face from increasing fossil fuel emissions. The Greenhouse Gas Reduction Act Plan has the potential to save lives and livelihoods and to leave a livable Maryland for our children and grandchildren. While the GGRA has 150 programs and policies that will help get us to clean energy goals, this important Act is due to expire in 2016. The Act must be renewed because the programs are key to making the greenhouse gas reductions that we desperately need.

The Renewable Portfolio Standard (RPS) for clean energy is an important feature of the GGRA. This framework for incentivizing clean, renewable sources, such as wind and solar, is essential if we are to cut Maryland carbon emissions 25 percent by 2020. However, with global warming accelerating faster than scientists predicted even five years ago, we can and should do more. We feel strongly that the RPS should be strengthened. In the future, we will need to increase the percentages of clean energy in the RPS and shorten the time frame for achieving these percentages, for example, realizing a 40 percent clean energy portfolio by 2025.

We are also facing the hard fact that the impacts of climate change fall relentlessly on our poorest communities. We urge the Commission to emphasize programs that permanently lower energy bills through conservation measures. Certain home repairs, better insulation and energy efficient appliances can lower energy bills and improve the health and quality of life for low-income families.

Betsy Singer, LWVMD
elizabethsinger446@hotmail.com

Maryland's Greenhouse Gas Reduction Plan
Testimony from Richard Reis, PE
Chair Energy Committee, Maryland Chapter of the Sierra Club
July 14, 2015

Hi, I'm Richard Reis. I serve as chair of the energy committee of the Maryland Sierra Club.

I thank the Maryland Department of the Environment and Maryland Commission on Climate Change for developing a Greenhouse Gas Reduction Plan and for holding this public forum.

I appreciate this plan because the world is facing a slow disaster as the effects of climate change increase over the coming years. As noted in your report, Maryland is especially vulnerable to these changes because of our long and low-lying coastline.

The report shows that Maryland can do its part in mitigating climate change and thus be a positive role model to the nation and the world. At the same time these steps, such as investing in clean renewable energy and energy efficiency, save money, grow our economy, and produce rewarding jobs for Marylanders.

I especially appreciate and endorse this sentence from the executive summary, page 8 under "Energy": "The Renewable Portfolio Standard can play an even greater role in meeting Maryland's greenhouse gas emissions reduction goal if high carbon-emitting fuels are eventually are eventually removed from Tier 1 eligibility and if the overall Renewable Portfolio Standard is accelerated to 25 percent by 2020." Thus we should increase the RPS, while cleaning it up.

Unfortunately, that statement is at odds with another statement on page 7 of the same document which calls for managing our forests for "renewable biomass for energy production". I take issue with the concept of burning forests for energy production, because it takes decades for those forests to rebuild and reclaim the carbon released by burning.

Finally, it's also important to note that since limiting heat-trapping carbon pollution will help also clear the air of health destroying toxins. This is because these decreases require a great reduction in the use of fossil fuels that emit like nitrogen oxides, ozone, sulfur dioxide, particulates, and heavy metals when burned.

Thank you for your time and attention. I'll be happy to answer questions as well.

Richard Reis, PE

Food & Water Watch • 3121 St. Paul Street, Suite 28 • Baltimore, MD 21218
T +410.394.7650 • www.foodandwaterwatch.org

food&water watch

**Maryland Commission on Climate Change Meeting**
**July 14, 2015**
**Public Comments from Food & Water Watch**

**About Food & Water Watch (FWW):** FWW champions healthy food and clean water for all. We stand up to corporations that put profits before people and advocate for a democracy that improves peoples' lives and protects the environment.

On behalf of Food & Water Watch's 23,000 members and supporters in Maryland, we urge the Maryland Commission on Climate Change to make the following recommendations in their report due to the state legislature in November 2015:

1. Maryland should eliminate dirty sources of energy from Tier I in the Renewable Energy Portfolio Standard (RPS), including manure to energy sources, to meet its greenhouse gas (GHG) reduction goals.
2. Maryland should eliminate pollution trading as a strategy to reduce greenhouse gas emissions.
3. Maryland should ban hydraulic fracturing and not rely on natural gas to meet its GHG reduction goals.

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## 1. Maryland should eliminate dirty energy sources from Tier I in the RPS, including manure to energy sources, to meet its GHG reduction goals.

- One of the recommendations in the GGRA Plan is to increase the amount of clean, renewable electricity—like solar and wind power—that we use to power our homes and communities. The Maryland Renewable Energy Portfolio Standard (RPS) is a law that requires Maryland to obtain 20 percent of its electricity from renewable sources, as defined by statute, by 2022, with a solar carve-out which requires that two percent be obtained from solar energy generation by 2020.

- The RPS is underperforming. The GGRA Plan predicted that the RPS is capable of reducing 10.96 million metric tons of $CO_2$ in 2020—nearly 20% of the state's total reduction goal. However, the program is only on track to reduce 4.1 million metric tons of $CO_2$, which is less than half of the original target.

- In addition to investing in new renewable energy in Maryland, the GGRA acknowledges that Maryland needs to narrow the qualifying sources to favor low or no carbon fuel sources to drive additional GHG emissions reductions.

- Currently, Maryland's RPS allows a number of different dirty fuel sources to qualify as renewable sources of energy, which are eligible to generate Tier 1 RECs. These dirty fuel sources include poultry litter-to-energy and energy from thermal biomass systems that use primarily animal manure, including poultry litter and associated bedding.

- These dirty energy sources have the potential to increase $CO_2$ emissions as well as other pollutants. For example, Fibrominn, the only operational poultry litter-fueled power plant in the United States, emits higher levels of $CO_2$, carbon monoxide, NOx, VOCs, and PM10 than Maryland's coal-fired power plants.

- In 2013, the State of Maryland signed a contract with Green Planet Power to build a similar "biomass" plant of up to 20 megawatts in size. The company has proposed combusting 56 percent litter and 44 percent wood waste. At best, the facility is a hybrid plant that will barely consume half the waste problem from chickens. In addition, the GPPS proposal actually states that the plant will consume 150,000 bone dry tons of wood fuel per year, enough to actually power all 20 megawatts of proposed generation. Either this is an error or the plant developers anticipate the possibility that the plant will sometimes run entirely on wood fuel, if built.

- The proposed power plant raises major carbon pollution concerns. Any facility that combusts biofuels like chicken litter or wood waste runs the risk of emitting even more carbon dioxide per unit of energy produced than coal combustion. Unfortunately, GPPS, in its proposal, erroneously declares wood waste and chicken litter to be "carbon neutral" with no details and no scientific grounding.

- To ensure that the RPS meets its emission reduction goals, Maryland's Commission on Climate Change should recommend to the State Legislature that they amend the RPS to eliminate dirty sources of energy from Tier 1, including all manure to energy sources, in their report due November 2015.

- Furthermore, the Commission should recommend that the legislature continue to reject attempts by companies like Perdue to create a new thermal tier in the RPS to increase financing for anaerobic digesters.

- While anaerobic digesters have been promoted as a solution for capturing methane emissions, research has demonstrated that anaerobic digesters are not the 'silver bullet' for manure management. The nutrient (nitrogen and phosphorus) loads are not reduced during the digestion process. The resulting effluent must still be managed appropriately and, thus, digesters do not effectively alleviate the environmental challenges associated with storing large quantities of manure-based nitrogen or phosphorous or applying it to crop fields in a manner that will not exacerbate surface or groundwater contamination. Utilization of biogas in digesters also carries air quality implications due to emissions from the combustion process.

2. **Maryland should eliminate pollution trading as a strategy to reduce greenhouse gas emissions.**

   - The GGRA plan includes a number of conclusory statements that nutrient trading will help decrease greenhouse gas emissions by stacking carbon credits onto existing nutrient credits.

   - In theory, pollution-trading programs generally exist for two reasons. First, to allow purchasers of credits who are subject to technological mandates on emission controls – in this case industrial GHG emitters – to evade the cost of those controls; and second, to create financial incentives for other industrial polluters, in this case Maryland agricultural operations, to do what they should be doing anyway to reduce their own contribution to the problem. This is a misguided plan for many reasons, but one of the biggest issues is that it destroys one of the most important aspects of our modern environmental and public protection framework - one that has mostly kept our waterways from being open sewers and our airways mostly breathable - a technology-driven approach that challenges industries to invent and implement better systems to reduce or eliminate pollution discharges.

- Another major shortcoming of trading, on the credit generating side, is that it is an avoidance tactic used to circumvent doing what needs to be done, that is, to place mandatory controls on all sources of pollution. If Maryland farmers can implement practices to reduce green house gas emissions, than those practices should be mandated by the state. If the state were really serious about reducing GHG emissions, then voluntary compliance would not be an option. Voluntary compliance has proven, time and again, to be a failed approach that only ensures ongoing problems and net increases of pollution.

- Finally, the Climate Commission should not pursue a trading strategy, because it will likely result in immoral outcomes. Historically, communities living near facilities that increase their pollution loads by purchasing credits are overwhelmingly poor or communities of color. Use of allowances generated by agricultural operations at industrial facilities would deny on-site pollution reductions for communities of color living near industrial facilities like refineries and power plants. In fact, the first potential pollution trade between an industrial facility and agricultural operations in Maryland is one proposed by power plant company NRG Energy who wants to buy credits to allow it to continue, and even increase, its pollution to a waterway in a community that is 70-80% Black and Latin.

**3. Maryland should ban hydraulic fracturing and not rely on natural gas to meet its reduction goals.**

- Hydraulic fracturing, or fracking, is the primary method of extracting natural gas in the United States today. Fracking, and the infrastructure necessary to support it, is a leading source of methane emissions, and burning natural gas results in significant carbon dioxide emissions. Science is clear that extracting and burning natural gas is a major source of climate pollution, on par with extracting and burning coal and oil.

- While fracking is not currently taking place in Maryland, at least 5 gas basins lie under the state and could be targeted for fracking. The state should ban fracking to keep this gas in the ground and protect communities from the local health and environmental and health impacts from widespread drilling and fracking.

- The state cannot not rely on natural gas to meet its emissions reduction targets. Natural gas is 80 to 98 percent methane, which is about 86 times as potent of a greenhouse gas as carbon dioxide over a 20-year timeframe. Current estimates vary regarding how much natural gas, and thus methane, leaks into the atmosphere. Generally, more methane leaks than officials estimate. According to the best available science, the equivalent of 3 percent of natural gas produced is leaked. This leakage completely offsets the reduced carbon dioxide emissions that come from switching from coal to natural gas.

- Sold as a climate benefit, natural gas is a false solution. When estimating the climate change impacts of fuel switching from coal to natural gas, the climate commission should take national estimates of methane leakage into account, and also emphasize the importance of the 20-year timeframe as we approach tipping points, and the prospect of irreversible changes in the stability of our climate.

- Methane and carbon dioxide emissions mean that natural gas is a climate problem, along with coal and oil. In order to achieve continued emissions reductions beyond 2020 and move towards the state's longer term goal of reducing emissions 90% by 2050, the state must end its reliance on all fossil fuels. Maryland can achieve its 2050 goal by aggressively implementing conservation policies, by taking advantage of energy efficiency solutions, and by building out zero-carbon power in the state, such as from solar and wind energy.

Climate Change Maryland

mde.maryland.gov

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**Please submit comments by Friday, August 28, 2015**

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Comments Submitted By:

Name: NINA BETH CARDIN ncardin@comcast.net

Representing: FAITH COMMUNITIES

Address:

Comments: THE EARTH, AIR, WATER, FOOD THAT WE ENJOY HAS PASSED THROUGH HUNDREDS OF GENERATIONS, BILLIONS OF PEOPLE. AND IT STILL WORKS SO THAT WE CAN ENJOY A HIGH QUALITY OF LIFE. IT IS OUR OBLIGATION, OUR MORAL CALLING TO ASSURE THAT ALL FUTURE GENERATIONS ENJOY THE BLESSINGS WE HAVE INHERITED AND PASS THEM ALONG TO OUR CHILDREN. THEIR RIGHTS ARE NO LESS THAN OURS. PLEASE DO WHAT IS RIGHT!

*(Please use an additional sheet or back of this form for comments if additional space is needed)*

1199SEIU
United Healthcare Workers East



**STATEMENT OF GIRUME ASHENAFI (OR NURSE MEMBER)**
**1199SEIU UNITED HEALTH CARE WORKERS EAST**
**IN SUPPORT OF THE MARYLAND GREENHOUSE GAS REDUCTION PLAN**
**BEFORE THE MARYLAND CLIMATE COMMISSION**
**July 14, 2015**

Chairman Grumbles and Members of the Maryland Climate Commission:

1199SEIU United Healthcare Workers East represents over 8,000 healthcare workers in Maryland. We represent workers at almost every stage of the health care delivery process, both in long term care facilities and hospitals.

The top programs in the Greenhouse Gas Reduction plan require Maryland to **use energy more efficiently and increase Maryland's use of clean, renewable energy while creating jobs and growing our economy. These are critical solutions to climate change and to improving the lives of the most vulnerable among us.** Every day, healthcare workers see firsthand the impacts of climate change and air pollution from dirty energy sources. Science and data back up their experiences:

- Last month, the international academic **Lancet Commission on Health and Climate Change found** the effects of climate change are being felt today, and **future projections represent an unacceptably high and potentially catastrophic risk to human health.** They site increased heat stress, increased frequency of intense storms, air pollution, food insecurity, and mental ill health among the direct and indirect effects of climate change.
- Climate change public health impacts fall disproportionately on Maryland's communities of color and poorest communities, which suffer from more polluted air and higher rates of breathing problems. Extreme weather events also disproportionately impact communities of color and low income communities.
- A 2014 study found that **communities of color breathe in nearly 40% more polluted air than whites, and poor white Americans endure 27% heavier pollution than do wealthy white Americans.**[1]
- **Nationally, 68% of African Americans live within 30 miles of a coal fired power plan.— the distance within which the maximum effects of the**

[1] Clark, Lara P., Dylan B. Millet, and Julian D. Marshall. "National Patterns in Environmental Injustice and Inequality: Outdoor NO2 Air Pollution in the United States." *PLOS ONE* (2014): 15 Apr. 2014. <http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0094431#references>

**smokestack plume are expected to occur. By comparison, about 56% of the white population live within 30 miles of a coal-fired power plant.**[2]

For us, fighting climate change is about fighting social injustice. That is why 1199SEIU members took to the streets of New York with over 400,000 people in the People's Climate March last summer.

Here in Maryland, one of the top programs in the GGRA Plan is increasing the amount of clean, renewable electricity—like solar and wind power—that we use to power our homes and communities. We commend Maryland for being on track to meet our current clean energy requirement of 20% by 2022. But, we need to do better. **We need to reach 25% clean electricity consumption by the year 2020.** 1199SEIU proudly supported legislation in 2015 to do just that. We also applaud Baltimore City for announcing last week a partnership with Civic Works to install solar arrays and cool roofs on ten homes and a community center in East Baltimore while giving local residents solar job training as part of the project. We can and should do more.

We thank Secretary Grumbles for his leadership on this issue and respectfully urge the Commission to recommend reauthorization of the Greenhouse Reduction Act. Thank you for your consideration.

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[2] U.S. Census, 2000. Estimated using 1990 racial fractions and 2000 census. Data compiled by MSB Energy Associates

Climate Change
Maryland

mde.maryland.gov

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Email: climate.change@maryland.gov

**Please submit comments by Friday, August 28, 2015**

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Comments Submitted By:

Name: Seth Bush for Earl Johnson

Representing: Oliver Community & East Baltimore

Address: ______

Comments: Attached.

*(Please use an additional sheet or back of this form for comments if additional space is needed)*

Earl Johnson
Balt Sustainabl
Commission

My name is Seth Bush, and I am a Baltimore resident. I recently met with a community leader from Oliver who couldn't be here tonight, and he had this to say.

Baltimore needs bold climate action, or our communities will suffer.

15,000 years ago early humans were are able to survive a dramatic change in the earth's climate commonly referred to as the ice age. They did this by being nomadic, creating new ways to live by depending on each other and by building innovative shelters. Baltimore is facing climate change issues today, no not an ice age, but it will be just as dramatic if you we don't face it head on.

One hundred year storms are becoming the norm, large storm cells that produce 2 to 4 inches of rain in under 20 min have already showed us that our storm water infrastructure is outdated and not up to the task in many of our urban communities. Our housing stock has become outdated and dilapidated. Many Baltimoreans know a friend or a family member with a leaky roof or a basement that floods with heavy rain. We all know that many of our children are living in homes with severe mold growth throughout the house, pests thriving in the moisture rich environment, and other problems endemic to homes that cannot withstand the stronger more frequent downpours and snow events we're starting to experience. These problems take an immeasurable toll that compounds and is compounded by so many other oppressive factors of life in a city with neglected infrastructure, unhealthy air, poor education, and a broken law enforcement system. There is a strong connection between not being able to live comfortably in your own home and not being successful in life, and climate change will make that situation worse if we do not act now.

If you're not following me or you don't see the correlation between the Ice Age and rain storms take this simple statement. The cave man was able to move, bond together, and adapt to a changing climate. For those that live in poor urban communities, there is no possibility of moving away from the homes passed down from one generation to the next. There is no new innovative housing that everyone can afford that doesn't come with a 3 year waiting list with no guarantee. In many cases there is no bonding together, or mass sharing, or resources. The cave man had a better chance of surviving climate change than we do living in the communities we live in. I can say this weird weather we have been having is only going to get worse and our most at risk communities are not ready and are already paying the toll of climate change.

We need to renew the Greenhouse Gas Reduction Act and we need to take bold action by setting even more ambitious reduction goals and strengthening the programs Maryland already has in place.

Beyond mitigation we need to focus energy on preparing our communities ~~from~~ for the change that is already inevitable. Low income communities & communities of color are the most vulnerable, and they need support programs now.

MARYLAND [redacted]

# Fwd: public comment to Climate Commission

**CLIMATE CHANGE -MDE-** <climate.change@maryland.gov> Tue, Aug 18, 2015 at 2:49 PM
[redacted]

---------- Forwarded message ----------
From: **Chris Schmitthenner** <somdgreen@yahoo.com>
Date: Fri, Aug 7, 2015 at 6:34 PM
Subject: public comment to Climate Commission
To: "climate.change@maryland.gov" <climate.change@maryland.gov>

Below is testimony I prepared to present on Aug. 4. Unfortunately the posted site for the hearing was incorrect, so I was unable to attend.
Christine Schmitthenner
27290 Woodburn Hill Rd.
Mechanicsville, MD 20659

Testimony, Christine Schmitthenner August 4, 2015 to Maryland Commission on Climate Change
I am a health care provider (nurse practitioner). I believe climate change is a serious threat not just to the quality of life on the planet, but to life itself on the planet. I believe action to prevent catastrophic consequences of climate change must be taken urgently, and it will soon be too late to prevent such consequences.
I am concerned about health consequences of climate change, and the threat to our food supplies due to climate change. Rising sea levels will affect our coastlines, and will impact sites such as Calvert Cliffs nuclear power plant and the Cove Point natural gas terminal in neighboring Calvert County.
We need to replace polluting sources of energy with cleaner energy sources such as solar and wind. Maryland ranks 5$^{th}$ in the nation in adult asthma and nearly 12 % of Maryland children have asthma. A 2014 study found the communities of color breathe in nearly 40% more polluted air than whites. Closing coal-fired power plants will reduce the pollution which triggers asthma. We need to provide training to transition workers from employment in industries such as coal to skills needed for renewable energy production.
We need to renew the Greenhouse Gas Reduction Act in 2016 and we need to expand Maryland's clean energy standard to 25% by 2020, and we need to look beyond 2020 to protect the lives of Marylanders and the future well-being of the planet. We need continued tax incentives for individuals and businesses to install solar or wind power, and for the purchase of energy efficient appliances and vehicles.
Kudos to the Maryland Public Service Commission's new requirement which which will save 1.2 million megawatt-hours of electricity per year, enough to close a 460 megawatt coal fired plant every 2 years. Kudos to President Obama and the Environmental Protection Agency for thenew clean power plan. Maryland can continue to be a leader in combating climate change, to protect it's citizens, and ultimately all life on the planet.

# Public Meeting Comments Template

**Date** July 16, 2015
Eastern Shore Public Meeting Comments

## *What do you want from this meeting?*

1. Who is going to benefit? Just the businesses and the farms or other people?

2. What happens now that Delmarva has been purchased by constellation?

3. Is there an education plan to help retard the impacts and to learn what people can mitigate impacts.

4. Are we including offshore wind?

5. Is there a public relations or citizen engagement program to push the programs forward?

## *PUBLIC COMMENTS*

1. Karl Schrass: NWF, sea level rise projections show that eastern shore
Locations are going to lose acres. We need to renew GGRA and increase the RPS to ensure that the eastern shore remains for future generations.

2. Rebecca Rehr: MdEHN, inclusion of public health on the commission and in all outreach of the commission. We should enhance community participation and make sure that the communities most impacted are included in the discussion.

3. Sara Via: PSR, sea level rise is going to tell the biggest part of the climate change story. The latest report indicates that there will be a 3 foot sea level rise by 2050 and that means that Crisfield would be under water. Incidents of salmonella infection are higher on the eastern shore because of flooding so the health impacts are tremendous. Our health infrastructure is also lacking for disasters. Agriculture will be impacted on the eastern shore as well because of increased salinity.

Reconditions:
1. Go back to the 2008 document and make sure that we are following the recommendations.
2. Increase education of all Marylanders about the changes happening as a result of climate change.
3. Every county and jurisdiction should be educated on the ways they can communicate climate change by utilizing the cooperative extensions.

4. Tammy Truitt: the state has a renewable program that takes into account environment and economics. Look at other areas that have invested heavily in renewables like Europe who are suffering as a result of the high cost of power.

5. Dave O'Leary: volunteer for the Maryland chapter of the Sierra Club, extending the plan is important to 2050 or closer in the future. Aligning state and local policies to make sure that the programs are actually happening in the future. The old recommendations didn't take into account fracking but now we need to take a look at the current landscape. Encourages and incorporates energy efficiency and investment into the program. Combustion fuels are taken out of the current RPS. Increased waste reduction and recycling and address the issues of methane emissions. We need to increase the circle of influence that encompasses our state energy cycle and use. Also should look into the multistage transportation corridor to take into account moving people and foods between Richmond and Boston.

6. Kathy MacGruder: MCEC, look at the way we invest in the internal compliance through RGGI so that we get the most out of deployment solutions and energy efficient. More private sector investment into the market- find ways to incentivize the public sector. Think about affordability and resiliency of the current energy system and what happens when the power goes out and make micro grids part of the solution.

7. Other thoughts:

A. we have to work hard at selling renewable energy
B. making sure that we are taking advantage of supply/demand opportunities and ensure that people aren't being disproportionately impacted
C. Still need more education on resiliency efforts

Food & Water Watch • 3121 St. Paul Street, Suite 28 • Baltimore, MD 21218
T +410.394.7650 • www.foodandwaterwatch.org

**Maryland Commission on Climate Change Meeting**
**July 14, 2015**
**Public Comments from Food & Water Watch**

**About Food & Water Watch (FWW):** FWW champions healthy food and clean water for all. We stand up to corporations that put profits before people and advocate for a democracy that improves peoples' lives and protects the environment.

On behalf of Food & Water Watch's 23,000 members and supporters in Maryland, we urge the Maryland Commission on Climate Change to make the following recommendations in their report due to the state legislature in November 2015:

1. Maryland should eliminate dirty sources of energy from Tier I in the Renewable Energy Portfolio Standard (RPS), including manure to energy sources, to meet its greenhouse gas (GHG) reduction goals.
2. Maryland should eliminate pollution trading as a strategy to reduce greenhouse gas emissions.
3. Maryland should ban hydraulic fracturing and not rely on natural gas to meet its GHG reduction goals.

---

## 1. Maryland should eliminate dirty energy sources from Tier I in the RPS, including manure to energy sources, to meet its GHG reduction goals.

- One of the recommendations in the GGRA Plan is to increase the amount of clean, renewable electricity—like solar and wind power—that we use to power our homes and communities. The Maryland Renewable Energy Portfolio Standard (RPS) is a law that requires Maryland to obtain 20 percent of its electricity from renewable sources, as defined by statute, by 2022, with a solar carve-out which requires that two percent be obtained from solar energy generation by 2020.

- The RPS is underperforming. The GGRA Plan predicted that the RPS is capable of reducing 10.96 million metric tons of $CO_2$ in 2020—nearly 20% of the state's total reduction goal. However, the program is only on track to reduce 4.1 million metric tons of $CO_2$, which is less than half of the original target.

- In addition to investing in new renewable energy in Maryland, the GGRA acknowledges that Maryland needs to narrow the qualifying sources to favor low or no carbon fuel sources to drive additional GHG emissions reductions.

- Currently, Maryland's RPS allows a number of different dirty fuel sources to qualify as renewable sources of energy, which are eligible to generate Tier 1 RECs. These dirty fuel sources include poultry litter-to-energy and energy from thermal biomass systems that use primarily animal manure, including poultry litter and associated bedding.

- These dirty energy sources have the potential to increase $CO_2$ emissions as well as other pollutants. For example, Fibrominn, the only operational poultry litter-fueled power plant in the United States, emits higher levels of $CO_2$, carbon monoxide, NOx, VOCs, and PM10 than Maryland's coal-fired power plants.

- In 2013, the State of Maryland signed a contract with Green Planet Power to build a similar "biomass" plant of up to 20 megawatts in size. The company has proposed combusting 56 percent litter and 44 percent wood waste. At best, the facility is a hybrid plant that will barely consume half the waste problem from chickens. In addition, the GPPS proposal actually states that the plant will consume 150,000 bone dry tons of wood fuel per year, enough to actually power all 20 megawatts of proposed generation. Either this is an error or the plant developers anticipate the possibility that the plant will sometimes run entirely on wood fuel, if built.

- The proposed power plant raises major carbon pollution concerns. Any facility that combusts biofuels like chicken litter or wood waste runs the risk of emitting even more carbon dioxide per unit of energy produced than coal combustion. Unfortunately, GPPS, in its proposal, erroneously declares wood waste and chicken litter to be "carbon neutral" with no details and no scientific grounding.

- To ensure that the RPS meets its emission reduction goals, Maryland's Commission on Climate Change should recommend to the State Legislature that they amend the RPS to eliminate dirty sources of energy from Tier 1, including all manure to energy sources, in their report due November 2015.

- Furthermore, the Commission should recommend that the legislature continue to reject attempts by companies like Perdue to create a new thermal tier in the RPS to increase financing for anaerobic digesters.

- While anaerobic digesters have been promoted as a solution for capturing methane emissions, research has demonstrated that anaerobic digesters are not the 'silver bullet' for manure management. The nutrient (nitrogen and phosphorus) loads are not reduced during the digestion process. The resulting effluent must still be managed appropriately and, thus, digesters do not effectively alleviate the environmental challenges associated with storing large quantities of manure-based nitrogen or phosphorous or applying it to crop fields in a manner that will not exacerbate surface or groundwater contamination. Utilization of biogas in digesters also carries air quality implications due to emissions from the combustion process.

2. **Maryland should eliminate pollution trading as a strategy to reduce greenhouse gas emissions.**

- The GGRA plan includes a number of conclusory statements that nutrient trading will help decrease greenhouse gas emissions by stacking carbon credits onto existing nutrient credits.

- In theory, pollution-trading programs generally exist for two reasons. First, to allow purchasers of credits who are subject to technological mandates on emission controls – in this case industrial GHG emitters – to evade the cost of those controls; and second, to create financial incentives for other industrial polluters, in this case Maryland agricultural operations, to do what they should be doing anyway to reduce their own contribution to the problem. This is a misguided plan for many reasons, but one of the biggest issues is that it destroys one of the most important aspects of our modern environmental and public protection framework - one that has mostly kept our waterways from being open sewers and our airways mostly breathable - a technology-driven approach that challenges industries to invent and implement better systems to reduce or eliminate pollution discharges.

- Another major shortcoming of trading, on the credit generating side, is that it is an avoidance tactic used to circumvent doing what needs to be done, that is, to place mandatory controls on all sources of pollution. If Maryland farmers can implement practices to reduce green house gas emissions, than those practices should be mandated by the state. If the state were really serious about reducing GHG emissions, then voluntary compliance would not be an option. Voluntary compliance has proven, time and again, to be a failed approach that only ensures ongoing problems and net increases of pollution.

- Finally, the Climate Commission should not pursue a trading strategy, because it will likely result in immoral outcomes. Historically, communities living near facilities that increase their pollution loads by purchasing credits are overwhelmingly poor or communities of color. Use of allowances generated by agricultural operations at industrial facilities would deny on-site pollution reductions for communities of color living near industrial facilities like refineries and power plants. In fact, the first potential pollution trade between an industrial facility and agricultural operations in Maryland is one proposed by power plant company NRG Energy who wants to buy credits to allow it to continue, and even increase, its pollution to a waterway in a community that is 70-80% Black and Latin.

**3. Maryland should ban hydraulic fracturing and not rely on natural gas to meet its reduction goals.**

- Hydraulic fracturing, or fracking, is the primary method of extracting natural gas in the United States today. Fracking, and the infrastructure necessary to support it, is a leading source of methane emissions, and burning natural gas results in significant carbon dioxide emissions. Science is clear that extracting and burning natural gas is a major source of climate pollution, on par with extracting and burning coal and oil.

- While fracking is not currently taking place in Maryland, at least 5 gas basins lie under the state and could be targeted for fracking. The state should ban fracking to keep this gas in the ground and protect communities from the local health and environmental and health impacts from widespread drilling and fracking.

- The state cannot not rely on natural gas to meet its emissions reduction targets. Natural gas is 80 to 98 percent methane, which is about 86 times as potent of a greenhouse gas as carbon dioxide over a 20-year timeframe. Current estimates vary regarding how much natural gas, and thus methane, leaks into the atmosphere. Generally, more methane leaks than officials estimate. According to the best available science, the equivalent of 3 percent of natural gas produced is leaked. This leakage completely offsets the reduced carbon dioxide emissions that come from switching from coal to natural gas.

- Sold as a climate benefit, natural gas is a false solution. When estimating the climate change impacts of fuel switching from coal to natural gas, the climate commission should take national estimates of methane leakage into account, and also emphasize the importance of the 20-year timeframe as we approach tipping points, and the prospect of irreversible changes in the stability of our climate.

- Methane and carbon dioxide emissions mean that natural gas is a climate problem, along with coal and oil. In order to achieve continued emissions reductions beyond 2020 and move towards the state's longer term goal of reducing emissions 90% by 2050, the state must end its reliance on all fossil fuels. Maryland can achieve its 2050 goal by aggressively implementing conservation policies, by taking advantage of energy efficiency solutions, and by building out zero-carbon power in the state, such as from solar and wind energy.

MARYLAND

[redacted]

# Fwd: Written testimony from George Kaplan

**CLIMATE CHANGE -MDE-** <climate.change@maryland.gov> Mon, Jul 27, 2015 at 7:24 AM
[redacted]

---------- Forwarded message ----------
From: **Joelle Novey** <joelle@gwipl.org>
Date: Sun, Jul 26, 2015 at 8:33 PM
Subject: Written testimony from George Kaplan
To: climate.change@maryland.gov

George Kaplan was unable to testify at the Eastern Shore commission hearing, but asked that I submit the remarks below on his behalf ...

Joelle Novey, director
Interfaith Power & Light (MD.DC.NoVA): Our religious response to climate change.

---------- Forwarded message ----------
From: "George Kaplan" <gkaplan@zoominternet.net>
Date: Jul 16, 2015 3:54 PM

>
> My name is George Kaplan and I live at 35 Oak Street, in Colora in Cecil County. I worship at St. Mary Anne's Episcopal Church in North East. I have been a member there since 2004. From 2009 to 2014 I was the chair of the Environmental Ministries Commission of the Episcopal Diocese of Easton. (Here, however, I am speaking only for myself.)
>
> Climate change is real and is caused mainly by human-generated greenhouse gas emissions. The science on this is clear and has been well documented for several decades. Climate change will be affecting people all over the world for the foreseeable future. The poor will be the most affected; so we as members of the faith community see this as a moral issue and have a responsibility to raise its importance in public policy discussions. In addition, we have been given the responsibility in Genesis to be stewards of Creation, and we have fallen short in our responsibilities to the Earth, which we view as a gift from God.
>
> My congregation, as well as my wife and I, have been attempting to cut down on our own energy use through conservation measures, switching to CFL light bulbs, and planting trees (the latter also has benefits in reducing runoff to the Bay). My congregation in particular has been quite aggressive in planting new trees and reducing electricity use.
>
> I wish that there were more sources of renewable energy in Maryland (I am fortunate that much of my home electricity in peak hours comes from the Conowingo hydroelectric plant). Reducing greenhouse gas emissions can have an economic benefit; many of my neighbors have installed solar cell arrays on their houses to reduce the need for electricity produced from fossil fuels. This puts more money in their pockets to spend in our state. Reducing air pollution from fossil fuel burning has also been shown to have a positive economic benefit in improving long-term public health and reducing medical costs.
>
> I hope that you, as leaders in Maryland, will continue to work for the reduction of greenhouse gas emissions and support local renewable energy sources. The Greenhouse Gas Emissions Reduction Act and the Renewable Portfolio Standard have been important in moving us in the direction we (and the rest of the county) need to go. The RPS should be strengthened, and the Reduction Act should be renewed.
>

> Thank you for your time.
>

CHESAPEAKE PSR PHYSICIANS FOR SOCIAL RESPONSIBILITY

8-31-15

Stuart Clark, Town Creek Foundation
John Quinn, Constellation Energy
Co-Chairs, Steering Committee
Maryland Commission on Climate Change

Dear Stuart and John:

On behalf of Chesapeake Physicians for Social Responsibility (CPSR), I am pleased to offer the following input into the Climate Commission's November 2015 report to the Governor and the General Assembly. Our comments focus on recommendations specific to the General Assembly's reauthorization in 2016 of the Greenhouse Gas Reduction Act (GGRA) and on the Greenhouse Gas Reduction Act Plan.

These comments supplement the many comments, both verbal and written, already submitted by members of CPSR to the Climate Commission. Our comments address four areas: setting goals to reduce greenhouse gas emissions; promoting clean renewable energy; reducing energy usage; and building carbon sinks.

**1. Set Goals to Reduce Greenhouse Gas Emissions:** Avoiding the most severe outcomes of climate change will require that industrialized countries reduce their greenhouse gas emissions by between 80% and 95% by 2050. Because Maryland is one of the states most susceptible to climate change, Maryland should be at the forefront of efforts to reduce greenhouse gas emissions. Specifically, we recommend that a reauthorized GGRA should:

- Reaffirm the state's commitment to reduce greenhouse gas emissions 25 percent from a 2006 baseline by 2020.
- Include the Maryland Department of the Environment's tentative recommendation that the state establish a goal of 45% reductions by 2030.
- Set up a process and short timeline for the state to develop a 2050 goal for greenhouse gas reductions. The process should be based on the

**325 East 25th Street, Baltimore, MD 21218, ph. 240-246-4492, email: twhitehouse@psr.org**

principles of sound science, and it should afford the opportunity for all residents and communities to be involved in this effort.

**2. Promote Clean Renewable Energy:** In 2013, Maryland's coal-fired power plants accounted for 44% of the state's energy production, while together solar and wind accounted for only 1%. Coal-fired power plants harm the health of Maryland residents. They are responsible for a large portion of the state's greenhouse gas emissions, toxic air pollution, and NOx and $SO_2$ emissions. In addition to coal, Maryland also relies on other dirty energy sources, such as incineration and black liquor.

To increase the use of clean, renewable energy and reduce the use of dirty energy, which would in turn improve the health of Maryland residents, we recommend that the Commission ask the Governor and the General Assembly to:

- Phase out all state subsidies of power plants that use fossil and combustible fuels. This would include amending laws and regulations that create indirect subsidies, such as those that allow coal-fired power plants to operate in the state without modern pollution control technologies, and those that classify greenhouse gas emitting fuels, such as black liquor and incineration, as a tier one source of energy under the Renewable Portfolio Standard (RPS).

- Raise the RPS to 25% by 2020 and increase the solar carve out from 2% to 2.5%, and, as part of the process for developing a 2050 goal for greenhouse gas reductions, to develop long-term options for further strengthening of the RPS.

- Expand efforts to promote community solar programs, solar usage in K-12 schools, and solar projects that offset municipal energy usage. These programs are valuable educational tools and will likely have strong educational effects in the communities benefiting from these sources of energy.

- Support a long-term moratorium on unconventional natural gas development in Maryland to allow for a greater understanding of the climate and health risks posed by production, distribution and use this fossil fuel.

**3. Reduce Energy Usage:** Energy efficiency programs save money and create jobs. Using less energy will greatly reduce air pollution and improve public health. To build on the Maryland Public Service Commission's recent decision to require electric utilities to achieve specific annual energy reduction goals, we recommend the state:

- Continue to expand energy efficiency programs in state buildings and departments.

- Develop programs for installation of efficiency measures in multifamily dwellings and low-income communities.

- Maximize its use of the Clean Energy Incentive Program under the Clean Power Plan for efficiency programs in low-income housing.

**4. Build Carbon Sinks:** Soils with a rich diversity of microorganisms play a critical role in sequestering atmospheric carbon captured during photosynthesis. To take advantage of this, the state should develop a program to improve the ability of the state's soils to act as a carbon sink. This would be a win-win from a health perspective, as the steps required to build healthy soils, such as the elimination of pesticide use, would also enhance the quality and quantity of healthy foods available to Maryland residents.

Thank you for the opportunity to provide comments on the work of the Climate Commission.

Sincerely,

Tim Whitehouse
Executive Director

**325 East 25th Street, Baltimore, MD 21218, ph. 240-246-4492, email: twhitehouse@psr.org**

Gwen DuBois MD, MPH
1817 Sulgrave Ave
Baltimore, Maryland 21209
August 31, 2015

Co-Chairs, Steering Committee
Stuart Clark, Town Creek Foundation
John Quinn, Constellation Energy
Maryland Commission on Climate Change

Dear gentleman,

Speaking for myself, I would like to both endorse Maryland's efforts to reduce climate forcing and air polluting emissions by urging the reauthorization of the Greenhouse Gas Reduction Act. I also urge that policy be adjusted to weed out technologies that are labeled as green yet are in reality big polluters making some Marylanders sick and even shortening their lives. Current policy rewards and promotes what it designates as Tier 1 sources, even if they emit methane and other climate forcing gases. One egregious example, waste to energy incinerators, would not be competitive without this Tier 1 designation. Incinerators achieve none of the ends that we are all here to promote. What we incinerate, we have to remake. This is at odds with the zero waste concept of reuse, reduce and avoid materials that cause waste. It's emissions are toxic: cadmium, chromium arsenic and particulate matter and all cause lung cancer; dioxins are cancer causing and endocrine disrupters; lead and mercury are heavy metals that cause brain damage especially in the young, newborn and yet to be born; beryllium causes a sarcoidosis like condition; nitrogen oxides (nox) diminishes growth of lungs in children, leading to respiratory problems in adults. The trucks that deliver the waste emit nox and volatile organic compounds (voc), the very ingredients along with sunlight, that create ozone. Ozone increases the incidence of asthma in young active children, increases costly ER visits and respiratory mortality. We are already exceeding EPA emission levels in this state and are required to have a plan to reduce ozone not increase emissions. As an energy source, per kWh, incinerators produce more CO, mercury, lead, nitrogen oxides and co2 than even dirty coa. Sited in neighborhoods that are densely populated and already exposed to more than their share of high levels of air polluting industry, this is an important environmental justice issue .

Incineration is just one example of a dirty Tier1 technology. I urge you to advocate that the state adopt a clean Tier1 designation that leads to lower C02 ,methane, nitrous oxide,and other climate forcing gases and at the same time fewer air toxins and criteria pollutants. Whether from conventional gas or future fracking, incineration of hazardous wastes or chicken manure, we should not reward energy production unless it is clean.

Guided by environmental justice principals Maryland should adopt programs that allow low income families including renters to take advantage of cost saving energy efficiency incentives and to promote rooftop solar.

Reauthorizing the GreenHouse Gas Reduction Act for 2016 is crucial as is making sure our state energy policies promote a healthy planet and healthy people. hoals for 2030 should be pushed higher than 45% reductions and programs should be expanded to incorporate energy justice principals. Not only should we avoid polluting the environment in lower income neighborhoods we should adopt programs that allow renters and landlords to participate in cost saving programs that promote greenhouse gas reductions .

Gwen L. DuBois MD, MPH GDuBois MD,
Chesapeake Physicians for Social Responsibility
Public Health Committee of Med/chi, Medical Association of Maryland

The following page contains a list of excellent articles and studies about the health impacts of incinerators . The first reference is a report by the non-profit Environmental Integrity project is the source of data I used on comparative emissions per kWh..

PDF]Waste-To-Energy - Environmental Integrity Project
www.environmentalintegrity.org/.../FINALWTEINCINERATORREPORT-...
Oct 1, 2011 - The Environmental Integrity Project (EIP)
[

Dioxin Emissions from a Solid Waste Incinerator and Risk of Non-Hodgkin Lymphoma
Floret, Nathalie*; Mauny, Frédéric*; Challier, Bruno*; Arveux, Patrick†; Cahn, Jean-Yves‡; Viel, Jean-François*
Epidemiology:
July 2003 - Volume 14 - Issue 4 - pp 392-398
doi: 10.1097/01.ede.0000072107.90304.01
Study linked incidence of non-Hodgkin's lymphoma to areas around incinerators with the highest dioxin exposures. 1980-95 exposures vbased on modeling

Risk for non Hodgkin's lymphoma in the vicinity of French municipal solid waste incinerators.
Viel JF, Daniau C, Goria S, Fabre P, de Crouy-Chanel P, Sauleau EA, Empereur-Bissonnet P.
Environ Health. 2008 Oct 29;7:51. doi: 10.1186/1476-0

Sarcoma risk and dioxin emissions from incinerators and industrial plants: a population-based case-control study (Italy)Zambon P, Ricci P, Bovo E, Casula A, Gattolin M, Fiore AR, Chiosi F, Guzzinati S.
Environ Health. 2007 Jul 16;6:19.

Systematic review of epidemiological studies on health effects associated with management of solid waste.
Porta D, Milani S, Lazzarino AI, Perucci CA, Forastiere F.
Environ Health. 2009 Dec 23;8:60. doi: 10.1186/1476-069X-8-60. Review.

http://www.atsdr.cdc.gov/csem/csem.asp?csem=7&po=10

Environmental Exposure to Lead and Children's Intelligence at the Age of Seven Years — The Port Pirie Cohort Study
Peter A. Baghurst, Ph.D., Anthony J. McMichael, Ph.D., Neil R. Wigg, M.B., B.S., Graham V. Vimpani, Ph.D., Evelyn F. Robertson, M.B., Ch.B., Russell J. Roberts, M.Clin.Psych., and Shi-Lu Tong, M.P.H.
N Engl J Med 1992; 327:1279-1284October 29, 1992DOI: 10.1056/NEJM199210293271805

[PDF]The Health Effects of Waste Incinerators - British Society for ...
www.bsem.org.uk/uploads/IncineratorReport_v3.pdf
and about the risks of other pollutants released from incinerators.

IN Krivoshto ,The Toxicity of Diesel Exhaust: Implications for Primary Care Physicians;J Am Board Fam MedJan-February 2008 vol 21 no. 1. 55-62r - 2008
Primary care phyp ...

[

Gwen L. DuBois MD, MPH
1817 Sulgrave Ave
Baltimore, Maryland 21209
July 18, 2015

Maryland Commission on Climate Change
Dear Commissioners,

Renewable portfolio standards
My name is Dr. Gwen DuBois and as a member of Chesapeake Physicians for Social Responsibility but speaking for myself , I would like to both endorse Maryland's efforts to reduce climate forcing and air polluting emissions and urge that policy be adjusted to weed out technologies that are labeled as green yet are in reality big polluters , making some Marylanders sick and even shortening their lives.. Current policy rewards and promotes what it designates as Tier1sources, even if they emit methane and other climate forcing gases. One egregious example, waste to. energy incinerators, would not be competitive without this Tier 1 designation. Incinerators achieve none of the ends that we are all here to promote. What we incinerate, we have to remake. This is at odds zero waste concept of reuse, reduce and avoid materials that cause waste. It's emissions are toxic: cadmium, chromium arsenic and part matter all cause lung cancer; dioxins are cancer causing and endocrine disrupters; lead and mercury are heavy metals that cause brain damage especially in the young, newborn and yet to be born. Beryllium causes a sarcoidosis like condition and nitrogen oxides (nox) diminishes growth of lungs in children, leading to respiratory problems in adults. Trucks with their daily deliveries of local and imported trash, emit NOX and volatile organic compounds (voc), the very ingredients along with sunlights, that create ozone.. Ozone increases the incidence of asthma in young active children, increases costly ER visits and respiratory mortality. We are already exceeding EPA emission levels in this state and are required to have a plan to reduce ozone not increase emissions.As an energy source, per kWh, incinerators produce more CO, Mercury, , lead, NOX and co2 than even dirty coal.. Sited in neighborhoods that are densely populated and already exposed to more than their share of high levels of air polluting industry, this is an important environmental justice issue ..

Incineration is just one example of a dirty Tier1 technology. I urge you to find a way to clean up the Tier 1 designation so that it really leads to lower C02 ,methane, nitrous oxide,and other climate forcing gases and at the same time fewer air polluting toxins,and criteria pollutants.Whether from conventional gas or future fracking, incineration of hazardous wastes or chicken manure, we should not reward energy production unless it is clean.

Gwen L. DuBois MD, MPH
Chesapeake Physicians for Social Responsibility
Also member Public Health Committee of Med/chi, Medical Association of Maryland
and Crabshell Alliance

The following page contains a list of excellent articles and studies about the health impacts of incinerators . The first reference is a report by the non-profit Environmental Integrity project is the source of data I used on comparative emissions per kWh..

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Primary care phyp ...

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MARYLAND

[redacted]

# Fwd: Amended: Comment Submitted to Maryland Climate Commission Public Hearing

**CLIMATE CHANGE -MDE-** <climate.change@maryland.gov> Tue, Aug 18, 2015 at 2:49 PM
[redacted]

---------- Forwarded message ----------
From: **Hilary (Anon) K.** <hilarydc@yahoo.com>
Date: Thu, Aug 6, 2015 at 6:26 PM
Subject: Amended: Comment Submitted to Maryland Climate Commission Public Hearing
To: "climate.change@maryland.gov" <climate.change@maryland.gov>

In addition to the comment previously submitted, I support the Greenhouse Reduction Plan and call for a moratorium on building new fossil fuel burning power plants and phasing out all coal burning plants.
If Maryland builds no new fossil fuel burning power plants, and phases out all coal burning plants, Maryland will succeed in fulfilling the Greenhouse Gas Reduction Act Plan mandate to reduce CO2 twenty-five percent by 2020.
~~Hilary Kacser

---

**From:** Hilary (Anon) K. <hilarydc@yahoo.com>
**To:** "climate.change@maryland.gov" <climate.change@maryland.gov>
**Sent:** Thursday, August 6, 2015 6:19 PM
**Subject:** Comment Submitted to Maryland Climate Commission Public Hearing

I write to submit a public comment on the ways that Maryland can improve progress moving forward on the Greenhouse Gas Reduction Act plan for mitigating climate change and carbon pollution.

# 1 -- I oppose the two proposed new Gas Powered Electric Plants in Brandywine, MD.
# 2 -- Though its advocates present Natural Gas as a cleaner alternative, in truth Natural Gas is a dirty fossil fuel, worse so because much of it comes from fracking (hydraulic fracturing). Just today *Scientific American* published that "Shallow Fracking Wells May Threaten Aquifers."
# 3 -- Being called "renewable" energy, burning black liquor, biomass, trash, toxic landfill gases, etc., produces worse climate impact than the coal fired power whose pollution Maryland seeks to mitigate. Even though these CO2 emissions from incinerating biomass, trash, etc., are allowed to not be counted, these are false solutions, just like natural gas, and should not count toward compliance with the Greenhouse Gas Reduction Act. Maryland must make the heroic effort to close these loopholes.
# 4 -- Instead, I advocate more clean solar power and clean wind power generation plants. These truly renewable energy sources really are clean.

Natural Gas is NOT part of a climate solution, nor should reliance upon Natural Gas be part of the Maryland Greenhouse Gas Reduction Plan.

Sincerely,
~~Hilary Kacser

From: **June Eakin** <june.eakin@mac.com>
Date: Sun, Aug 23, 2015 at 10:42 PM
Subject: Renew and strengthen MD's plan to cut global warming pollution
To: climate.change@maryland.gov

To the Maryland Climate Commission:

I want to see Maryland take the strongest possible steps to reduce global warming pollution. We have a moral obligation to protect a livable future for children growing up today, and we have a huge economic opportunity to be a regional leader in solar, wind and energy efficiency. Help MD be the "little engine who could" to reduce greenhouse gases.

That's why I fully support renewing and extending the Greenhouse Gas Reduction Act. The current GGRA law has driven tremendous progress towards reducing emissions and growing the state's economy. Maryland should build on that progress and stay at the forefront of climate action by extending the law's mandate to 2030 and setting a greenhouse gas reduction target of 45% below 2006 levels by 2030, in line with other leading states.

I also want to see our state step up investments in clean, renewable energy now.

One of the top programs in the GGRA Plan is increasing the amount of clean, renewable electricity—like solar and wind power—that we use to power our homes and communities. We need to reach 25% clean electricity consumption by the year 2020 to ensure we meet our 2020 goal for reducing greenhouse gas emissions, as well as the longer-term goals that scientists say are necessary to avoid the worst impacts of climate change.

Ultimately, Maryland needs to do much more. The Climate Commission should look at the state programs that Maryland will need to strengthen now in order to continue reducing greenhouse gas emissions beyond 2020.

Sincerely,
June Eakin

June Eakin
13221 Glenhill Rd
Silver Spring, MD 20904

MARYLAND

[redacted]

# Fwd: Public input on Maryland's Climate Action Plan (in lieu of testifying at the Maryland Greenhouse Gas Reduction Plan Public Hearing)

**CLIMATE CHANGE -MDE-** <climate.change@maryland.gov> Mon, Jul 27, 2015 at 7:24 AM
[redacted]

---------- Forwarded message ----------
From: **Kristin Cook** <kristingamzoncook@gmail.com>
Date: Fri, Jul 24, 2015 at 11:45 AM
Subject: Public input on Maryland's Climate Action Plan (in lieu of testifying at the Maryland Greenhouse Gas Reduction Plan Public Hearing)
To: climate.change@maryland.gov

Dear Commission on Climate Change,

I regret that I am unable to make any of the public listening sessions but thought it important to put my comments in writing nonetheless.

I would like to focus on one main idea which is that Natural Gas is a fossil fuel that will move us backward in fighting climate change. Natural Gas and the process in which it is procured is DEVASTATING to our climate due to the potent greenhouse gas of methane* which makes up Natural Gas. Not to mention that fracking poisons our water when the chemicals are injected deep into the ground, fracking causes earthquakes**, fracking is water intensive, and studies are showing that cancer and stillborn deaths are on the rise near fracking sites***.

In order to achieve continued emissions reductions beyond 2020 and move towards the state's longer term goal of reducing emissions 90% by 2050, **the state must end its reliance on *all* fossil fuels, including natural gas**, and embrace energy efficiency and zero-carbon fuels like solar energy!

Maryland must stay committed to science-based cuts in pollution, and therefore must renew the Greenhouse Gas Reduction Act in 2016. Expanding Maryland's clean electricity standard to 25 percent by 2020 is the most straightforward way to achieve the emission reductions.

Thank you for listening,

Kristin Cook
9408 Jongroner Court
Potomac, MD 20854
240.483.6789

**The state should not rely on natural gas to meet its emissions reduction targets because natural gas is 80 to 98 percent **methane**, which is approximately **86 times as potent a greenhouse gas (GHG) as carbon dioxide** over a 20 year timeframe.*

***http://www.nytimes.com/2015/01/08/us/new-research-links-scores-of-earthquakes-to-fracking-wells-near-a-fault-in-ohio.html?_r=0*

****http://www.newsweek.com/2014/05/30/utah-boom-town-spike-infant-deaths-raises-questions-251605.html*


DANGER
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AREA

---------- Forwarded message ----------
From: **larry Carson** <karasov1@hotmail.com>
Date: Mon, Aug 24, 2015 at 2:04 PM
Subject: my comments on renewing the legislation
To: "climate.change@maryland.gov" <climate.change@maryland.gov>

To whom it may concern,

If Maryland's Greenhouse Gas reduction Act made sense in 2009, it surely makes even more sense now, when it must be renewed to survive. Every year there are more people living in Maryland and around the Chesapeake Bay, and thus more to fear from pollution of our atmosphere and our waters.

To me, developing a strong social culture for preserving our environment and helping our Bay is just common sense, but it is vitally important to us, our children and grandchildren.

Please renew this bill and strengthen it, to do more!

Larry Carson

Columbia, 410-381-6506

MARYLAND

[redacted]

# Fwd: Lost time

[redacted]

Wed, Jul 15, 2015 at 9:44 AM

---------- Forwarded message ----------
From: **CLIMATE CHANGE -MDE-** <climate.change@maryland.gov>
Date: Wednesday, July 15, 2015
Subject: Fwd: Lost time
[redacted]

---------- Forwarded message ----------
From: **Peggy Taliaferro** <sparksmct@aol.com>
Date: Thu, Jul 9, 2015 at 11:13 AM
Subject: Lost time
To: "climate.change@maryland.gov" <climate.change@maryland.gov>

We must support the MD Green House Gas Reduction Act. We have dragged our feet too long on this issue and must now get on with it for the sake of our State, Country and the world.

Margaret C Taliaferro

Sent from my iPad

[redacted]

MARYLAND
CLEAN ENERGY CENTER

July 14, 2015

Maryland Commission on Climate Change
Honorable Ben Grumbles, Chairman
Secretary of the Environment
Maryland Department of Environment
Office of the Secretary
1800 Washington Boulevard
Baltimore, Maryland 21230-1718

Ladies & Gentlemen:

On behalf of the Board of Directors of the Maryland Clean Energy Center, I want to thank you for the work you are leading to set the agenda for our state to address the potential impacts of Climate Change in a proactive manner.

The Maryland Clean Energy Center (MCEC) is an instrumentality of State that was created in 2008 by the General Assembly to advance the adoption and deployment of clean energy and energy efficiency technologies, products, and services as part of a broader economic development and job creation strategy. The work at MCEC is directly linked to goals established by policy makers in Maryland to reduce greenhouse gas emissions and consumer demand for energy, and to increase the deployment of renewable energy generation. Through its enabling statute, MCEC is uniquely positioned to leverage private sector investment in energy solutions that will allow Maryland to more effectively reach established and projected Greenhouse Gas Reduction Act Goals.

As you contemplate various strategies to be included in the Maryland Greenhouse Gas Reduction Act Plan, for 2016 and beyond, the Board would like you to consider the following:

- Cost, and potential economic impact is undoubtedly a key consideration for policy makers and consumers in choosing to adopt any strategies designed to reduce greenhouse gas emissions. The economic benefits of reduced greenhouse gas emissions (e.g. job creation, lower health care costs, and more affordable energy) should be among the relevant metrics tied to the strategies advanced by the plan.

- In order to drive consumer adoption and deployment of energy efficiency and renewable energy technologies and measures that will ultimately assist in reducing greenhouse gas emissions, it is imperative to create the market conditions for successful adoption and deployment. This includes supporting the development and commercialization of new technologies that can more readily help address and reduce the impacts of climate change.

- Public sector investment and spending in isolation cannot address the challenge of transitioning Maryland's energy economy. Consumers both commercial and residential are demanding further options for renewable energy generation, energy efficient buildings and homes, and alternative fuel vehicles. As a result, it is important that Maryland adopts policies that leverage greater public investments with private sector investments to meet growing demands for clean energy solutions.

1212 West Street, Suite 200 ● Annapolis, MD 21401 ● Phone: 443-949-8505 ● Fax: 443-949-8525 ● www.mdcleanenergy.org

- As a state participating in the Regional Greenhouse Gas Initiative (RGGI), Maryland is the recipient of an average $90 M per year in proceeds from the sale of allowances. These proceeds are directed to be spent in the following manner: 50% towards programs that provide low income utility rate relief, 40% towards deployment of renewable energy and energy efficiency measures, and 10% dedicated to fund administration.

As the Maryland Commission on Climate Change proceeds to draft the updated Climate Action Plan, MCEC humbly requests that the following recommendations be included in the agenda:

- In addition to the economic metrics currently measured, Maryland should include the following additional metrics: early stage and venture capital investment in clean energy technologies, job creation associated with those capital investments, reduced healthcare costs, and tracking business losses as a result of climate change impacts such as sea level rise and extreme weather events.

- Maryland should direct a portion of the RGGI proceeds to be invested in clean energy finance mechanisms (e.g. "green bank") to be managed through the Maryland Clean Energy Center. These mechanisms will help attract greater private sector capital investments into Maryland's energy economy. The mechanisms would encourage bank investors to finance solutions for low income stakeholders and entrepreneurs, which otherwise might not have access to capital.

- Maryland should also direct a portion of the RGGI proceeds to support the ongoing operation of the Maryland Home Energy Loan Program managed by the Maryland Clean Energy Center. Since its inception the program has allowed over 2,600 residential property owners to make energy efficiency improvements on their homes and save over 19 million kWhs of energy that would otherwise be in demand.

- Maryland should investigate ways to reduce the amount of RGGI funds spent on rate payer utility bill payment assistance and consider deploying energy efficiency measures and renewable energy generation systems to assist consumers. Especially for those consumers who own and reside in their homes, and are chronically dependent on the relief funding, to be able to reduce their bills to an affordable level.

- Maryland should better coordinate its public and private sector energy and environmental resources and capabilities (e.g. MDE, DBED, TEDCO, University System of Maryland, John Hopkins University, and the Maryland Clean Energy Center) to support validation and commercialization of clean tech innovation. Working alongside private sector stakeholders, this coordination will stimulate job creation and investment in clean technology solutions in Maryland.

Thank you for the opportunity to contribute input through the plan development process. MCEC staff and our esteemed Board members stand ready to assist in any way deemed valuable by the Commission. Our offices can be reached by phone at 443-949-8505 or by email at info@mdcleanenergy.org for your convenience. Please contact my office directly if you require an immediate response.

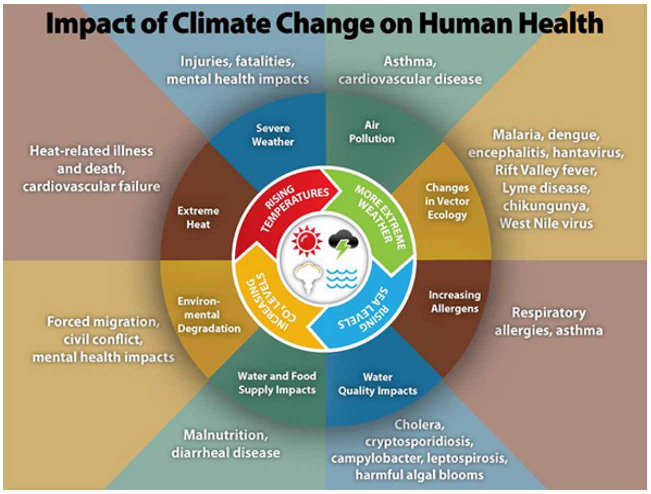
Best regards,

I. Katherine Magruder

I. Katherine Magruder
Executive Director

# Considerations: Health & Climate Change

*July 2015 - Prepared by Allison Rich - Maryland Environmental Health Network www.MdEHN.org*




**Threat**: "Climate change – caused by carbon pollution – is one of the most significant public health threats of our time," EPA Administrator Gina McCarthy, 09/20/2013

**Opportunity**: Through common-sense measures to cut carbon pollution, we can protect the health of our Nation, while stimulating the economy and helping to prevent the worst impacts of climate change. [i] Renewing the Greenhouse Gas Reduction Act is one such common-sense measure.

## Vulnerable Populations will suffer the greatest health burdens

### Children, the elderly, and people already suffering illness in Maryland

- Climate change will put vulnerable populations at greater risk – including:
  - Children, who breathe more air relative to their size than adults, are at higher risk of worsened asthma and respiratory symptoms from air pollution and severe weather or illness following severe weather
  - Older adults, especially those with pre-existing health conditions, are at a high risk of cardiac and respiratory impacts of air pollution or illness following serve weather
  - People already suffering from allergies, asthma, weak immune systems, and other illnesses are more susceptible to experiencing health impacts related to climate change
  - Communities burdened with higher rates of diabetes, obesity, or asthma may be at greater risk of climate-related health impacts

## Air pollution caused by greenhouse gas emissions are hazardous to health

### Ground-Level Ozone

- Tropospheric, or ground-level ozone, is formed by chemical reactions between greenhouse gases in the presence of sunlight. (This is not to be confused with stratospheric ozone, which protects us from harmful UV rays from the sun.)
- Exposure to ground-level ozone inhibits lung function and is anticipated to cause:
  - 1,000 to 4,300 additional premature deaths nationally per year by 2050 [ii]
  - 2.8 million more instances of acute respiratory symptoms such as asthma attacks, shortness of breath, coughing, wheezing, and chest tightness, by 2020
  - 24,000 more seniors and 5,700 more infants hospitalized for respiratory related problems, by 2050 [iii]

## Severe weather will increase the need for and disrupt health care services

### Extreme Heat Events

- Extreme heat events are expected to become more frequent and severe due to climate change and will have implications for health care services including:

  - Health services utilization, disruption to the healthcare delivery system, and quality of patient care during disasters [i]
  - Increase in hospital visits for cardiovascular, respiratory, cerebrovascular diseases, mental health problems, mortality, injury, and illness
- Extreme heat exposure from climate change can be deadly:
  - During June 30–July 13, 2012, maximum daily temperatures in Maryland, Ohio, Virginia, and West Virginia averaged is 9.5°F warmer than normal. 12 Maryland residents died during this period due to excessive heat exposure [v]
  - Severe weather will also include flooding, droughts, storms, and fires that impact healthcare services as well as long term health concerns

## Population health status does not return after severe weather events:

- A study of Hurricane Katrina measured health impacts a year after the hurricane and found an increase in disease prevalence, increased health burden directly associated with disruption from Hurricane Katrina, and the adverse effect on morbidity was strongest for nonwhite subjects[vi]

## Sea level rise, heavy rainfall, and storm surges will increase will disrupt communities and increase water borne disease and disrupt communities

- ### Sea Level Rise
  - Rising seas and eroding shorelines displace coastal communities
  - Sea level rise and storm surge threatens drinking water supplies and agricultural fields with salt-water intrusion
  - Potential changes in exposure to diseases

- ### Flooding and Heavy Rainfall

The frequency of heavy precipitation events has already increased for the nation as a whole (75% increase for the Northeast), and is projected to continue increasing. With nearly 3,000 miles in coastline, Maryland is vulnerable to health concerns from flooding including:

  - Failure of septic systems - Waterborne diseases contaminating drinking water
  - Sewage back-up in plumbing or basements
  - Floodwater containing toxins, bacteria, and sewage, can contaminate drinking water, vegetables growing in fields or gardens, and recreational water sources
  - Water intrusion in buildings, worsening indoor air quality and/or causing toxic mold to grow in ceilings, walls, or insulation [vii]
- Between 2007-2013, Baltimore had on average 13.1 nuisance flood days per year, while Annapolis had 39. Annapolis and Baltimore have the highest increase in number of flood days in the nation [viii]

## Allergens related to pollen will increase:

- The length of the ragweed pollen season has increased in parts of the US by 11-27 days because of rising temperatures. As the climate warms more pollen is produced and pollen season lengthens, there will be an increase in health problems related to allergens:
  - Increases in the symptoms of seasonal allergies
  - Pollen triggers asthma attacks, leading to more ER and hospital visits

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[i] The Health Impacts of Climate Change on Americans The White House, 6 / 2014
[ii] "Climate Effects on Health – Air Pollution" Centers for Disease Control, 12/11/2014
[iii] Climate Change and Your Health: Rising Temperatures, Worsening Ozone Pollution Union of Concerned Scientists, 2011
[iv] "Heat-Related Deaths After an Extreme Heat Event — Four States" Centers for Disease Control, 2013
[v] Health of Medicare Advantage Plan Enrollees at 1 Year After Hurricane Katrina, Burton, et all., The American Journal of Managed Care Vol. 15 No. 1, 01/ 2009
[vi] Climate Change Impacts in the United States U.S. Global Change Research Program, 2014
[vii] Sea Level Rise and Nuisance Flood Frequency Changes around the United States, National Oceanic and Atmospheric Association, July 2014

Maryland Motor Truck Association

Good stuff. TRUCKS BRING IT

August 21, 2015

ARMA
AUG 24 2015
DIRECTOR'S OFFICE

George Aburn, Jr.
Director, Air & Radiation Management Administration
Maryland Department of the Environment
Montgomery Park Business Center
1800 Washington Blvd.
Baltimore, MD 21230

Dear Mr. Aburn:

As the Maryland Commission on Climate Change is developing its reports this fall, I am writing to discourage the Commission from including specific policy recommendations in its final reports given that impact of many of the policy options being considered have not been thoroughly evaluated. One such example that would greatly impact the trucking industry is the establishment of a vehicle miles traveled (VMT) tax.

Those who support a VMT do so typically with two goals: 1) to further fund road construction projects; and 2) to discourage people from driving. Neither of these goals are achieved through a VMT.

*To further fund road construction projects* – a funding source must be reliable and enforceable. The fuel tax has performed well as a funding source in large part because government collects it up-front from very few taxpayers. Both state and federal fuel taxes are collected from fuel suppliers, who pass the tax down the chain of distribution. At most, there are only a few hundred suppliers per state, they are mostly large entities, and government knows who and where they are. As a result, the fuel tax is easy and cheap to collect, and hard to evade.

A weight-distance tax, the closest thing to a VMT in this country, is widely evaded. A weight-distance tax is not subject to withholding, and government must try to collect it from a multitude of taxpayers, most of them small. Currently only four states have weight-distance taxes, with over 20 states having repealed them because they are difficult to collect and easy to evade. Estimates of evasion range up to 50%. Subsequently a VMT would have to be collected from *millions* of taxpayers – all those driving cars in the taxing jurisdiction. MMTA cannot imagine such a tax being collected successfully, let alone efficiently.

VMT proponents claim that modern technology can reduce the cost of evasion through the use of on-board recorders to compile mileage and location date. Requiring "black boxes" in private vehicles raises serious questions of the efficiency and intrusiveness of a VMT. How much would the chosen technology cost? Would drivers require training to use it? Would it be accurate and reliable? Could it be cheated readily? If the tax were imposed at the state level, what about drivers coming in from other states? The traditional fuel tax is an inexpensive tax to administer; a VMT would not be.

*To discourage people from driving* – the second reason many advocate for a VMT is a belief that it would reduce vehicle emissions by discouraging people from driving. There is no verifiable evidence to support

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SERVING MARYLAND'S TRUCKING INDUSTRY

this claim and, even if it was demonstrated, the impacts are limited only to those who have a choice about driving (e.g. passenger car drivers). That choice does not exist for the trucking industry.

Trucking is a non-discretionary user of the state's highways. Trucks are the hub of Maryland's distribution wheel, playing a vital role in the state's economic development as they support the manufacturing, agricultural, and retail industries. Maryland's trucking industry employs over 104,000 people. 93% of our communities are solely dependent on trucks for their goods, meaning citizens have no other way to get the food, furniture, fuel, medicine and other products they need. Discouraging the movement of freight through a VMT tax is not a good idea for economic growth.

A VMT tax may sound fair on the surface — make every driver pay — but that is only if you focus on miles traveled. Concerns about global warming should be addressed by encouraging the development of more efficient vehicles. It is pollution, not traveling, that is the concern. In June 2015 the Obama administration recognized this and announced a new plan to further improve fuel efficiency and reduce greenhouse gas emissions from medium and large trucks. This is the second wave of standards focusing on these vehicles and builds on fuel efficiency and carbon pollution standards already being implemented for model years 2014-2018.

I appreciate your consideration as the Maryland Commission on Climate Change continues its work.

Sincerely,

Louis Campion
President & CEO

cc: Pete Rahn, Secretary, Maryland Department of Transportation

**About Maryland Motor Truck Association:** Maryland Motor Truck Association is a non-profit trade association that has represented the trucking industry since 1935. In service to its 1,000+ members, MMTA is committed to supporting and advocating for a safe, efficient and profitable trucking industry across all sectors and industry types, regardless of size, domicile or type of operation.

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CHOPTANK RIVERKEEPER®

midshoreriverkeeper.org
info@midshoreriverkeeper.org

July 16, 2015

Attention: Maryland's Commission on Climate Change

Subject: Renewal of Maryland's Greenhouse Gas Reduction Act

Dear Sir or Madam:

My name is Matthew Pluta and I am submitting this comment as the Choptank Riverkeeper. This comment focuses on the continued efforts needed in Maryland to cut greenhouse gas emissions in order to reduce the impacts from climate change.

With more than 3,000 miles of tidal shoreline, Maryland is the third most vulnerable state to sea level rise - a major consequence of climate change. In addition to rising sea levels, Maryland's climate has become wetter and warmer, resulting in more runoff and more nutrients reaching our waterways. These two consequences have the ability to significantly impact the human habitat and aquatic ecosystems that greatly impact Maryland's economic, recreational and cultural livelihood.

Shorelines of the Chesapeake Bay and its major tributaries are areas of high density that continue to grow as the population increases and more people move to the Chesapeake region. In order to plan for population growth and the negative impacts of water encroaching on these communities, local governments need to be equipped with the tools necessary to build more resilient infrastructure and utilities before our people are run out of their homes, towns, and cities. These tools include better technology used for mapping and modeling, research focused on hardened structures and natural coastal barriers, and the ability to make sound management decisions through policy.

As our waters receive more nutrients from runoff, we will continue to see degradation in our water quality and aquatic ecosystems. Marylanders have always been dependent on the abundance of aquatic resources. As nutrient levels increase, so does the abundance of potentially toxic algae – a public health concern for human contact and water consumption. Commercial fishing industries continue to diminish as high levels of nutrients create hot spots in the water, resulting in low levels of dissolved oxygen and poor conditions for the survival of aquatic organisms.

As an advocate for the rivers and the Bay, I feel it's important that Maryland continues to raise the bar in terms of cutting greenhouse gas emissions. If Maryland doesn't strive to be leader in reducing its dependencies on fossil fuels and gas emissions, then the other Chesapeake Bay states won't be as likely to do so either. It's important that beyond 2016 the state of Maryland continues to focus on aggressive measures needed to protect the people of Maryland and water quality in the Chesapeake Bay.

Sincerely,

Matthew Pluta
Choptank Riverkeeper

Consideration of Items for Inclusion in the MCCC / MDE Reports
*Email from Stuart Clarke, Monday July 20, 2015*

## Maryland Department of Transportation (MDOT) Responses August 24, 2015

### 1. **Goal Setting**

Do you believe that the MDE report and/or the Commission report should include a recommendation that the GHG reduction goal be expanded and extended and, if so to what and why?

**MDOT RESPONSE:**

MDOT feels it is premature to include an expanded or extended greenhouse gas reduction goal in the October 2015 update to the 2013 Greenhouse Gas Reduction Act (GGRA) Plan or the November 2015 Maryland Commission on Climate Change (MCCC) Report.

Before Maryland commits to any future goals, the Scientific and Technical Working Group (STWG) and the Mitigation Working Group (MWG) should establish a common understanding, by sector, of business-as-usual (BAU) emission trends and/or optional realistic emission scenarios in Maryland through potential goal years (2030 and/or 2050). This understanding will help inform a responsible discussion of future goal setting based on our best understanding of economic, social, and technology trends and how they will impact emissions. For the transportation sector, this is particularly relevant, as metropolitan planning organizations (MPOs) have recently developed or are developing long-range transportation plans and associated economic and land use forecasts through 2040. At a minimum the outcomes of these plans should be considered in any goal setting exercise.

---

### 2. **Accounting**

Have you any specific concerns, suggestions, or recommendations about accounting – how to better measure and track greenhouse gas emissions reductions?

**MDOT RESPONSE:**

MDOT recommends that accounting and tracking take place no more frequently than on an annual basis.

Quarterly or monthly tracking in the transportation sector is an inefficient way to manage resources. MDOT has already established more effective, annual tracking mechanisms, which cover many, if not all, of the transportation sector policies outlined in the GRRA Plan.

MDOT's Attainment Report (AR) serves as an annual, statewide report on "Transportation System Performance" exploring how MDOT and its modal agencies have worked together in the past year, including project and program completions and successes, and assessing progress towards achieving goals and objectives of the Maryland Transportation Plan (MTP), including environmental stewardship.

3. **Program Implementation and Performance**

a. Are there specific GGRP programs that you believe should be discontinued and, if so, which ones and why?
b. Are there specific GGRP programs whose implementation and performance need to be improved and if so, which are they, what do you see to be the implementation and performance deficiencies, and what steps do you think need to be taken in order to achieve improvements?
c. Are there new programs that need to be explored and/or initiated and, if so, what are they, and why would they be important?

**MDOT RESPONSE:**

a. The federal government (FHWA and EPA) have concurred in asking the State of Maryland to keep GHG reduction efforts separate from the federally required transportation conformity process. As such, the enhancement option under policy ID H.1, Evaluating the GHG Emissions Impact of Major New Transportation Projects, should be removed. The enhancement states that the policy itself is "*envisioned as a first step toward a more robust federal conformity process for GHG emissions that would eventually tie the allocation of State and federal transportation funding to demonstrated progress toward the long-term GHG emission targets.*"

b. It is difficult to completely segment the GHG emission impacts of smart growth and land use/location efficiency (policy ID P.1) and the benefits of the funded Maryland transportation plans and programs, which include assumptions on future locality land use and development. As a result there are likely some overlaps in GHG emissions accounting that have not completely been accounted for. Through 2020, the overlaps are anticipated to be negligible, as the time required to achieve extensive change in growth patterns toward smart growth that would move the needle on VMT is well beyond 2020. For long-range analysis through and beyond 2030, the interaction between land use policies and VMT reduction strategies become a more critical part of GHG planning. MDOT recommends enhanced coordination with MDP on this topic and possibly a reconsideration of the organization of the land use policy options related to VMT reduction strategies.

c. There is some discrepancy regarding the reporting of the Maryland Clean Car Program. While it was, without a doubt, an innovative program at the time of its implementation, large portions of the program have been met or exceeded by new federal standards. There is only a small portion of the program's ZEV mandate and 2011 emissions benefits that can be attributed to efforts outside of the federal programs regulating average fuel economy from 2012-2025. A breakdown of the actual emissions benefits are included in Table 1.

**Table 1: Light Duty Vehicle (LDV) and Fuel Program Emission Benefits**

| Fuel Programs / Vehicle Standards (LDVs) | Emissions Benefits ($mmtCO_2e$) |
|---|---|
| **Tier 3 (fuels only)** | 0.002 |
| **Maryland Clean Car** | 0.001 |
| **2007-2025 National Standards** | 5.061 |
| **Total** | 5.064 |

There are no greater benefits in the transportation sector than those obtained from the increased fuel efficiency of the motor vehicle fleet. In fact, as the vehicles become cleaner, the impact that VMT reduction can have on GHG emissions becomes smaller. For example, in 2006, a 1.84 billion VMT reduction was required to reduce GHG emissions by 1 $mmtCO_2e$. Due to the impact of technologies on the more fuel efficient vehicle fleet, in 2020 a 2.12 billion reduction in VMT will be required to achieve the same result, a 1 $mmtCO_2e$ reduction. This trend will only accelerate beyond 2020 as more efficient vehicles and zero-emission vehicles (ZEV) hit the market.

As a result, MDOT recommends a restructuring of the transportation sector policies as illustrated in Table 2. This reorganization will help to better communicate and track the benefits of transportation technologies, i.e. the focus will be on the fleet not on the regulations.

## Table 2: Suggested Reorganization of Maryland Transportation Sector Policies in the GGRP

| NEW GGRP Policy ID | NEW GGRP Policy Name | Former GGRP Policy ID | Notes |
|---|---|---|---|
| E. | Transportation Technologies and Fuels | E. | |
| E.1 | ***Federal Vehicle and Fuel Standards*** | E.1.B-E.1.D | Transportation technologies were formerly categorized by specific vehicle emission standards, for example, Maryland Clean Car or CAFE. MDOT Suggests that it might be beneficial to structure on-road technologies standards by vehicle type (LDV or HDV). |
| E.1.A | Light Duty Vehicles (LDVs) | E.1.A / E.1.B | |
| E.1.B | Heavy-Duty Vehicles (HDVs) | E.1.C | |
| E.1.C | Renewable Fuel Standards | E.1.D | |
| E.1.D | Tier 3 Fuels | E.1.A / E.1.B | |
| E.2 | ***Maryland Clean Car*** | E.1.A | |
| E.2.A | Electric & Low Emitting Vehicle Initiatives | E.3 | |
| E.3 | ***Airport Initiatives*** | E.2.B | |
| E.4 | ***Port Initiatives*** | E.2.C | |
| E.5 | ***Freight & Freight Rail Programs*** | E.2.D | Should include improvements to the rail and freight system, e.g. capacity improvements or general system improvements. It should also include any truck or rail-related technologies (APUs, TSE, etc.) |
| F. | Maryland Transportation Plans & Programs / Initiatives | F. | Should include any new initiatives and the impacts of the transportation plans and programs which were formerly included at the end of the GGRP emissions summary as a "forecasted VMT related reduction." |
| **F.1** | ***Public Transportation Initiatives*** | F.1 | |
| **F.2** | ***Travel Demand Management (TDM) Strategies*** | E.2.A / F.1 / G. | These strategies were found under transportation technologies, pricing and public transportation. MDOT suggests that these strategies comprise their own policy group. |
| **F.3** | ***Intercity Transportation Initiatives*** | F.2 | |
| **F.4** | ***Bike & Pedestrian Initiatives*** | H.2 | |
| **F.5** | ***Pricing Initiatives*** | G. | Formerly included park and ride lots and Commuter Connections - those should be placed under TDM strategies in the future. |
| G | Other Innovative Transportation Strategies / Programs | H. | MDOT suggests deleting this category. |
| **G.1** | ***Evaluate the GHG Impacts of Major Transportation Projects*** | H.1 | DELETE |

## 4. **Economic Impact and Cost Benefit Analysis**

a. Is the existing methodology for assessing the GGRP's economic impact adequate and, if not, how does it need to be changed?
b. Are there important ***costs*** associated with GGRP implementation that are not being adequately conceptualized and accounted for, and that you believe should be incorporated into the GGRP rubric?
c. Are there important ***benefits*** associated with GGRP implementation that are not being adequately conceptualized and accounted for, and that you believe should be incorporated into the GGRP rubric?

**MDOT RESPONSE:**

a-c. More explanation within the GGRP regarding the logic behind the job creation and product outputs is needed, particularly in cases where the economic impact analysis shows negative results for a specific GGRP policy. It would also be valuable to develop a baseline(s) for jobs and any other economic benefits. The baseline(s) could be used to provide perspective on the magnitude of any forecast benefits.

In the economic analysis conducted in 2012/2013, MDOT worked with RESI to establish an assumption that only 25% of the total CTP costs associated with GHG beneficial projects would be input into the economic analysis. MDOT is still comfortable with this assumption. However, MDOT would like to explore the option with RESI/MDE of running the economic analysis using the total costs and then consider how to breakdown the economic outputs associated with GHG reducing projects after the analysis is complete.

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## 5. **Communications and Planning**

The MDE and Commission reports constitute important opportunities to frame Maryland's climate change planning and programming, and to establish an agenda for how that planning and programming should evolve over time. In this regard:

a. Are there key points that these reports should make in the way that they frame and communicate the GHG reduction challenge and opportunity?
b. Are there specific strategies and approaches that the reports should highlight as the most important ***next steps*** in the evolution of Maryland's climate change planning and programming?

**MDOT RESPONSE:**

a. Key points should include the fact that each sector has strengths and weaknesses in terms of achieving emissions reductions. The MCCC should be wary of generalizations that claim that certain sectors outperform others. That line of thought might lead the state away from the development and implementation of the most cost-effective GHG emission reduction strategies. The report should also highlight the fact that existing policies are making a difference and are also achieving co-benefits.

b. The most important strategies and approaches to highlight are those that provide the most efficient and cost-effective means of GHG emissions reductions. All of the strategies should be well-reasoned and, to the extent possible, quantified in terms of emissions benefits, the cost of implementation and the economic benefits of implementation. Those strategies that are analyzed as being the easiest to implement and the most cost-effective should be highlighted.

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NATIONAL WILDLIFE FEDERATION

**Mid-Atlantic Regional Center**

706 Giddings Avenue, Suite 1B ■ Annapolis, MD 21401 ■ www.nwf.org/Mid-Atlantic

August 25, 2015

Maryland Commission on Climate Change
Maryland Department of Environment
1800 Washington Boulevard
Baltimore, MD 21230-1720
climate.change@maryland.gov

Dear Maryland Commission on Climate Change;

Please accept the included comments on Maryland's Greenhouse Gas Reduction Plan from National Wildlife Federation's Maryland members and supporters.

Thank you,

Hilary Falk
Executive Director, Mid-Atlantic Regional Center
National Wildlife Federation

Dear Maryland Commission on Climate Change,

With more than 3,000 miles of tidal shoreline, Maryland is one of the most vulnerable states to sea level rise, driven by climate change. Already many of the Chesapeake Bay's coastal marshes and small islands have been inundated. As a result of rising sea levels due to melting of ice caps and warming waters, coastal marshes are drowning, threatening important habitat for many species.

The Greenhouse Gas Reduction Act (GGRA) is the legal framework that drives Maryland's carbon reducing efforts. We need to renew it in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change. We need to put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050. One of the top programs in the GGRA Plan is increasing the amount of clean, renewable energy--like solar and wind power--that we use to power our homes and communities. We should increase the energy to come from renewable sources to 25% by 2020.

Please submit a report to the General Assembly that compels them to renew the Act and fortify the plan and associated programs so we can reap the benefits in 2020 and beyond.

Sincerely,

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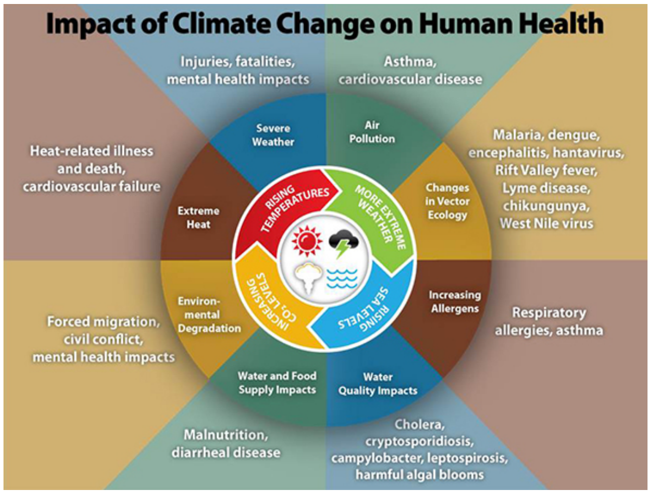
| James | Togashi | 3959 Wendy Ct | Silver Spring | MD | 20906-5270 |
| Ferold | Torchenot | 7080Cradlerock way | Columbia | MD | 21045 |
| Jason | Tyler | 47 E Montgomery St | Baltimore | MD | 21230-3808 |
| Susan | Valiga | 1616 Marshall Ave | Rockville | MD | 20851-1453 |
| Colleen | Van Buskirk | 42490 Wilderness Rd | Leonardtown | MD | 20650-3618 |
| Sara | Via | 4811 Manor Ln | Ellicott City | MD | 21042-6119 |
| Peter | Vida | 1342 Brook Rd | Catonsville | MD | 21228-5703 |
| MERRILL | WEINRICH | 8809 Cunningham Dr | Berwyn Heights | MD | 20740-2311 |
| Deborah | Wagner | 198 Market St | Brookeville | MD | 20833-2522 |
| Libby | Waite | 2912 Weisman Rd | Silver Spring | MD | 20902-2142 |
| Ellen | Walderman-Blazucki | 2425 Chetwood Cir | Timonium | MD | 21093-2533 |
| Kelley | Waller | 4208 Red Cedar Ln | Burtonsville | MD | 20866-1165 |
| Russell | Waller | 4208 Red Cedar Ln | Burtonsville | MD | 20866-1165 |
| Susan | Ward | 5916 Broad Run Rd | Jefferson | MD | 21755-9113 |
| P. D. | Waterworth | 10001 Old Franklin Ave | Lanham | MD | 20706-2319 |
| Derek | Watkins | 205 Pauline Ct | Arnold | MD | 21012-1168 |
| Joe | Weaver | 10800 Anderson Dr | Williamsport | MD | 21795-1301 |
| Glen | Webb | 4700 Centennial Ln | Ellicott City | MD | 21042-6312 |

| | | | | | |
|---|---|---|---|---|---|
| Brenda | Weber | 9125 Dunloggin Rd | Ellicott City | MD | 21042-5248 |
| Caitlin | Welsh | 13271 Styer Ct | Highland | MD | 20777-9754 |
| Susan | Whalen | 12523 Milestone Manor Ln | Germantown | MD | 20876-5901 |
| Janet | Wheatley | 102 Richardson Dr | Cambridge | MD | 21613-1130 |
| Robbie | White | 1401 Billman Ln | Silver Spring | MD | 20902-1413 |
| April | Wielgosz | 646 Echo Cove Dr | Crownsville | MD | 21032-1058 |
| Cheryl | Wilhelm | 332 Stonewall Rd | Baltimore | MD | 21228-5448 |
| Ellen | Wilhite | 5225 Pooks Hill Rd Apt 1106n | Bethesda | MD | 20814-2044 |
| Elizabeth | Williams | 114 Somerset Ave | Cambridge | MD | 21613-1206 |
| Mark | Willis | No mail please | Kensington | MD | 20895 |
| Toni | Willis | 7644 Allendale Cir | Hyattsville | MD | 20785-4101 |
| Frank | Wilsey | 2702 Whitney Ave | Baltimore | MD | 21215-4149 |
| Jordann | Wine | 8500 Meadowlark Ln | Bethesda | MD | 20817-2921 |
| Cheryl | Woerner | 1310 Jewell Rd | Dunkirk | MD | 20754-9577 |
| Claire | Wolfe | 14305 Long Channel Dr | Germantown | MD | 20874-5413 |
| Stacey | Wolfe | 8225 Bodkin Ave | Lake Shore | MD | 21122-4752 |
| Jane | Woltereck | 13600 Royal Crest Rd | Phoenix | MD | 21131-1526 |
| Laurie | Wright | 224 Embleton Rd | Owings Mills | MD | 21117-1727 |
| Tammy | Wright | 3010 Crain Hwy | Waldorf | MD | 20601-2801 |
| Calvin | Wyne | 3515 Baptist Church Rd | Nanjemoy | MD | 20662-3467 |
| Allen | Yun | 1613 Auburn Ave | Rockville | MD | 20850-1143 |
| Ellen | Zaccagnino | 13120 Wonderland Way | Germantown | MD | 20874-6808 |
| Miyako | Zeng | 7370 Hilltop Dr | Frederick | MD | 21702-3602 |
| james | balder | 2124 Freeland Rd | Freeland | MD | 21053-9587 |
| kathy | bovello | 4515 Willard Ave | Chevy Chase | MD | 20815-3622 |
| renee | burgan | 913 Mulberry Ave | Hagerstown | MD | 21742-3958 |
| susan | burket | 2321 Quebec School Rd | Middletown | MD | 21769-7102 |
| aimee | coogan | 16960 Oakmont Ave | Gaithersburg | MD | 20877-4127 |
| Matthew | durbin | 17423 Lappans Rd | Fairplay | MD | 21733-1100 |
| stuart | fishelman | 823 E Belvedere Ave | Baltimore | MD | 21212-3723 |
| april | garcia | 17124 Downing St | Gaithersburg | MD | 20877-3633 |
| cynthia | hallsmith | PO Box 31 | Upperco | MD | 21155-0031 |
| andrew | hargosh | 79 Linden St | Frostburg | MD | 21532-2116 |
| kelvin | hobson | 4 Crosswall Ct | Nottingham | MD | 21236-2610 |
| steven | hoffman | 8528 Park Heights Ave | Baltimore | MD | 21208-1717 |
| pam | longenecker | 1211a Marda Ln | Annapolis | MD | 21403-1706 |
| suzanne | mead | 30 Capetown Rd | Ocean Pines | MD | 21811-1602 |
| dev | menon | 22141 Fair Garden Ln | Clarksburg | MD | 20871-4028 |
| Lisa | meyerhardt | 600 Jasper St | Baltimore | MD | 21201-1916 |
| eric | nylen | 4800 Auburn Ave | Bethesda | MD | 20814-4048 |
| sylvia | ramsey | 6325 Tamar Dr | Columbia | MD | 21045-4212 |
| michelle | rayner | 2604 Erdman Ave | Baltimore | MD | 21213-1126 |
| Sam | river | 5 Bay Tree Ln | Bethesda | MD | 20816-1046 |
| christine | shenot | 183 Doncaster Rd | Arnold | MD | 21012-1040 |
| marian | soriano | 9 Dumbarton Ct | Annapolis | MD | 21403-3406 |

# Considerations: Health & Climate Change

*July 2015 - Prepared by Allison Rich - Maryland Environmental Health Network www.MdEHN.org*




**Threat**: "Climate change – caused by carbon pollution – is one of the most significant public health threats of our time," EPA Administrator Gina McCarthy, 09/20/2013

**Opportunity**: Through common-sense measures to cut carbon pollution, we can protect the health of our Nation, while stimulating the economy and helping to prevent the worst impacts of climate change. [i] Renewing the Greenhouse Gas Reduction Act is one such common-sense measure.

## Vulnerable Populations will suffer the greatest health burdens

### Children, the elderly, and people already suffering illness in Maryland

- Climate change will put vulnerable populations at greater risk – including:
  - Children, who breathe more air relative to their size than adults, are at higher risk of worsened asthma and respiratory symptoms from air pollution and severe weather or illness following severe weather
  - Older adults, especially those with pre-existing health conditions, are at a high risk of cardiac and respiratory impacts of air pollution or illness following serve weather
  - People already suffering from allergies, asthma, weak immune systems, and other illnesses are more susceptible to experiencing health impacts related to climate change
  - Communities burdened with higher rates of diabetes, obesity, or asthma may be at greater risk of climate-related health impacts

## Air pollution caused by greenhouse gas emissions are hazardous to health

### Ground-Level Ozone

- Tropospheric, or ground-level ozone, is formed by chemical reactions between greenhouse gases in the presence of sunlight. (This is not to be confused with stratospheric ozone, which protects us from harmful UV rays from the sun.)
- Exposure to ground-level ozone inhibits lung function and is anticipated to cause:
  - 1,000 to 4,300 additional premature deaths nationally per year by 2050 [ii]
  - 2.8 million more instances of acute respiratory symptoms such as asthma attacks, shortness of breath, coughing, wheezing, and chest tightness, by 2020
  - 24,000 more seniors and 5,700 more infants hospitalized for respiratory related problems, by 2050 [iii]

## Severe weather will increase the need for and disrupt health care services

### Extreme Heat Events

- Extreme heat events are expected to become more frequent and severe due to climate change and will have implications for health care services including:

- Health services utilization, disruption to the healthcare delivery system, and quality of patient care during disasters [i]
- Increase in hospital visits for cardiovascular, respiratory, cerebrovascular diseases, mental health problems, mortality, injury, and illness

- Extreme heat exposure from climate change can be deadly:
  - During June 30–July 13, 2012, maximum daily temperatures in Maryland, Ohio, Virginia, and West Virginia averaged is 9.5°F warmer than normal. 12 Maryland residents died during this period due to excessive heat exposure [v]
  - Severe weather will also include flooding, droughts, storms, and fires that impact healthcare services as well as long term health concerns

## Population health status does not return after severe weather events:

- A study of Hurricane Katrina measured health impacts a year after the hurricane and found an increase in disease prevalence, increased health burden directly associated with disruption from Hurricane Katrina, and the adverse effect on morbidity was strongest for nonwhite subjects[vi]

## Sea level rise, heavy rainfall, and storm surges will increase will disrupt communities and increase water borne disease and disrupt communities

- ### Sea Level Rise
  - Rising seas and eroding shorelines displace coastal communities
  - Sea level rise and storm surge threatens drinking water supplies and agricultural fields with salt-water intrusion
  - Potential changes in exposure to diseases

- ### Flooding and Heavy Rainfall

The frequency of heavy precipitation events has already increased for the nation as a whole (75% increase for the Northeast), and is projected to continue increasing. With nearly 3,000 miles in coastline, Maryland is vulnerable to health concerns from flooding including:

  - Failure of septic systems - Waterborne diseases contaminating drinking water
  - Sewage back-up in plumbing or basements
  - Floodwater containing toxins, bacteria, and sewage, can contaminate drinking water, vegetables growing in fields or gardens, and recreational water sources
  - Water intrusion in buildings, worsening indoor air quality and/or causing toxic mold to grow in ceilings, walls, or insulation [vii]

- Between 2007-2013, Baltimore had on average 13.1 nuisance flood days per year, while Annapolis had 39. Annapolis and Baltimore have the highest increase in number of flood days in the nation [viii]

## Allergens related to pollen will increase:

- The length of the ragweed pollen season has increased in parts of the US by 11-27 days because of rising temperatures. As the climate warms more pollen is produced and pollen season lengthens, there will be an increase in health problems related to allergens:
  - Increases in the symptoms of seasonal allergies
  - Pollen triggers asthma attacks, leading to more ER and hospital visits

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[i] The Health Impacts of Climate Change on Americans The White House, 6 / 2014
[ii] "Climate Effects on Health – Air Pollution" Centers for Disease Control, 12/11/2014
[iii] Climate Change and Your Health: Rising Temperatures, Worsening Ozone Pollution Union of Concerned Scientists, 2011
[iv] "Heat-Related Deaths After an Extreme Heat Event — Four States" Centers for Disease Control, 2013
[v] Health of Medicare Advantage Plan Enrollees at 1 Year After Hurricane Katrina, Burton, et all., The American Journal of Managed Care Vol. 15 No. 1, 01/ 2009
[vi] Climate Change Impacts in the United States U.S. Global Change Research Program, 2014
[vii] Sea Level Rise and Nuisance Flood Frequency Changes around the United States, National Oceanic and Atmospheric Association, July 2014

From: **Rebecca Ruggles** <rebeccalruggles@gmail.com>
Date: Thu, Aug 20, 2015 at 3:08 PM
Subject: Public Comment to MCCC
To: climate.change@maryland.gov

I am submitting the attached statement of the health impacts of climate change in support of renewing the Md Greenhouse Gas Reduction Act. I also urge the Md Climate Change Commission to recommend that the state legislature mandate a goal for 2030, consistent with the recent proposal of the Maryland Department of the Environment, of 45% by 2030 from 2006 levels.

Thank you.

Rebecca Ruggles

Rebecca Ruggles, Director
Maryland Environmental Health Network
410-903-9498
rebeccalruggles@gmail.com
www.MdEHN.org
*"All progress has resulted from people who took unpopular positions." -Adlai Stevenson*

MARYLAND

[redacted]

# Fwd: Your God complex

**CLIMATE CHANGE -MDE-** <climate.change@maryland.gov> Thu, Jul 30, 2015 at 9:41 AM
[redacted]

---------- Forwarded message ----------
From: **Robert Mccolley** <z061957@yahoo.com>
Date: Tue, Jul 28, 2015 at 7:08 AM
Subject: Your God complex
To: "climate.change@maryland.gov" <climate.change@maryland.gov>

Get over yourselves!! You can't even predict weather it will be sunny or rain a day ahead of time!!

Sent from my iPhone

[redacted]

# Fwd: Climate Change - Do everything we can!

**CLIMATE CHANGE -MDE-** <climate.change@maryland.gov> Tue, Aug 18, 2015 at 2:45 PM

[redacted]

---------- Forwarded message ----------
From: **Robert Bruninga** <bruninga@usna.edu>
Date: Tue, Aug 18, 2015 at 1:01 PM
Subject: Climate Change - Do everything we can!
To: climate.change@maryland.gov
Cc: bruninga@usna.edu

Maryland,

Do not let the Governor roll back progress. Maryland sits in one of the most populated regions in the country and we have to breath the air we are polluting and burning up every day.

We can do this! At my house, we have reduced our Fossil Fuel consumption by 90% by going solar on the house, by going Ground-source-heatpump, and by commuting in an EV. And it costs us LESS than just continuing with the status quo! Of the original 3000 gallons equivalent we were consuming we are now down under 300/year and that is only the occasional trips in the Prius to the kids and Gramma's.

We can do it. It is easy, and it costs less in the long run. Stop putting off the fixes. Move forward on GHG reduction!

Bob Bruninga, PE

Senior Research Engineer, US Naval Academy

IEEE National Committee on Transportation and Aerospace

Maryland EV Infrastructure Council – public participant

EV Association of DC/MD

410-293-6417

From: **ActionOn ClimateChange** <actiononclimatechange@gmail.com>
Date: Sun, Aug 23, 2015 at 1:06 PM
Subject: Comments for the Maryland Climate Commission
To: climate.change@maryland.gov

Testimony to Maryland Climate Coalition

My name is Ruth White and I live in Columbia MD.

I am testifying for myself as a private citizen concerned about the impact of climate change. Until recent years, I was concerned that oil and coal are the main causes of climate change and focused on our need to move from these fuels to clean energy. I started hearing that "natural gas" is a bridge fuel and cleaner.

Then I began to hear about fracking for natural gas. As I followed the work of O'Malley's Marcellus Shale Safe Drilling Initiative I learned that the majority of the gas being extracted now is from fracking[1]. And that the methane and other greenhouse gas emissions from the entire production lifecycle of fracked gas is as bad or worse than coal. A Cornell study concludes: "the GHG footprint of shale gas approaches or exceeds coal ..."[2]

I have heard people from the fracking fields in Pennsylvania talk about the impact on their water (which is now documented by the most recent EPA study).[3] And that fracking from nearby States is adversely affecting air quality in Baltimore. [4]

But what concerns me most is the impact the entire production process of fracking for natural gas is having on creating greenhouse gases causing runaway climate change already responsible for deaths and destruction around the the world. But what is happening now will be insignificant compared to the climate chaos in the world my grandson inherits. It is for my 4 year old grandson and all the children of his generation that take the time to come here to submit testimony.

Our use of wind and solar is growing but is not growing fast enough. Under a new law Maryland is now on a path to create regulations allowing fracking for gas as soon as October 2017. [5] The Commission should carefully consider whether plans to frack in Maryland are consistent with reducing climate change impact in Maryland.

In addition Maryland (and the Federal Energy Regulatory Commission) are currently approving pipelines and compressor stations bringing fracked gas from other states, infrastructure which leaks and emits methane all along the way further contributing to climate change. As coal plants are being closed, new gas power plants are being opened.

I looked at the October 2013 report on Maryland's Greenhouse Gas Reduction Act Plan {6}.. Between pages 65 and 66 it mentions the value of "fuel switching" from coal to gas:

> Between the retirement of thousands of MW of coal-fired power plants and continued availability of inexpensive natural gas, it is highly likely that natural gas will continue to produce an increasing share of electricity in PJM and continue to contribute to a reduction in GHG emissions in Maryland for years to come.
>
> It is important to add, that when the full fuel cycle emissions of fuel switching from coal-fired electricity to natural gas are considered, the emissions reductions are smaller, and potentially can be much smaller.
>
> In sum, Maryland’s GHG reduction efforts are, in the near term, likely to continue to benefit to some extent from the ongoing power plant fuel switch from coal to natural gas. However, given the uncertainty of the economy, energy markets, and methane leakage rates, the climate benefits associated with fuel switching are difficult to quantify or assure. Fuel switching to natural gas has not, therefore, been included as a strategy within the State’s GGRA Plan. Moreover, because natural gas is a fossil fuel with carbon emissions, it should be considered as a transitional fuel as the State works to achieve a 90 percent Statewide reduction in GHG emissions by 2050.

As you can see from my prior statements I consider this an erroneous analysis and would like the Commission to recommend against fuel switching as misguided and recommend all out rapid switching to renewables.

In addition, exporting fracked gas from Cove Point (which has been approved by FERC) adds to Maryland's fracking infrastructure (the facilities at Cove Point and associated pipelines and compressor stations) and thus Maryland greenhouse gas emissions.

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[1] http://blogs.wsj.com/corporate-intelligence/2015/04/01/how-much-u-s-oil-and-gas-comes-from-fracking/
[2] http://www.eeb.cornell.edu/howarth/Howarth%20et%20al%20%202011.pdf
[3] http://www2.epa.gov/hfstudy
[4] www.baltimoresun.com/features/green/blog/bal-study-links-air-pollution-in-baltimore-to-fracking-outside-maryland-20150430-story.html
[5] http://mgaleg.maryland.gov/2015RS/chapters_noln/Ch_480_sb0409T.pdf

[6] http://climatechange.maryland.gov/site/assets/files/1392/mde_ggrp_report.pdf

# Southern Maryland Public Meeting Comments

## Tuesday, August 4th, 2015

***What do you want from this meeting?***

1. A clean environment for my grandchildren
2. A sustainable environment
3. An explanation of how the State is going to meet the 25% greenhouse gas (GHG) reduction goal
4. Citizens should mobilize around climate change the way people mobilized around World War II
5. To address particular climate change problems in Calvert County
6. It would be useful to know about the bills that are going to be introduced during the next legislative session
7. An explanation of why the State did not have the public meeting in Lusby, an epicenter for climate change

***PUBLIC COMMENTS***

1. A member of the Master Gardeners should be on the Maryland Climate Change Commission (MCCC).

2. Do not rely on natural gas to reduce GHG emissions. The MCCC should account for methane emissions out of state. Also, don't let Covepoint come to fruition until an environmental impact statement is done.

3. The State was instrumental in permitting Covepoint and should stop it from moving forward.

4. The State should publicize public health issues associated with air pollution/ climate change, such as asthma and cancer. The State should work on regulations to reduce emissions from power plants. The law that allows some power plants not to report data should be repealed.

5. The State should put an air monitor at Covepoint. It seems suspicious that the AES project did not go through, but Dominion's project did.

6. There needs to accountability and monitoring and natural gas should not be seen as a benefit for GHG reductions.

7. The State should fine companies that are not meeting their GHG emission reduction goals and give the money to companies that are meeting their goals.

8. The State needs to be more aware of impacts of local land use decisions. When the State issues a permit, they are not looking out for local communities.

9. Is there anything in the MCCC law requiring the Commission to look at GHG emissions on a local level? In other words, it seems like the MCCC just has to look at ways to reduce total GHGs emissions in the State, not at GHG emissions levels in certain counties. So, Calvert County may end up having more GHG emissions than Frederick County as long as the State as a whole is reducing GHG emissions.

10. Is there a citizen advisory committee for the MCCC? If not, there should be.

11. There is no way to measure how close the State is to achieving the 25% GHG reduction goal without collecting data and performing monitoring. The largest sources of pollution are not monitored. Citizens are held accountable for emissions from their cars and power plants are not held accountable. Covepoint is going produce emissions that are equal to 400,000 cars.

From: **Tiffany Hartung** <HartungT@nwf.org>
Date: Tue, Aug 25, 2015 at 9:00 AM
Subject: National Wildlife Federation comments
To: "climate.change@maryland.gov" <climate.change@maryland.gov>

Please find the attached comments from National Wildlife Federation to the Maryland Commission on Climate Change on the Greenhouse Gas Reduction Plan.

----------------------
Tiffany Hartung
Sr. Coordinator, Maryland Climate Coalition
706 Giddings Avenue, Suite 1-B, Annapolis, MD 21401
O: (443) 759-3402 | C: (248) 933-2451
Hartungt@nwf.org
MarylandClimateCoalition.org

# Western Maryland Public Meeting Comments

## Tuesday, July 28, 2015

***What do you want from this meeting?***

1. Glad the Commission is in western Maryland and she hopes that the state has a better understanding of the concerns of mountain Maryland
2. What is the base year for the emissions goals? Lower than what it was in 2006
3. Why was 2006 chosen as the base year? Because the commission started in 2007 and our most current inventory was for 2006 and other states have similar goals but have different starting dates and you need to make even with the other states.
4. The 25% is based on renewables (and conservations) and yet 18 of the 22 counties already prohibit industrial wind farms so how do we get to those numbers without their buy in?
5. The documents reference forests but Maryland doesn't have protections or zoning for forests. There are no CCCs in place for forests

***PUBLIC COMMENTS***

#1, Steven Buckingham, Frederick county minister: the earth is our home and life on this planet will be impacted unless we have new tactics. As UU, we work with other faiths to balance between individual needs and other organisms. To live we must consume and dispose and we need to burden it less to maintain the essentials of our lives and respond from our moral and spiritual life. Strongly support the GGRA because it balances environmental and economic needs and we urge a continuation and strengthening of the current plan. We live in western Maryland because we love living near nature and dot want to see it destroyed or degraded for profits.

#2, Ann Briston, Marcellus shale safeguard tats force: in a report about methane gas is similar to what we are seeing in Garrett county, 10,000 pounds Of fugitive gas emissions. Maryland must have baseline numbers before it moves forward with natural gas. Two assessments, life cycle and baseline should be looked at so that alternative energies aren't negated as a true bridge.

#3, Barbara Beeler, friends of deep creek lake: broaden the programs for bay to include all waterways in the state. Invasive species reduction adaptive features so that we are managing the waterways because they are impacted by the climate changes.

#4, Sen. Roger Manno: he is now on the AELR committee and has a concern. Gov. Hogan repealed the nitrogen oxide regulation in his second day in office which has never been done in 400 years. So he is not publishing the regulations even though it has passed and this is a negative impact on the GGRA as they are the law of maryland an has to go through emergency regulations.

#5, Mark Stuzman, Engage mountain maryland: a town in Garrett county no longer draws gas and covers 50 square miles and holds and distributes gas in winter months and 80 well bores and releases 10,000 pounds of methane into the atmosphere. Would like to work with the state as a citizen group to help reduce emissions. With Maryland's intent to reduce emissions so the GGRA should recommend to repeal fracking in the state in two years.

#6, Woody Getz, as an individual from frostburg: member of an elected body works with MEA for the smart energy community program. Wants to look at the top down regulation opportunities and grassroots work bottom up. Frostburg worked to generate own electricity and use less electricity by 2022 and the community can pick the mix. Anyway that that kind of model can be applied throughout the state would be ideal for the GGRA.

#7, Eric Robison, safe western Maryland (wind turbine lawsuit): looking at the time frame for public comment really bothers him. There are so any components and impacts that can't be distilled in two minutes and especially in Appalachia since those people aren't necessarily able to make comments in the time frame or can't write but are tremendously impacted so we need more outreach to more areas of the state.

Stuart: In an effort to address that, we are Planning to go throughout the state to discuss the report, we captured your email addresses to send the draft to you prior to completion and we plan on staying in touch with a work plan for 2016 to come back out to hear in more depth. Also we need your help to identify who is missing from the conversations.

#8, Michael Weddle, physician and Garett county resident and homeowner: concerned with fracking on value to home and the impacts on climate change. Studies in nature, scientific America, journal for climate change, cornell university there are a bunch of studies. In 2008, there was a 90% reduction oak of GGRA by 2050 and that would be tremendously helpful.

#9, Reverend Karen Crosby, st.johns in frostburg: they have been in allegany since 1840 and have a historical connection to coal. The companies are scraping every remnant of coal to put

The church is working to Reduce Plastic at meals, reroof and rewired the church and want to look into solar on the panels but located in a historic district so that may be a concern and something the GGRA could think about. Looking to strengthen the GGRA. Frostburg did just approve solar panels for businesses and resident in the historic district.

#10, Natalie Atherton: we need a revolution because this is a huge issue and yet we are just talking about band aids. We need to have a moral revolution and we can't keep working within the confines of over consumptive lifestyles. Don't trade the smaller things and let people pollute.

#11, Tim Whitehouse, poolville Maryland and PSR: encourage a 2050 vision of 90% reduction of gg emissions and how to engage residents as energy consumers seeing themselves as producers. Also recognizing low income communities since they are impacted most and worst and the principal has been recognized but we have some of the most portly controlled coal plants in the country and the MDE regulations are a big step backwards to ensure that the coal plants have the strongest restrictions in place and the actions need to be in existence. There needs to be an honest assessment of the barriers that make changes difficult. Hope the commission makes the distinction between renewable meaning no GG emmissions and those things like incineration and biomass because they do pollute and aren't truly renewable

#12, William Neil: the time you ask for doesn't exist, two minutes isn't enough. We are boxed into corners and slow and careful dialogue is how we have been working with since abolitionist and FDR working against fascist issues and we continue to slow path. Public and private investments for natural gas need to be used for solar and renewable. 1. Say no to fracking 2. We need a public investment like solar city. 3. We will have to undergo a Pearl Harbor catastrophe to get people to change. "The time does not exist" - James Baldwin quote so we need to work now and quickly. We are way behind.

#13, Marcia Tirocke, resident: 3 years ago moved to Garett county and have never been happier. Thinking of fracking frightens her and we need to be focusing on renewable energy. There are No safety protocols or state of the art clean up materials and all the companies do is try to hide the destruction.
"This is obviously some strange use of the word safe I want previously aware of" - hitchhikers guide to the galaxy

#14, Derek Johnson: solar panels on his house when he first moved to Garrett but only leases them through sungevity. There is no reason why every south facing, unobstructive roof can't have solar collectors on them. Garett county seems to have the most renewable energy in the state - just signed 3 contracts for solar and they will be providing more energy than the county government uses. There should be more of these models. He produces about half the energy he uses now and the rest comes from Ethical electric.

#15, Additional Comments
: zero ware is very important and we need to vamp up the efforts in western Maryland

#16, Jim guy, fracking opponent and systems engineer: he is concerned about misinformation and people who are influenced by big interest and monetary issues. Is possible to have a peer reviewed journal reading list to share with people and ask them to read it so they are better informed.

Idea for outreach: small group discussion, simulate the kitchen table

**Testimony on the Maryland Greenhouse Gas Reduction Act Plan**

Before the Maryland Commission on Climate Change
UMCES Appalachian Laboratory
301 Midlothian Road
Frostburg, MD 21532

The earth is our home. We are part of this world and its destiny is our own. Life on this planet will be gravely affected unless we embrace new practices, ethics, and values to guide our lives on a warming planet. We as Unitarian Universalists are called to join with others to halt practices that fuel global warming/climate change, to instigate sustainable alternatives, and to mitigate the impending effects of global warming/climate change with just and ethical responses. As a people of faith, we commit to a renewed reverence for life and respect for the interdependent web of all existence. We are called to defer to a balance between our individual needs and those of all other organisms.

Entire cultures, nations, and life forms are at risk of extinction while basic human rights to adequate supplies of food, fresh water, and health as well as sustainable livelihoods for humans are being undermined. To live, we must both consume and dispose. Both our consumption and our disposal burden the interdependent web of existence. To sustain the interdependent web, we must burden it less while maintaining the essentials of our lives. Our world is calling us to gather in community and respond from our moral and spiritual wealth; together we can transform our lives into acts of moral witness, discarding our harmful habits for new behaviors and practices that will sustain life on Earth, ever vigilant against injustice.

We strongly supported the Greenhouse Gas Reduction Act (GGRA) passed by the General Assembly in 2009 because it required the adoption of a Greenhouse Gas Reduction Plan for state actions to achieve a 25% reduction in GHG from 2006 levels by 2020. While these targets may not be enough to stem or reverse the consequences of climate change, they are at least a carefully considered, rational, balanced and meaningful way to assure that our state is doing what it can. It balances environmental and economic needs and deserves to be pursued with vigor. We urge the Commission to recommend a continuation of the Plan and, if possible, strengthen it by setting even more ambitious goals.

On a personal note, those of us who live in the mountains of Western Maryland do so because we love it: its space to live and to move around, to breathe its fresh air and enjoy its natural beauty. We like being close to the natural world and do not want to see it degraded and exploited in order to build corporate profits while endangering the future we leave to our children and grandchildren. Please keep us on the right and moral path towards a livable climate and a sustainable world.

*Stephen C. Buckingham*
Lay Community Minister and Co-chair
Unitarian Universalist Legislative Ministry of Maryland
14 Eastern Circle
Middletown, MD 21769

July 28, 2015

# THE TIME YOU ASK FOR DOESN'T EXIST

## STATEMENT OF WILLIAM NEIL, CITIZEN, TO THE MARYLAND CLIMATE CHANGE COMMISSION

I have two minutes to comment upon your more than "150" programs, and the slow, voluntary, incremental "Maryland temperament" approach. I strongly protest being forced into this two minute "corner," but that's where citizens seem to be these days, boxed into corners, as Yanis Varoufakis has warned us, and the fate of Greece has demonstrated.

It is true, though, that decent democracies often work that way, by slow and careful dialogue and that is as it should be. That's mostly the way the abolitionist movement worked for 30-years, from 1830-1860, and how FDR brought the nation to the necessary intervention against fascism in the 1940's. And that's the way the movement to stop global warming has been working. But we are not succeeding, and we are not going to get there in time, and there are huge consequences looming if we are "late." Forget the 150 programs to track: look at the tiny percentage of alternative energy generated inside Maryland – or the nation – under 1% of the total.

There are three major things we need to do change this. First, the public and private investments that have poured into gas and oil fracking need instead to "deploy" to solar generation and in selected locations, to wind power - and to remaking our grid. Our nation has to be willing to invest trillions to do this, just as we were willing to spend trillions on mission impossibles in the Middle East, being poised for yet another. We can't do both. Therefore, say no unequivocally to fracking in Maryland. And to the Donald Rumsfeld like foreign policy voices, "new Russia Cold War" included.

Second, we need a public financing program, through public banks, to match on a sounder, less complicated basis what Elon Musk has done with the too complex Wall Street derivative model at Solar City, the one used in Garrett County that no one wants to talk much about.

And third, sadly, we will probably have to undergo the climatological equivalent to Pearl Harbor to change more minds, especially those in one of our two parties, before we reach a national feeling to match that of FDR's One Hundred Days and post December 7, 1941 mobilization

That's where I am after reading Naomi Klein, Richard Smith, Pope Francis - and James Hansen's latest paper. Hansen has told us "what time it is": that we can't afford 2 degrees of climate warming. Climate Pearl Harbor arrives with rapidly rising sea levels and catastrophic weather changes much sooner, even with one degree of warming, which we already have.

The poles which have delineated our world are melting as I speak, and the disorientation is already well under way.

My message to the Commission is the same one that James Baldwin delivered to novelist William Faulkner, his pleas to the North to let the South "go slow" in the early 1960's, which I first read as a Lafayette College freshman in 1968, and I have never forgotten Baldwin's stinging reply:

> "... the time Faulkner asks for does not exist – and he is not the only Southerner who knows it. There is never time in the future in which we will work out our salvation. The challenge is in the moment, the time is always now."

That's always been the type of constructive pressure our slow moving political system has required "to get there in time." Usually, it comes from *outside* the two party system. It doesn't always work neatly, as the Civil War demonstrated. Let's hope it succeeds this time. More than you think depends on "getting there" in time.

William R. Neil

Frostburg, MD 21532

Sources:

James Baldwin, Nobody Knows My Name, 1961, Chapter 7.

James Hansen et al: "Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observation s that 2 degrees of global warming is highly dangerous," July 23, 2015, Atmospheric Chemistry and Physics. http://www.atmos-chem-phys-discuss.net/15/20059/2015/acpd-15-20059-2015.html

Naomi Klein, "Capitalism vs the Climate," November 9, 2011, The Nation. http://www.thenation.com/article/capitalism-vs-climate/

__________, This Changes Everything: Capitalism vs the Climate, 2014.

Pope Francis, Encyclical Letter, Laudato Si (On Care for our Common Home), June 18, 2015 http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html

Richard Smith, Green Capitalism: The God that Failed, 2014, http://www.worldeconomicsassociation.org/downloads/green-capitalism-the-god-that-failed/

Maryland Climate Commission

7/28/15 public comment:

I am a Garrett County resident and served on Gov. O'Malley's Marcellus Shale Safe Drilling Initiative and appreciate the formidable task before you, particularly in these times of rapidly evolving and welcomed research on the life cycle of climate-forcing natural gas emissions.

Just this month is a study published on methane emissions from only transmission and storage of natural gas (Zimmerle et al., 2015). These data are congruent with what we're seeing in Garrett County -- of the over 11,000 tons of methane reported to be emitted per year from the Accident compressor station and underground storage facility, at least 10,000 tons are fugitive emissions.

In the prestigious journal NATURE last year (McJeon et al. 2015) modeling of the impact of natural gas for climate change revealed the core finding that:

". . . increases in unconventional gas supply in the energy market could substantially change the global energy system over the decades ahead without producing commensurate changes in emissions or climate forcing." And that:

". . . abundant natural gas leads to greater consumption of natural gas. Coal loses the largest market share to natural gas, but natural gas also gains market share at the expense of nuclear and renewables."

Maryland must have baseline methane measures in order to determine the net effects of proposed methane-producing operations, particularly in the near term since science predicts a short-term tipping point with respect to ecological homeostasis.

It is irresponsible to be silent about speculative financial practices that are currently building out a natural gas infrastructure designed to exceed any bridging strategy as yet unarticulated.

In summary, it is an unproven & untenable hypothesis that natural gas is the bridge to sustainability.

I urge you to recommend two assessments: life cycle and baseline. Fuel switching is NOT a solution for climate change -- it will incentivize natural gas build out and de-incentivize alternative energy development. Thank you.

Ann Bristow, Ph.D., 92 Carey Run Road, Frostburg, MD 21532

# Greenhouse Gas Reduction Plan
## Tuesday, July 28, 2015 Testimony

Mark Stutzman
100 G Street
Mountain Lake Park, MD 21550

Accident, a town in Garrett County was once a huge natural gas resource using traditional vertical wells. It no longer draws gas but is a natural underground storage field covering roughly 53 square miles. It holds and distributes gas to the Northeast during the winter months when demand is high. It is also home to a compressor station and over 80 well bores that are under constant maintenance. This aging facility built in the 1960s is releasing 10,000 tons of methane into the air annually with no mandatory air monitoring. This would be an obvious good starting point to reduce emissions in our state. I would recommend more extensive independent monitoring, oversight and enforcement to help Maryland reach it's emissions goals. I am representing Engage Mountain Maryland and our organization would be willing to work with the Greenhouse Gas Reduction Plan to form a citizens air monitoring program to assist in collecting useful data. These programs can be costly, but with the help of the state and a mutual goal, it would be a worthwhile endeavor.

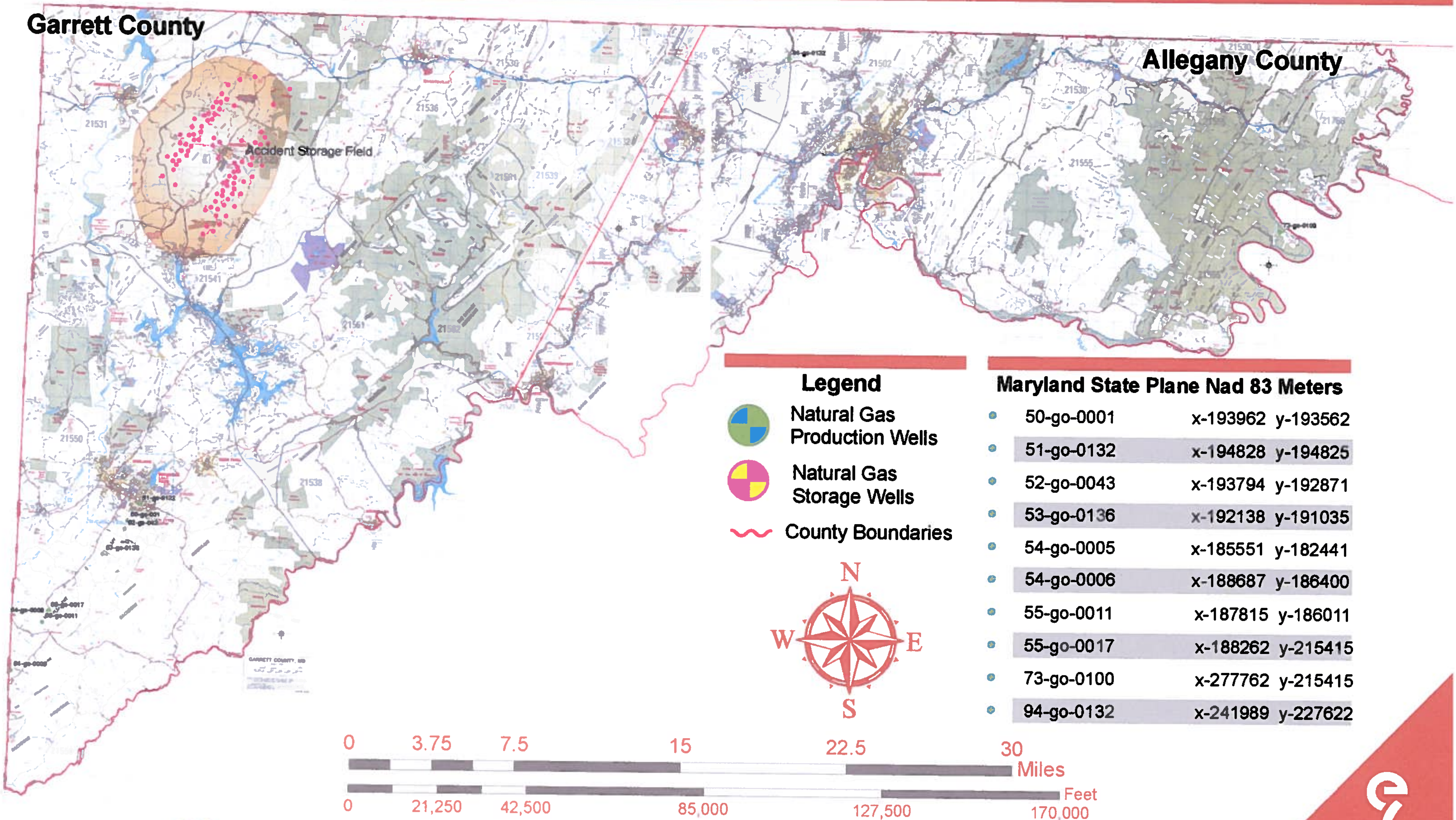
I would also like to address that Garrett County is a location sited for natural gas development that would involve high-volume hydraulic fracturing, or "fracking". Fortunately, the state adopted a moratorium on fracking until 2017. With Maryland's intent to lower emissions and reduce the burden on our environment, it would be ridiculous and counter-intuitive to allow fracking in our state. The Greenhouse Gas Reduction Plan should make a recommendation to prohibit fracking in our state in order to achieve it's goals. There are two years to identify the natural gas industry as a source of conflict to the mission that has been set forth.

I'm proud of Maryland for taking a proactive step to helping with a global concern. We all share our air and water and must each do our part to alleviate the environmental impacts we impose.

Thank you,

Mark Stutzman, VP, Eloqui, Inc.
Engage Mountain Maryland, Founding Member

# NATURAL GAS WELLS IN MARYLAND




**Maryland State Plane Nad 83 Meters**

| | | |
|---|---|---|
| 50-go-0001 | x-193962 | y-193562 |
| 51-go-0132 | x-194828 | y-194825 |
| 52-go-0043 | x-193794 | y-192871 |
| 53-go-0136 | x-192138 | y-191035 |
| 54-go-0005 | x-185551 | y-182441 |
| 54-go-0006 | x-188687 | y-186400 |
| 55-go-0011 | x-187815 | y-186011 |
| 55-go-0017 | x-188262 | y-215415 |
| 73-go-0100 | x-277762 | y-215415 |
| 94-go-0132 | x-241989 | y-227622 |

Accident Storage Field Boundary overlay supplied by Spectra Energy.
Map prepared for display and public education only by Engage Mountain Maryland, 2015.

MARYLAND MDE engage MOUNTAIN MARYLAND

ROGER MANNO
*Legislative District 19*
Montgomery County

Budget and Taxation Committee
Health and Human Services Subcommittee
Pensions Subcommittee

*Chair*
Joint Committee on Administrative, Executive, and Legislative Review
*Chair*
Spending Affordability Committee

Joint Committee on Federal Relations
Joint Committee on Pensions

*Vice Chair*
Montgomery County Delegation

THE SENATE OF MARYLAND
ANNAPOLIS, MARYLAND 21401

James Senate Office Building
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Annapolis, Maryland 21401
410-841-3151 · 301-858-3151
800-492-7122 *Ext.* 3151
*Fax* 410-841-3740 · 301-858-3740
Roger.Manno@senate.state.md.us

April 27, 2015

The Honorable Benjamin H. Grumbles
Secretary of the Maryland Department of the Environment
1800 Washington Blvd
Baltimore, MD 21230

**Re: Emergency/Proposed Regulations**
**DLS Control No. 15-051**
**Control of NOx Emissions from Coal-Fired Electric Generating Units:** COMAR 26.11.38.01-.05

Dear Secretary Grumbles:

Thank you for your submission on April 17, 2015, of the emergency/proposed regulations (DLS Control No. 15-051, COMAR 26.11.38.01-.05) regarding the control of nitrogen oxides (NOx) emissions from coal-fired electric generating units. As Senate Chair of the Joint Committee on Administrative, Executive, and Legislative Review (AELR Committee), I have had an opportunity to review these regulations. With great apprehension and despite the unresolved legal and procedural issues discussed below, I will vote to support the emergency/proposed regulations because I understand the exigency of having these requirements in effect for the upcoming ozone season.

As you are aware, the Maryland Department of the Environment submitted similar NOx regulations to the AELR Committee on November 3, 2014 (DLS Control No. 14-327), that were then published in the Maryland Register on December 1, 2014 (41:24 Md. R. 1449-54). After waiting the requisite 45 days from this publication date[1], former Secretary of the Department Robert Summers adopted the NOx regulations on January 16, 2015, and subsequently submitted a notice of adoption to the Division of State Documents, as required under § 10-114(a) of the State Government Article. While Governor Hogan withdrew the notice of adoption on January 21, 2015, thus preventing the notice from being published in the Maryland Register, the NOx regulations were already adopted by the Department and remain in effect.

[1] Section 10-111(a)(1) of the State Government Article prohibits a unit from adopting a proposed regulation until after submission of the proposed regulation to AELR and at least 45 days after its first publication in the Maryland Register.

The Administrative Procedure Act (APA) defines a "regulation" as "...a statement...that...is *adopted* by a unit..." (§ 10-101(g) of the State Government Article) (emphasis added). A regulation is not defined by its date of publication, but rather by its date of adoption. Therefore, adoption occurs when a regulation becomes effective, not when the regulation is published, and thus the regulations published on December 1, 2014, went into effect when adopted by Secretary Summers on January 16, 2015.

Since the NOx regulations published on December 1, 2014 have been adopted, any changes to these regulations should be properly made through the regulatory process set out in Subtitle 1 of the APA.[2] I bring this to your attention because it is my opinion that the text of the emergency/proposed regulations that the Department submitted to AELR on April 17, 2015 is inaccurate. Specifically, the emergency/proposed regulations do not include the text of COMAR 26.11.38.04 dealing with additional NOx emission control requirements beginning June 1, 2020. If it is the Department's intent to repeal COMAR 26.11.38.04, the text of the regulation should be included in the document with brackets around the text to be repealed so that the public is notified as to the changes being made. Additionally, the notice provision before the text of the emergency/proposed regulations states that the Department is introducing "new regulations" for the control of NOx emissions from coal-fired electric generating units, and immediately before the text of the emergency/proposed regulations is the statement "all new matter." Arguably, neither of these statements is accurate since these regulations are already in effect.

The AELR Committee is currently polling on these emergency/proposed regulations, as the Committee understands the exigency with which to move forward with NOx regulations. Furthermore, it is my understanding that this matter is the subject of pending litigation, which, if resolved in a manner consistent with the positions stated herein, would render the adoption of these emergency/proposed regulations duplicative in nature and technically inaccurate. Therefore, I would strongly encourage the Department to avoid any legal or procedural challenges, and instead, withdraw these emergency/proposed regulations. If, however, the Department chooses to amend the current regulations, it should resubmit regulations addressing these concerns.

I am happy to discuss these issues and concerns in more detail should that become necessary. I look forward to assisting the Department in this process, and I appreciate our ongoing work together.

Thank you for your attention to this matter.

Sincerely,

Senator Roger P. Manno

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[2] Section 10-101(g) of the State Government Article includes "an amendment or repeal of a statement" in the definition of "regulation". Under § 10-110(c), a unit must submit a proposed regulation to AELR 15 days before submittal of the regulation for printing to the Maryland Register.

MARYLAND

[redacted]

# Fwd: "The Time You Ask for Doesn't Exist": Open Letter to MD's Climate Change Commission

**CLIMATE CHANGE -MDE-** <climate.change@maryland.gov> Thu, Jul 30, 2015 at 9:40 AM

[redacted]

---------- Forwarded message ----------
From: <wrn1935@comcast.net>
Date: Tue, Jul 28, 2015 at 12:53 PM
Subject: Fwd: "The Time You Ask for Doesn't Exist": Open Letter to MD's Climate Change Commission
To: climate.change@maryland.gov

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**From:** wrn1935@comcast.net
**To:** wrn1935@comcast.net
**Sent:** Tuesday, July 28, 2015 12:26:58 PM
**Subject:** "The Time You Ask for Doesn't Exist": Open Letter to MD's Climate Change Commission

Dear Citizens and Elected Officials:

July 28, 2015

-

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Richard Smith, **Green Capitalism: The God that Failed**, 2014, http://www.worldeconomicsassociation.org/downloads/green-capitalism-the-god-that-failed/

MARYLAND [redacted]

# Fwd: Comment for the record -- Prince George's hearing

**CLIMATE CHANGE -MDE-** <climate.change@maryland.gov> Tue, Aug 18, 2015 at 2:50 PM
[redacted]

---------- Forwarded message ----------
From: **Woody Woodruff** <woodlanham@gmail.com>
Date: Fri, Aug 7, 2015 at 10:47 PM
Subject: Comment for the record -- Prince George's hearing
To: climate.change@maryland.gov

**To the Maryland Climate Commission: a comment for the record (hearing of Aug. 6, 2015, Prince George's County)**

I attended the hearing of Aug. 6 and enjoyed the optimistic tone of the participants, although everyone still noted that there was plenty to accomplish – beginning with renewing the Climate Plan next year in the General Assembly. No one thinks it will be easy to keep opponents from chipping away at it.

My concern with the overall proceeding, a concern that keeps recurring, is the acquiescent tone. The system of economic arrangements in our society is something it seems we have to live with, not something we need to question or change. In most of the macro remedies that are proposed by folks of the sort who spoke last night, the role of corporate concerns is the real elephant in the room, taken for granted – we are resigned to that role of the private corporation in our discussion of public goods.

There are few areas in the overall path to sustainability where this corporate factor is more critical than in energy as provided to the public – electric power. It is a public good. It is nevertheless provided by huge corporations with immense clout. Their hooks are sunk deeply into state government, particular in the Hogan administration, but also in the largely Democratic legislature.

A hearing Aug. 5 in Baltimore just the day before the Commission meeting provided solid evidence that corporate power in the statewide electric grid is a pernicious influence. The Air Quality advisory panel was totally buffaloed by the MDE's numbing PowerPoint presentation justifying a rollback of the O'Malley air quality rules for power plants. The presentation, which soaked up nearly all the time for public comment, was contested ably by the Sierra Club reps, but it was the bused-in crowd of IBEW members, unduly threatened with job loss and plant closure by the corporate chiefs, whose enforced and well-scripted testimony carried the day.

As long as the PJM grid is in the hands of corporations, every incremental gain toward sustainability in electric power provision will be fought with the help of captive workers and claims of job loss. The customers of the grid are paying for poor, unreliable service and persistent dirty air while Wall Street siphons off the dividends and CEOs reap bonuses**. Maryland needs to reverse its deregulation policy on power and return to a public system**, publicly owned and managed, which can make the transition to sustainability more quickly, effectively cross-train workers instead of terrorizing them with threats of job loss, and provide cleaner power to the public.

As long as a sustainable future is held hostage by a corporate present, progress will be constrained and the climate change we are trying to mitigate will inexorably wreck our state's, and planet's, economy and social cohesion. But by then the CEOs will have retired to gated, climate-controlled comfort somewhere far from here.

Woody Woodruff

Lanham, Md.

--

Woody Woodruff
Communication Designer

"Chance favors the prepared mind" -- Louis Pasteur

From: **Seth Bush** <seth.bush@sierraclub.org>
Date: Mon, Aug 24, 2015 at 5:39 PM
Subject: Comments from Maryland Sierra Club
To: climate.change@maryland.gov

Dear Larissa,

Please find comments from MD Sierra Club supporters attached and a cover letter describing the format in which I am sharing them. I chose to share the comment language and a database of the signers for easier reference and databasing. The full comments are also attached for your records, but they're all identical.

Best,
Seth

--

***Seth Bush***
**MD Organizing Representative**
Sierra Club

(267) 474-3488 | seth.bush@sierraclub.org
3000 Chestnut Ave. | Suite 202 | Baltimore, MD 21211 (map)

LinkedIn: www.linkedin.com/in/sbush

Georgia Conroy
1772 Lang Dr
Crofton, MD 21114-2145
(410) 258-8388

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

With more than 3,000 miles of tidal shoreline, Maryland is the third most vulnerable state to sea level rise -- one of the major consequences of climate change. Large swaths of the state along the Chesapeake Bay, including Baltimore's Inner Harbor, are already experiencing higher incidence of flooding each year due to rising seas. As previously found by Maryland scientists, a continued increase in greenhouse gas emissions would mean sea level rise more than 5 feet by the end of the century. To put that in perspective, 5 feet of sea level rise would put 3,700 miles of road underwater and cost taxpayers billions of dollars.

Furthermore, the GGRA Plan is helping to clean up the air we breathe by investing in clean renewable energy instead of polluting fossil fuels. The National Academy of Sciences estimates that illness caused by polluting energy sources costs Maryland households an average of $73 per month. Replacing dirty energy sources with more clean energy will improve our health and save Maryland money.

On the other hand, current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal would result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Georgia Conroy

Janet Rivas
1033 S Beechfield Ave
Baltimore, MD 21229-4939
(207) 210-7144

Jul 1, 2015

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Heather Moyer
2002 Grinnalds Ave
Baltimore, MD 21230-1509
(410) 368-1323

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Joan Murtagh
7115 Garland Ave
Takoma Park, MD 20912-6421
(301) 270-4342

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Rebecca Oliver
23 Loring Ct
Sparrows Point, MD 21219-1430

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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On the other hand, current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal would result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Rebecca Oliver

Robby Roberts
1908 Forest Dr
Annapolis, MD 21401-4340
(410) 267-7769

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Robby Roberts

Rusty Simpson
2110 Park Ave
Baltimore, MD 21217-4819
(410) 527-9999

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Rusty Simpson

Kristen Friedel
1703 E West Hwy Apt 618
Silver Spring, MD 20910-3034

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Kristen Friedel

Albert Garcia-Romeu
231 S Wolfe St
Baltimore, MD 21231-2622

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Albert Garcia-Romeu

Timothy Judson
7333 New Hampshire Ave
Takoma Park, MD 20912-6958

Jul 1, 2015

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Sincerely,
Timothy Judson

Kristin Person
3621 Roland Ave
Baltimore, MD 21211-2449

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Kristin Person

Frode Jacobsen
7721 Paddock Way
Windsor Mill, MD 21244-1292

Jul 1, 2015

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Sincerely,
Frode Jacobsen

Grace Morsberger
4826 Langdrum Ln
Chevy Chase, MD 20815-5413

Jul 1, 2015

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Sincerely,
Grace Morsberger

Anne Bastian
1523 Enyart Way Unit 303
Annapolis, MD 21409-5963
(443) 949-0635

Jul 1, 2015

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Sincerely,
Anne Bastian

Carol Casey
2213 Canary Ct
Baltimore, MD 21231-2725

Jul 1, 2015

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Sincerely,
Carol Casey

Ronald Schlesinger
5801 Nicholson Ln Apt 1205
Rockville, MD 20852-5725
(301) 881-3363

Jul 1, 2015

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Ronald Schlesinger

Kaleena Johnson
5055 Clifford Rd
Perry Hall, MD 21128-9155

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Sincerely,
Kaleena Johnson

Frances Hickey
7701 Winterberry Pl
Bethesda, MD 20817-4849

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Robert Gole
9400 Ewing Dr
Bethesda, MD 20817-2436
(301) 530-5818

Jul 1, 2015

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Robert Gole

Terren Leyden
4 Stag Horn Ct
Cockeysville, MD 21030-4123

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Sincerely,
Terren Leyden

Elizabeth Lertch
607 Somerset Rd Apt 5
Baltimore, MD 21210-2733
(410) 718-9580

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

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Sincerely,
Elizabeth Lertch

Wayne Schafer
719 Maiden Choice Ln Apt Br421
Catonsville, MD 21228-6194
(443) 575-6042

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Wayne Schafer

Eileen Zimmerly
116 Fairview Ave. N
# 1
Bethesda, MD 20814-1745
(301) 897-0240

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Eileen Zimmerly

Barbara Shaffer
4900 Bangor Dr
Kensington, MD 20895-1212

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Barbara Shaffer

Lorraine Pearsall
7708 Takoma Ave
Takoma Park, MD 20912-4126
(301) 585-8062

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Lorraine Pearsall

Richard Spittel
5506 Rockleigh Dr
Halethorpe, MD 21227-2824

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Richard Spittel

Ferold Torchenot
7080 Cradlerock Way
Columbia, MD 21045-4842
(443) 812-5405

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Ferold Torchenot

Toni Freeman
2804 Southbrook Rd
Dundalk, MD 21222-2238
(410) 282-9450

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
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Ana Hart
2909 Gibbons Ave
Baltimore, MD 21214-2221

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Ana Hart

Ashleigh Mott
28 Oak Shade Rd
Gaithersburg, MD 20878-1046
(240) 997-8567

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Ashleigh Mott

Kim Cooke
708 Northwest Dr
Silver Spring, MD 20901-1432
P

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Kim Cooke

Sienna Wagner
7101 Marlborough Dr
Baltimore, MD 21234-7525
(443) 454-2564

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Sienna Wagner

Ann Borlo
4100 Byeforde Ct
Kensington, MD 20895-3605

Jul 1, 2015

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Sincerely,
Ann Borlo

Geoffrey Goodson
TOWSON University
Towson, MD 21252-0001
(410) 704-2893

Jul 1, 2015

Maryland Commission on Climate Change

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Kristine Amari
10338 Sixpence Cir
Columbia, MD 21044-3807
(828) 668-2633

Jul 1, 2015

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Sincerely,
Kristine Amari

Anette Stauske
1087 Wayson Way
Davidsonville, MD 21035-2202
(410) 798-1633

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

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Sincerely,
Anette Stauske

Bobby Bauer
10422 Inwood Ave
Wheaton, MD 20902-3846
(301) 649-6262

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Bobby Bauer

Eugene Clark
5829 Winding Oaks Ct
Frederick, MD 21704-6865
(240) 818-5852

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Eugene Clark

Jordann Wine
8500 Meadowlark Ln
Bethesda, MD 20817-2921

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Jordann Wine

Birgit Sharp
585 Fairhaven Rd
Tracys Landing, MD 20779-2506
(732) 690-0910

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Birgit Sharp

Stephen Berte
201 Ali Dr
Middletown, MD 21769-7866
(240) 285-9611

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Stephen Berte

Brenda Braham
12217 Peach Crest Dr Apt C
Germantown, MD 20874-2545
(301) 540-5383

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Brenda Braham

Kevin Walsh
8508 16th St
Silver Spring, MD 20910-2969
(203) 313-8841

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Kevin Walsh

Maryann Almond
8040 Quarterfield Rd
Severn, MD 21144-2115
(410) 969-5841

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Maryann Almond

Carlos Arieira
11552 Brandy Hall Ln
North Potomac, MD 20878-2426

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Carlos Arieira

Bruce Trout
3518 Rosemary Ln
Ellicott City, MD 21042-1131
(410) 442-1141

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Bruce Trout

Martha Pirrone
1 N Church St
Middletown, MD 21769-8090
(301) 371-7590

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Martha Pirrone

Thomas Hervey
360 Old Trail Rd
Baltimore, MD 21212-1516
(410) 825-1081

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Thomas Hervey

Kim Derrickson
11 Kitzbuhel Rd
Parkton, MD 21120-9023
(410) 343-0774

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Kim Derrickson

Mara Aronovich
1131 University Blvd W
Silver Spring, MD 20902-3357

Jul 1, 2015

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Mara Aronovich

Jessica Peraza
8830 Piney Branch Rd
Silver Spring, MD 20903-3546
(240) 593-9211

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

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Sincerely,
Jessica Peraza

Sue Cohen
14403 Butternut Ct
Rockville, MD 20853-2324

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Sue Cohen

Pamela Mason
9 Bush Chapel Rd
Aberdeen, MD 21001-2911
(630) 485-1392

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Pamela Mason

Jamshid Lotfi
3 Houndstooth Ct
Owings Mills, MD 21117-1503
(410) 363-1042

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Jamshid Lotfi

Barbara Roberts
6079 Melbourne Ave
Deale, MD 20751-9719
(301) 261-9727

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Barbara Roberts

John Mcgarrity
10402 Gardiner Ave
Silver Spring, MD 20902-4109

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
John Mcgarrity

Emily Nolan
321 Lynn Manor Dr
Rockville, MD 20850-4429
(301) 801-4145

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Emily Nolan

Sandra Novotny
11407 Cam Ct
Kensington, MD 20895-1313

Jul 1, 2015

Maryland Commission on Climate Change

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Sandra Novotny

Elizabeth Perera
4605 Chestnut St
Bethesda, MD 20814-3723
(917) 575-9328

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Elizabeth Perera

Kevin Kriescher
4 E 32nd St Apt 106
Baltimore, MD 21218-3303
(315) 212-3445

Jul 1, 2015

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Sincerely,
Kevin Kriescher

Donna Dannals
9 Elizabeth Ct
Sparks, MD 21152-9444

Jul 1, 2015

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Donna Dannals

Douglas Sedon
19935 Beallsville Rd
Beallsville, MD 20839-3300
(301) 418-0886

Jul 1, 2015

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Douglas Sedon

Thomas Jones
913 Beaverbank Cir
Towson, MD 21286-3314

Jul 1, 2015

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Sincerely,
Thomas Jones

David Hurley
2010 Elm St
Bel Air, MD 21015-1504

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
David Hurley

Rowena Schokman
13130 Diamond Hill Dr
Germantown, MD 20874-5901

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Rowena Schokman

Sunil Misra
7025 Flintfeet Ln
Columbia, MD 21045-5206

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Sunil Misra

Charles Upton
11414 Cedar Ridge Dr
Potomac, MD 20854-3762
(240) 505-0416

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Charles Upton

Robert Black
16912 Glen Oak Run
Derwood, MD 20855-1517

Jul 1, 2015

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Sincerely,
Robert Black

Robert Woods
112 Weber St
Havre DE Grace, MD 21078-3910
(410) 939-4936

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Sincerely,
Robert Woods

William Derge
9435 Hickory View Pl
Montgomery Village, MD 20886-1410
(301) 926-6079

Jul 1, 2015

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Sincerely,
William Derge

St John Martin
635 Shore Rd
Severna Park, MD 21146-3427
(410) 647-6796

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
St John Martin

Albert Manus
4102 Spring View Dr
Jefferson, MD 21755-7907
(732) 363-7776

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Albert Manus

Richard Cashen
562 Stoney Hill Ct
Odenton, MD 21113-1850
(443) 961-3303

Jul 1, 2015

Maryland Commission on Climate Change

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Linda Gore
60 Oak Shade Rd
Gaithersburg, MD 20878-1048
(301) 990-7168

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Sincerely,
Linda Gore

Kristin Mcgovern
9863 Greenbriar Way
Middle River, MD 21220-1746

Jul 1, 2015

Maryland Commission on Climate Change

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Kristin Mcgovern

Kathy Poole
6101 Blackburn Ln
Baltimore, MD 21212-2513

Jul 1, 2015

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(410) 939-4936

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Sincerely,
Robert Woods

Rosa Shoshana Mintz Urquhart
8722 Leonard Dr
Silver Spring, MD 20910-5006
(240) 595-7109

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Sincerely,
Rosa Shoshana Mintz Urquhart

William Rakowski
3431 Woodstock Ave
Baltimore, MD 21213-1122

Jul 1, 2015

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
William Rakowski

Mark Welsh
3737 Harmony Church Rd
Havre DE Grace, MD 21078-1017
(443) 504-2998

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Mark Welsh

Jeanne Chisholm
6301 Wynkoop Blvd
Bethesda, MD 20817-5931
(720) 255-2512

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

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Sincerely,
Jeanne Chisholm

Julie Baldwin
1501 Rainbow Dr
Silver Spring, MD 20905-4142
(301) 388-0849

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Julie Baldwin

Randall Davis
3512 Northwind Rd
Parkville, MD 21234-1221

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Randall Davis

Robbie White
1401 Billman Ln
Silver Spring, MD 20902-1413
(301) 949-7223

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Robbie White

Christi Magruder
10428 Edgewood Ave
Silver Spring, MD 20901-1949
(301) 754-2117

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Christi Magruder

Mary Olson
9100 Chanute Dr
Bethesda, MD 20814-3941

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Mary Olson

Lisa Meyerhardt
600 Jasper St
Baltimore, MD 21201-1916

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Lisa Meyerhardt

Helena Doerr
1401 Poplar Run Dr
Silver Spring, MD 20906-6716

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Helena Doerr

Connie Schaefer
3500 Pear Tree Ct Apt 34
Silver Spring, MD 20906-2555

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Connie Schaefer

Joseph Walstrum
9106 Covered Bridge Rd
Parkville, MD 21234-2512
(410) 665-3039

Jul 1, 2015

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Sincerely,
Joseph Walstrum

Lawrence Somer
9116 Sudbury Rd
Silver Spring, MD 20901-3524

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Lawrence Somer

Donna Betteridge
14707 Winthrop Dr
Silver Spring, MD 20905-5871

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Donna Betteridge

Karina Marzban
237 Jay Dr
Rockville, MD 20850-4773

Jul 1, 2015

Maryland Commission on Climate Change

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Karina Marzban

John Wolford
515 S Washington St
Baltimore, MD 21231-3031
(410) 675-0376

Jul 1, 2015

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Douglas Smith
1333 Tall Timbers Dr
Crownsville, MD 21032-1531
(410) 923-0595

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Furthermore, the GGRA Plan is helping to clean up the air we breathe by investing in clean renewable energy instead of polluting fossil fuels. The National Academy of Sciences estimates that illness caused by polluting energy sources costs Maryland households an average of $73 per month. Replacing dirty energy sources with more clean energy will improve our health and save Maryland money.

On the other hand, current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal would result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Douglas Smith

Ruth Moreno
18025 Lafayette Dr
Olney, MD 20832-2130

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Ruth Moreno

Rheta Johnson
8033 Cobble Creek Cir
Potomac, MD 20854-2732

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Rheta Johnson

Anthony Iacovelli
234 Canfield Ter
Frederick, MD 21702-8712
(443) 956-0560

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Anthony Iacovelli

Steven Rosen
809 Hope Ct
Gaithersburg, MD 20878-1884
(301) 258-2719

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Steven Rosen

James Johnson
15010 Athey Rd
Burtonsville, MD 20866-1644

Jul 1, 2015

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Sincerely,
James Johnson

Ellis Woodward
3422 Seneca St
Baltimore, MD 21211-1415
(410) 243-4174

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Ellis Woodward

Jo Anne Kenney
26 Capricorn Ct
Rockville, MD 20855-2566
(301) 650-8660

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Jo Anne Kenney

Dianne Dunlap
8814 Washington St
Savage, MD 20763-9765

Jul 1, 2015

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Dianne Dunlap

Karan Hughes
3210 N Leisure World Blvd
Silver Spring, MD 20906-5698

Jul 1, 2015

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Sincerely,
Karan Hughes

Jeff Komisarof
9033 Rouen Ln
Potomac, MD 20854-3135
(215) 731-0630

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Sincerely,
Jeff Komisarof

Kelvin Hobson
4 Crosswall Ct
Nottingham, MD 21236-2610
(410) 931-2059

Jul 1, 2015

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Sincerely,
Kelvin Hobson

P Hickey
456 Worthington Rd
Millersville, MD 21108-1614

Jul 1, 2015

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Sincerely,
P Hickey

Amy Daugherty
1407 Parker Rd
Baltimore, MD 21227-1418
(443) 529-3960

Jul 1, 2015

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Sincerely,
Amy Daugherty

Kathy Carey
6692 Hillandale Rd
Chevy Chase, MD 20815-6406

Jul 1, 2015

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Sincerely,
Kathy Carey

Patricia Soffen
5310 Honey Ct
Ellicott City, MD 21043-8205
(410) 869-0552

Jul 1, 2015

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Patricia Soffen

Antonia De Chirico
Via Del Bosco 12
Mezzago, MD 20883

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

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Sincerely,
Antonia De Chirico

Andriana Canning
2415 Arapaho Way
Gambrills, MD 21054-1627

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Andriana Canning

Michele Shipp
22 Anna Ct
Gaithersburg, MD 20877-3429

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Michele Shipp

John Lundquist
237 S Ellwood Ave
Baltimore, MD 21224-2211
(410) 534-0360

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
John Lundquist

Frank Dall
PO Box 86467
Montgomery Village, MD 20886-6467
(301) 527-0508

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Frank Dall

Jason Clancy
307 Meares Ct
Annapolis, MD 21401-4217

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Jason Clancy

James Balder
2124 Freeland Rd
Freeland, MD 21053-9587

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
James Balder

Louis Ostrach
9303 Chanute Dr
Bethesda, MD 20814-3944
(240) 475-3699

Jul 1, 2015

Maryland Commission on Climate Change

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Louis Ostrach

Stacey Wolfe
8225 Bodkin Ave
Lake Shore, MD 21122-4752

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Stacey Wolfe

Wilfred Candler
1514 Winchester Rd
Annapolis, MD 21409-5848
(410) 757-5626

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Wilfred Candler

Jill Lambe
720 Bayfield St
Takoma Park, MD 20912-7302
(301) 434-9599

Jul 1, 2015

Maryland Commission on Climate Change

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Rhea Troffkin
7808 Ivymount Ter
Potomac, MD 20854-3218

Jul 1, 2015

Maryland Commission on Climate Change

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Rhea Troffkin

Betty Krier
6612 Poplar Ave
Takoma Park, MD 20912-4813
(301) 270-0503

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Betty Krier

James Togashi
3959 Wendy Ct
Silver Spring, MD 20906-5270
(301) 949-1786

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
James Togashi

Ellen Scaruffi
1 Belleview Dr
Severna Park, MD 21146-4845
(410) 544-5594

Jul 1, 2015

Maryland Commission on Climate Change

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Ellen Scaruffi

Louise Gregg
5701 Chinquapin Pkwy Apt D
Baltimore, MD 21239-2554
(210) 663-2635

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Louise Gregg

Zach Bowser
12386 Boncrest Dr
Reisterstown, MD 21136-1708
(443) 668-9618

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Zach Bowser

Christine Katz
4304 Calvert Cir
Frederick, MD 21703-7551
(301) 509-6936

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Christine Katz

Sarah Pollock
6413 Lochridge Rd
Columbia, MD 21044-4032

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Sarah Pollock

Anthony Meoni
14125 Clarksville Pike
Highland, MD 20777-9524
(301) 854-0777

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Anthony Meoni

Harry Knox
9900 Georgia Ave Apt 615
Silver Spring, MD 20902-5243
(301) 589-8042

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Harry Knox

David Stoddard
3316 Kilkenny St
Silver Spring, MD 20904-1735

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
David Stoddard

Alan Oresky
15620 Aitcheson Ln
Laurel, MD 20707-3031
(301) 549-1918

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Alan Oresky

Debbie Gousha
3315 Willoughby Rd
Parkville, MD 21234-4831
(410) 665-1205

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Debbie Gousha

Mary Russell
107 S Clinton St
Baltimore, MD 21224-2341

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Mary Russell

Jeffrey Myers
10 Stitchberry Ct
Reisterstown, MD 21136-3215
(410) 526-5851

Jul 1, 2015

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Sincerely,
Jeffrey Myers

Norman Handwerger
7023 Concord Rd
Pikesville, MD 21208-6004
(410) 486-0261

Jul 1, 2015

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Sincerely,
Norman Handwerger

Erika Tait
Watkins Rd
Germantown, MD 20876

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Erika Tait

Eric Nylen
4800 Auburn Ave Apt 1102
Bethesda, MD 20814-4060
(301) 897-8714

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Eric Nylen

Laura Welch
7118 Cedar Ave
Takoma Park, MD 20912-4252
(301) 565-4399

Jul 1, 2015

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Laura Welch

Donald Haendiges
1158 Annis Squam Harbour
Pasadena, MD 21122-2552
(410) 255-6014

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Donald Haendiges

Angela Bailey
1922 Wilkens Ave # 1
Baltimore, MD 21223-3444
(443) 621-4898

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

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Sincerely,
Angela Bailey

Amanda Milster
198 Halpine Rd Apt 1237
Rockville, MD 20852-7612
(314) 322-1080

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Amanda Milster

Sean Konig
8500 16th St
Silver Spring, MD 20910-2966

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Sean Konig

Doug Krause
31 Battleford Bay
fargo, MD 21230-3405
(555) 555-5555

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Doug Krause

Alan Wojtalik
3723 Green Oak Ct
Baltimore, MD 21234-4258

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Alan Wojtalik

Susannah Phillips
864 Stonehurst Ct
Annapolis, MD 21409-4663

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Susannah Phillips

M. Langelan
7215 Chestnut St
Chevy Chase, MD 20815-4051
(301) 654-0175

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
M. Langelan

Pier Mantovani
9039 Sligo Creek Pkwy Apt 503
Silver Spring, MD 20901-3300
(240) 555-5555

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Pier Mantovani

Anna Mcnaught
742 E Lake Ave
Baltimore, MD 21212-3135

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Anna Mcnaught

Dave Bucklin
613 S Streeper St
Baltimore, MD 21224-3831

Jul 1, 2015

Maryland Commission on Climate Change

Subject: PLEASE Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

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Dave Bucklin

Alison Bucklin
613 S Streeper St
Baltimore, MD 21224-3831

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Do the right thing for Marylanders!! Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Alison Bucklin

Omar Siddique
4517 Rebecca Ct
Ellicott City, MD 21043-6010
(410) 465-8504

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Omar Siddique

Kathryn Bernson
1313 Hollins St
Baltimore, MD 21223-2415

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Kathryn Bernson

Regina Minniss
6 W Mount Vernon Pl Apt 301
Baltimore, MD 21201-5189

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Regina Minniss

Brad Knopf
1018 Magothy Park Ln
Annapolis, MD 21409-5300

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Brad Knopf

Carl Smith
8412 Each Leaf Ct
Columbia, MD 21045-5636

Jul 1, 2015

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Carl Smith

Lacey Levitt
111 Hamlet Hill Rd
Baltimore, MD 21210-1556

Jul 1, 2015

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Sincerely,
Lacey Levitt

Amy Dolina
1114 Charing Cross Dr
Crofton, MD 21114-1357
(410) 721-9185

Jul 1, 2015

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Sincerely,
Amy Dolina

Randy Murbach
4010 Macalpine Rd
Ellicott City, MD 21042-5325
(240) 565-0030

Jul 1, 2015

Maryland Commission on Climate Change

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Randy Murbach

Mary Grahe
538 Millshire Dr
Millersville, MD 21108-1621

Jul 1, 2015

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Sincerely,
Mary Grahe

jerry druch
3040 Barclay St
Baltimore, MD 21218-3936

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
jerry druch

Suhas Malghan
2411 Everton Rd
Baltimore, MD 21209-4305

Jul 1, 2015

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Ann Frankowski
9465 Black Velvet
Columbia, MD 21046-2016
(301) 498-1292

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Sincerely,
Ann Frankowski

Laura Smolar
6640 Sanzo Rd
Baltimore, MD 21209-2410

Jul 1, 2015

Maryland Commission on Climate Change

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Ruth Moreno
18025 Lafayette Dr
Olney, MD 20832-2130

Jul 1, 2015

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Ruth Moreno

Ellen Wilhite
5225 Pooks Hill Rd Apt 1106n
Bethesda, MD 20814-2044

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Ellen Wilhite

Tim Wadkins
65 Pine Tree Ln
Pisgah Forest, NC 28768-9559
(484) 786-3392

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Tim Wadkins

Jeff Maurer
6629 Commodore Ct
New Market, MD 21774-6697
(240) 939-0509

Jul 1, 2015

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Sincerely,
Jeff Maurer

J B Van Wely
2210 E Lombard St
Baltimore, MD 21231-2021
(555) 555-1212

Jul 1, 2015

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J B Van Wely

Molly Wilson
2439 Old National Pike
Middletown, MD 21769-9026

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Furthermore, the GGRA Plan is helping to clean up the air we breathe by investing in clean renewable energy instead of polluting fossil fuels. The National Academy of Sciences estimates that illness caused by polluting energy sources costs Maryland households an average of $73 per month. Replacing dirty energy sources with more clean energy will improve our health and save Maryland money.

On the other hand, current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal would result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Molly Wilson

James Langworthy
3114 Gracefield Rd Apt 112
Silver Spring, MD 20904-1894
(301) 586-0244

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
James Langworthy

Gillian Sawyer
10930 Little Sparrow Pl
Columbia, MD 21044-3673

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Gillian Sawyer

Anna Schrad
11001 Old Court Rd
Woodstock, MD 21163-1105

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Anna Schrad

Margaret Loomis
10206 Day Ave
Silver Spring, MD 20910-1042

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Margaret Loomis

Sima Bakalian
5012 Cloister Dr
Rockville, MD 20852-3364

Jul 1, 2015

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Sincerely,
Sima Bakalian

Gracinda Rodrigues
7831 Clark Station Rd
Severn, MD 21144-1912

Jul 1, 2015

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Sincerely,
Gracinda Rodrigues

Patricia James
22 Edgewood Green Ct
Annapolis, MD 21403-5510
(410) 280-6287

Jul 1, 2015

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Sincerely,
Patricia James

Pat Burton
17109 Qn Victoria Ct Apt 101
Gaithersburg, MD 20877-3620
(240) 632-9307

Jul 1, 2015

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Sincerely,
Pat Burton

Marian Katz
2420 Evans Dr
Silver Spring, MD 20902-4939
(301) 681-9363

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Marian Katz

Tahma Metz
5424 Beech Ave
Bethesda, MD 20814-1730

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Sincerely,
Tahma Metz

Dina Lassow
16 Hesketh St
Chevy Chase, MD 20815-4225
(301) 654-2733

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Dina Lassow

Vicki Ferguson
7117 Garland Ave
Takoma Park, MD 20912-6421
(301) 806-2571

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Miyako Zeng
7370 Hilltop Dr
Frederick, MD 21702-3602

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Mai Czerny
8126 Sommerville Drive
Gaithersburg, MD 20913

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Nancy Lyon
4911 Crescent St
Bethesda, MD 20816-1701
(301) 229-2452

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Nancy Lyon

Robert Rynasiewicz
329 Hopkins Rd
Baltimore, MD 21212-1820
(410) 377-9319

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

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Sincerely,
Robert Rynasiewicz

Beverly Chemai
13316 Waterside Cir
Germantown, MD 20874-3734
(240) 426-6646

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Beverly Chemai

Paulette MacMillan
5106 Maple Park Ave
Gwynn Oak, MD 21207-6516

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Paulette MacMillan

Kathryn Carpenter
2708 Fenimore Rd
Silver Spring, MD 20902-2610

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Kathryn Carpenter

Alfred Teuscher
6004 Ryland Dr
Bethesda, MD 20817-2543

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Alfred Teuscher

Heloisa Kinge
5411 McGrath Blvd
Rockville, MD 20852-8617

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Heloisa Kinge

Cheryl Belsley
6887 Sanderling Ct
New Market, MD 21774-6819

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Cheryl Belsley

Michiko Perry
6286 Wild Swan Way
Columbia, MD 21045-7417
(410) 290-0348

Jul 1, 2015

Maryland Commission on Climate Change

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Michiko Perry

Art Wagner
200 Oak Dr
Pasadena, MD 21122-4973
(111) 111-1111

Jul 1, 2015

Maryland Commission on Climate Change

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Sincerely,
Art Wagner

Vivi Spicer
629 Ritchie Ave
Silver Spring, MD 20910-5240
(301) 588-8396

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Vivi Spicer

myrene oconnor
14654 Good Hope Rd
Silver Spring, MD 20905-6018
(301) 518-4313

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
myrene oconnor

Anne Greene
17219 Quaker Ln
Sandy Spring, MD 20860-1266
(301) 570-3283

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Anne Greene

Patricia Chambers
PO Box 212
Abingdon, MD 21009-0212

Jul 2, 2015

Maryland Commission on Climate Change

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Malgorzata Schmidt
244 Dill Ave
Frederick, MD 21701-4906

Jul 2, 2015

Maryland Commission on Climate Change

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Derek Watkins
205 Pauline Ct
Arnold, MD 21012-1168

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Derek Watkins

Cristoforo Padula
5257 Buckeystown Pike
Frederick, MD 21704-7535
(240) 429-7939

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Cristoforo Padula

Christopher Ecker
9737 Lake Shore Dr
Gaithersburg, MD 20886-4264

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Christopher Ecker

David Land
821 Malibu Dr
Silver Spring, MD 20901-3649
(240) 863-3095

Jul 2, 2015

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Sincerely,
David Land

Nancy Plaxico
3303 Shore Dr
Annapolis, MD 21403-4724
(410) 280-1972

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Nancy Plaxico

Lucy Howard
2400 Castleton Rd
Darlington, MD 21034-1204
(410) 457-4112

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Lucy Howard

Kim Peabody
8524 Rhuddlan Rd
Nottingham, MD 21236-2622

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Que Tran
9502 Curran Rd
Silver Spring, MD 20901-4746

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Que Tran

Judith Konig
2916 Louise Ave
Baltimore, MD 21214-1239

Jul 2, 2015

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Tom Kim
12431 Loft Ln
Silver Spring, MD 20904-6604

Jul 2, 2015

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Tom Kim

Debra Morrison
7843 E Shore Rd
Pasadena, MD 21122-1667

Jul 2, 2015

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Ken Clark
9515 Red Rain Path
Columbia, MD 21046-2073
(301) 725-3306

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Ken Clark

james oconnor
14654 Good Hope Rd
Silver Spring, MD 20905-6018
(240) 246-7602

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
james oconnor

Adam Hovav
7209 Willowdale Ave
Baltimore, MD 21206-1248

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Adam Hovav

Ellie Robbins
5719 Ridgway Ave
Rockville, MD 20851-1927
(202) 763-2690

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Ellie Robbins

Jennifer Alford
2537 W Baltimore St
Baltimore, MD 21223-2001
(410) 303-8965

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Jennifer Alford

Christine Shenot
183 Doncaster Rd
Arnold, MD 21012-1040
(410) 241-6887

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Christine Shenot

Thomas Shireman
601 Robinhood Rd
Havre DE Grace, MD 21078-1915
(717) 669-1351

Jul 2, 2015

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Sincerely,
Thomas Shireman

Jessica Reynolds
8011 Hollow Reed Ct
Frederick, MD 21701-3276

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Jessica Reynolds

Dave Jordahl
317 S Church St
Middletown, MD 21769-8044

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Dave Jordahl

William Hovatter
3742 Roland Ave
Baltimore, MD 21211-2248

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
William Hovatter

Louise Jackman
128 Post Rd
Aberdeen, MD 21001-2534
(410) 602-8454

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Louise Jackman

Elizabeth Miller
13308 Wye Oak Dr
Darnestown, MD 20878-3538

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Elizabeth Miller

Laura Gousha
3314 Keswick Rd
Baltimore, MD 21211-2629

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Laura Gousha

Gloria Todman
5804 Hamlin Ave
Baltimore, MD 21215-3916

Jul 2, 2015

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Sincerely,
Gloria Todman

Ed Lough
4600 Roland Ave
Baltimore, MD 21210-2543
(410) 467-0000

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Ed Lough

Diana Lippy
2728 Waldor Dr
Baltimore, MD 21234-1032

Jul 2, 2015

Maryland Commission on Climate Change

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Diana Lippy

Erick Martinez
6314 Greenspring Ave
Baltimore, MD 21209-3231

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Sincerely,
Erick Martinez

Theresa O'Leary
5113 Crossfield Ct Apt 15
Rockville, MD 20852-2146
(301) 468-5723

Jul 2, 2015

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The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Theresa O'Leary

Kathy Allison
1704 McAuliffe Dr
Rockville, MD 20851-1160
(301) 774-9452

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

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Sincerely,
Kathy Allison

Robin Pollock
12510 Eastbourne Dr
Silver Spring, MD 20904-2039
(301) 538-4800

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Robin Pollock

Lorraine Raschiatore
3034 Brandt Ct Unit A
Fort Meade, MD 20755-1906

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Lorraine Raschiatore

Michael Dennis
137 Timberbrook Ln Apt 301
Gaithersburg, MD 20878-2878
(301) 947-4303

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Michael Dennis

Scott Douglass
301 Hart Rd
Gaithersburg, MD 20878-5793
(202) 689-4825

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Scott Douglass

Sarah Parr
1602 Twin Maple Ave
Baltimore, MD 21204-1955
(410) 321-0076

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Sarah Parr

Kendra Holt
1111 University Blvd W
Wheaton, MD 20902-3351

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Kendra Holt

Joan Gugerty
13907 Manor Rd
Baldwin, MD 21013-9608

Jul 2, 2015

Maryland Commission on Climate Change

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Joan Gugerty

Laurie Miller
8224 Brandon Dr
Millersville, MD 21108-1343
(410) 987-4505

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Laurie Miller

Lynn Johnson
5409 Bishops Head Ct
Columbia, MD 21044-1905

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Lynn Johnson

Jennifer Kunze
1402 Hollins St
Baltimore, MD 21223-2416
(240) 397-4126

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Jennifer Kunze

Robert Brosius
3010 Fallstaff Manor Ct
Baltimore, MD 21209-2823
(917) 678-1637

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Robert Brosius

Inghard Del Toro
13303 Dovedale Way Apt J
Germantown, MD 20874-4463
(972) 359-9218

Jul 2, 2015

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Sincerely,
Inghard Del Toro

Eleanor Milligan
228 Jefferson Pike
Knoxville, MD 21758-9625
(301) 834-9346

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Eleanor Milligan

Lauren Carney
17392 Tassajara Cir
Morgan Hill, CA 95037-7022
(408) 679-8071

Jul 2, 2015

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Sincerely,
Lauren Carney

Ahmand Page
1619 Winding Brook Way
Windsor Mill, MD 21244-1477

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Ahmand Page

Alan Stein
10 Glenamoy Rd Unit 301
Timonium, MD 21093-1998

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Alan Stein

Kristin Cook
9408 Jongroner Ct
Potomac, MD 20854-2826
(240) 483-6789

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Kristin Cook

David O'Leary
500 Albany Ave
Takoma Park, MD 20912-4140
(301) 577-2990

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
David O'Leary

Jim Krebs
2002 Stockton Rd
Phoenix, MD 21131-1130
(443) 222-2534

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Jim Krebs

Mark Chapin
1160 Green Holly Dr
Annapolis, MD 21409-4631
(410) 212-8949

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Mark Chapin

Rachel Toker
5227 Wyoming Rd
Bethesda, MD 20816-2269
(301) 229-3390

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Rachel Toker

K.R. Baker
319 Double Eagle Dr
Linthicum, MD 21090-2730

Jul 2, 2015

Maryland Commission on Climate Change

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Susan Valiga
1616 Marshall Ave
Rockville, MD 20851-1453

Jul 2, 2015

Maryland Commission on Climate Change

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Sincerely,
Susan Valiga

Jacqueline Walsh
1015 N Calvert St Apt 2
Baltimore, MD 21202-3828
(410) 322-9857

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Jacqueline Walsh

Katherine Gilbert
7105 Georgia St
Chevy Chase, MD 20815-4133
(301) 986-0618

Jul 3, 2015

Maryland Commission on Climate Change

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Sincerely,
Katherine Gilbert

Allan Davis
8304 Brookmere Blvd
Frederick, MD 21702-2346

Jul 3, 2015

Maryland Commission on Climate Change

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Sincerely,
Allan Davis

Philip Zimmermann
4105 Sweet Air Rd
Baldwin, MD 21013-9623

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Philip Zimmermann

Cynthia Skeen
9330 Wild Grass Ct
Jessup, MD 20794-9595

Jul 3, 2015

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Sincerely,
Cynthia Skeen

Naomi Dyer
15101 Falconbridge Ter
North Potomac, MD 20878-3410
(301) 515-8486

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Naomi Dyer

Tazuko Ichikawa
2609 Fenimore Rd
Silver Spring, MD 20902-2707
(301) 942-5104

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Tazuko Ichikawa

Alexa White
1000 Hilltop Cir
Baltimore, MD 21250-0001

Jul 3, 2015

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Sincerely,
Alexa White

Trisha Thomas
3334 Arundel On The Bay Rd
Annapolis, MD 21403-4735

Jul 3, 2015

Maryland Commission on Climate Change

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Sincerely,
Trisha Thomas

Cynthia Rafferty
804 Redwood Trl
Crownsville, MD 21032-1833

Jul 3, 2015

Maryland Commission on Climate Change

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Cynthia Rafferty

Carla Tevelow
10205 Wincopin Cir Apt 308
Columbia, MD 21044-3435

Jul 3, 2015

Maryland Commission on Climate Change

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Sincerely,
Carla Tevelow

Sigrid Dorf
79 Milburn Cir
Pasadena, MD 21122-6161
(410) 255-8330

Jul 3, 2015

Maryland Commission on Climate Change

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Sigrid Dorf

Barbara Filigenzi
2198 Hallmark Dr
Gambrills, MD 21054-2126
(410) 721-7842

Jul 3, 2015

Maryland Commission on Climate Change

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Sincerely,
Barbara Filigenzi

Elliott & Adele Fein
5 Carter Ct
Rockville, MD 20852-1005
(301) 762-6261

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Elliott & Adele Fein

Mike Moran
10660 Greenbough Ct
Columbia, MD 21044-2210
(410) 884-6792

Jul 3, 2015

Maryland Commission on Climate Change

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Sincerely,
Mike Moran

Carol Dean
925 Bowleys Quarters Rd
Baltimore, MD 21220-4012

Jul 3, 2015

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Sincerely,
Carol Dean

Lisa Childress
5302 Quail Creek Ct
Ijamsville, MD 21754-9517

Jul 3, 2015

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Lisa Childress

Wayne Straight
961 Day Rd
Sykesville, MD 21784-5604
(410) 555-5555

Jul 3, 2015

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Wayne Straight

Evan Krichevsky
9205 Copenhaver Dr
Potomac, MD 20854-3016
(301) 251-0619

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Evan Krichevsky

Rick Thomason
20133 Laurel Hill Way
Germantown, MD 20874-1021

Jul 3, 2015

Maryland Commission on Climate Change

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Sincerely,
Rick Thomason

George Kramer
1720 Elkridge Dr
Edgewater, MD 21037-2341

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
George Kramer

Linda & James Seewagen
9925 Whitworth Way
Ellicott City, MD 21042-5625
(410) 465-6749

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Linda & James Seewagen

Kelley Dempsey
5342 Saint James Pl
Frederick, MD 21703-2834
(301) 524-3689

Jul 3, 2015

Maryland Commission on Climate Change

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Sincerely,
Kelley Dempsey

Marilyn Story
906 Palladi Dr
Baltimore, MD 21227-1236
(410) 948-5174

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Marilyn Story

Leslie Englehart
5200 Kalmia Dr
Dayton, MD 21036-1232
(301) 922-6004

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Leslie Englehart

Russell Donnelly
2114 Oak Rd
Baltimore, MD 21219-2214
(410) 388-0898

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Russell Donnelly

Andrew Ireland
7525 Hampden Ln
Bethesda, MD 20814-1331
(240) 328-9691

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Andrew Ireland

catherine scott
maryland avenue
bethesda, MD 20816

Jul 3, 2015

Maryland Commission on Climate Change

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Sincerely,
catherine scott

Rosetta Rizzo
7 Foxleigh Grn
Lutherville Timonium, MD 21093-4521
(410) 494-0336

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Rosetta Rizzo

Maxwell Dudek
5014 Hampden Ln
Bethesda, MD 20814-2309

Jul 3, 2015

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Sincerely,
Maxwell Dudek

Izzy Q
9641 Reach Rd
Potomac, MD 20854-2857
(301) 309-6170

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Izzy Q

Marsha Jenkins
9494 Greco Garth
Columbia, MD 21045-4415

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Marsha Jenkins

Veronica Poklemba
11209 Jon Ct
Ijamsville, MD 21754-9118
(301) 865-4829

Jul 4, 2015

Maryland Commission on Climate Change

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Sincerely,
Veronica Poklemba

Lilian Burch
7111 Woodmont Ave Apt 504
Bethesda, MD 20815-6233

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Lilian Burch

Linda Wolfe
11307 Empire Ln
Rockville, MD 20852-2864
(301) 299-8102

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Linda Wolfe

Ruth Carr
9707 Old Georgtwn Rd Apt 2519
Bethesda, MD 20814-1761
(301) 897-7374

Jul 4, 2015

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Sincerely,
Ruth Carr

Kathryn Miller
7914 Stonehearth Rd
Severn, MD 21144-1437
(410) 551-4203

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Kathryn Miller

Sally Yost
6303 Blenheim Rd
Baltimore, MD 21212-2502
(410) 377-2982

Jul 4, 2015

Maryland Commission on Climate Change

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Sincerely,
Sally Yost

Alan Penczek
19 Jonathans Ct
Cockeysville, MD 21030-1419

Jul 4, 2015

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Sincerely,
Alan Penczek

Maryanne Martin Bailey
18 Marshs Victory Ct
Catonsville, MD 21228-2439
(410) 747-8489

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Maryanne Martin Bailey

Joann Schropp
840 South River Landing Rd
Edgewater, MD 21037-1555
(443) 607-8528

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Joann Schropp

Dessie Beale
3449 Falls Rd
Baltimore, MD 21211-2405

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Dessie Beale

Rolyn Mackenzie
5019 Norrisville Rd
White Hall, MD 21161-9503

Jul 4, 2015

Maryland Commission on Climate Change

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Sincerely,
Rolyn Mackenzie

John Oliva
2900 Shipmaster Way Apt 305
Annapolis, MD 21401-7808
(410) 224-6708

Jul 4, 2015

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Sincerely,
John Oliva

Steve Shapiro
3007 Westfield Ave
Baltimore, MD 21214-1434
(410) 550-0067

Jul 4, 2015

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Sincerely,
Steve Shapiro

Sharon Bowyer
632 Harvey St
Baltimore, MD 21230-4727
(410) 752-6859

Jul 4, 2015

Maryland Commission on Climate Change

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Sincerely,
Sharon Bowyer

Richard Brewster
10 Oakwood Rd
Baltimore, MD 21222-2407

Jul 4, 2015

Maryland Commission on Climate Change

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Sincerely,
Richard Brewster

Marta Schley
4522 Middleton Ln
Bethesda, MD 20814-3514
(301) 652-8109

Jul 4, 2015

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Marta Schley

Michael Virga
12225 Stardrift Dr
Germantown, MD 20876-5918

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Michael Virga

Pat O'Brien
15 Clarion Ct
Cockeysville, MD 21030-2653
(410) 628-7107

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Pat O'Brien

Virginia Whalen
2401 Forest Edge Ct Unit 103l
Odenton, MD 21113-2841
(410) 744-6674

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Virginia Whalen

Joanne Cafiero
14112 Castaway Dr
Rockville, MD 20853-2626
(301) 460-2759

Jul 4, 2015

Maryland Commission on Climate Change

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Sincerely,
Joanne Cafiero

Colm Gage
18781 Nathans Pl
Montgomery Village, MD 20886-4241
(301) 926-7765

Jul 5, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Colm Gage

Craig Taylor
433 Essexwood Ct
Essex, MD 21221-6813

Jul 5, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Sincerely,
Craig Taylor

Harry Cording
530 Meadow Hall Dr
Rockville, MD 20851-1556

Jul 5, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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Harry Cording

James David
14220 Bradshaw Dr
Silver Spring, MD 20905-6503

Jul 5, 2015

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James David

Craig Beach
417 Cockeys Mill Rd
Reisterstown, MD 21136-5111

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Sincerely,
Craig Beach

Robert M. Brown
2315 Salem Village Rd Apt F
Baltimore, MD 21234-2554
(410) 663-0973

Jul 5, 2015

Maryland Commission on Climate Change

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Sincerely,
Robert M. Brown

Erin Subramanian
613 Joppa Farm Rd
Joppa, MD 21085-4445

Jul 5, 2015

Maryland Commission on Climate Change

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Sincerely,
Erin Subramanian

Paul Shread
12180 Flowing Water Trl
Clarksville, MD 21029-1682

Jul 5, 2015

Maryland Commission on Climate Change

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Paul Shread

David Grauer
111 Park Dr
Catonsville, MD 21228-5153
(410) 744-0791

Jul 5, 2015

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Sincerely,
David Grauer

Cecilia Dalnekoff
2532 Carrollton Rd
Annapolis, MD 21403-4203
(410) 269-0382

Jul 5, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

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2532 Carrollton Rd
Annapolis, MD 21403-4203

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Cecilia Dalnekoff

Carol Casey
2213 Canary Ct
Baltimore, MD 21231-2725

Jul 6, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Carol Casey

Wayne Zink
805 Quincy Rd
Baltimore, MD 21286-7806
(443) 561-9010

Jul 6, 2015

Maryland Commission on Climate Change

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Sincerely,
Wayne Zink

James David
14220 Bradshaw Dr
Silver Spring, MD 20905-6503

Jul 6, 2015

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Sincerely,
James David

Cheryl Fahlman
9224 Sandy Lake Cir
Gaithersburg, MD 20879-1478
(301) 208-9174

Jul 6, 2015

Maryland Commission on Climate Change

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Sincerely,
Cheryl Fahlman

Stephanie Compton
107 W 29th St Apt 3
Baltimore, MD 21218-4737
(443) 253-2581

Jul 6, 2015

Maryland Commission on Climate Change

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Sincerely,
Stephanie Compton

Lezlie Ramsey
8641 Pete Wiles Rd
Middletown, MD 21769-8908

Jul 6, 2015

Maryland Commission on Climate Change

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Sincerely,
Lezlie Ramsey

Laurel Peltier
4 Bellemore Rd
Baltimore, MD 21210-1313
(443) 857-7777

Jul 6, 2015

Maryland Commission on Climate Change

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Sincerely,
Laurel Peltier

Stephanie Joyner
406 Harwood Rd
Catonsville, MD 21228-5813
(410) 747-2812

Jul 6, 2015

Maryland Commission on Climate Change

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Sincerely,
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Nikki Wojtalik
3723 Green Oak Ct
Parkville, MD 21234-4258

Jul 7, 2015

Maryland Commission on Climate Change

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Sincerely,
Nikki Wojtalik

Angela Miotto
3142 Gracefield Rd
Silver Spring, MD 20904-5852
(301) 441-3910

Jul 7, 2015

Maryland Commission on Climate Change

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Sincerely,
Angela Miotto

Naomi Kumar
19213 Bonmark Ct
Germantown, MD 20874-1449

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Sincerely,
Naomi Kumar

Daniel Inman
7073 Gresham Ct W
Frederick, MD 21703-9527
(301) 378-3150

Jul 7, 2015

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Sincerely,
Daniel Inman

Natalie Mebane
13818 Notley Rd
# 20904
Silver Spring, MD 20904-1120
(240) 432-6365

Jul 7, 2015

Maryland Commission on Climate Change

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Sincerely,
Natalie Mebane

Russell Rohrback
155 Allendale Ave
Aberdeen, MD 21001-2001
(410) 202-8262

Jul 7, 2015

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Sincerely,
Russell Rohrback

Christy Berman
4503 Araby Church Rd
Frederick, MD 21704-7704
(301) 662-7582

Jul 7, 2015

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Christy Berman

Carmen Leitch
1207 Glyndon Ave
Baltimore, MD 21223-3612

Jul 8, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

With more than 3,000 miles of tidal shoreline, Maryland is the third most vulnerable state to sea level rise -- one of the major consequences of climate change. Large swaths of the state along the Chesapeake Bay, including Baltimore's Inner Harbor, are already experiencing higher incidence of flooding each year due to rising seas. As previously found by Maryland scientists, a continued increase in greenhouse gas emissions would mean sea level rise more than 5 feet by the end of the century. To put that in perspective, 5 feet of sea level rise would put 3,700 miles of road underwater and cost taxpayers billions of dollars.

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Sincerely,
Carmen Leitch

Nancy Pirtle-Connelly
1803 Winans Ave
Baltimore, MD 21227-4438

Jul 8, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Nancy Pirtle-Connelly

John Kester
624 Sonata Way
Silver Spring, MD 20901-5001
(301) 754-1260

Jul 8, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan! & support higher Renewable Stds

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
John Kester

Abby Anderson
W 3rd St
Frederick, MD 21701

Jul 10, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

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Sincerely,
Abby Anderson

Corrine Mohnasky
360 Dameron S
Laurel, MD 20724-2441
(301) 498-7975

Jul 10, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Corrine Mohnasky

Joel Peck
3011 Rices Ln
Windsor Mill, MD 21244-1357

Jul 11, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Joel Peck

Nitin Agarwal
348 Market St E
Gaithersburg, MD 20878-6442

Jul 11, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Nitin Agarwal

Jul 1, 2015

Maryland Commission on Climate Change
Maryland Department of Environment
1800 Washington Boulevard
Baltimore, MD 21230-1720
climate.change@maryland.gov

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

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Sincerely,
Sierra Club Supporter

| DATE_SUBMITTED | LAST_NAM | FIRST_NAM | HOME_STREET1 | HOME_CITY |
|---|---|---|---|---|
| 7/2/2015 6:33 | Parker | Jeanette | 308 Audrey Ave | Brooklyn |
| 7/1/2015 17:29 | Myers | Jeffrey | 10 Stitchberry Ct | Reisterstown |
| 7/1/2015 14:33 | Aronovich | Mara | 1131 University Blvd W | Silver Spring |
| 7/1/2015 16:52 | Katz | Christine | 4304 Calvert Cir | Frederick |
| 7/1/2015 20:39 | James | Patricia | 22 Edgewood Green Ct | Annapolis |
| 7/1/2015 14:51 | Derge | William | 9435 Hickory View Pl | Montgomery Village |
| 7/1/2015 14:43 | Dannals | Donna | 9 Elizabeth Ct | Sparks |
| 7/1/2015 18:37 | Peters | Sarah | 6070 California Cir Apt 308 | Rockville |
| 7/2/2015 11:46 | Gugerty | Joan | 13907 Manor Rd | Baldwin |
| 7/1/2015 21:09 | Metz | Tahma | 5424 Beech Ave | Bethesda |
| 7/1/2015 21:27 | Cowan | Donald & A | 600 Hawkesbury Ln | Silver Spring |
| 7/2/2015 7:48 | Clark | Ken | 9515 Red Rain Path | Columbia |
| 7/8/2015 18:19 | Kester | John | 624 Sonata Way | Silver Spring |
| 7/3/2015 8:49 | Dyer | Naomi | 15101 Falconbridge Ter | North Potomac |
| 7/2/2015 21:30 | Toker | Rachel | 5227 Wyoming Rd | Bethesda |
| 7/1/2015 18:06 | Wojtalik | Alan | 3723 Green Oak Ct | Baltimore |
| 7/1/2015 15:17 | Davis | Randall | 3512 Northwind Rd | Parkville |
| 7/3/2015 14:11 | Filigenzi | Barbara | 2198 Hallmark Dr | Gambrills |
| 7/2/2015 8:18 | Wasserman | Barbara | 13200 Triadelphia Rd | Ellicott City |
| 7/1/2015 19:38 | Wadkins | Tim | 1015 Ripley St Apt 102 | Silver Spring |
| 7/1/2015 14:30 | Trout | Bruce | 3518 Rosemary Ln | Ellicott City |
| 7/4/2015 11:41 | Miller | Kathryn | 7914 Stonehearth Rd | Severn |
| 7/8/2015 13:01 | Leitch | Carmen | 1207 Glyndon Ave | Baltimore |
| 7/2/2015 6:14 | Peabody | Al | 8524 Rhuddlan Rd | Nottingham |
| 7/1/2015 13:59 | Conroy | Georgia | 1772 Lang Dr | Crofton |
| 7/1/2015 14:53 | Manus | Albert | 4102 Spring View Dr | Jefferson |
| 7/1/2015 14:00 | Rivas | Janet | 1033 S Beechfield Ave | Baltimore |
| 7/1/2015 16:06 | Hickey | P | 456 Worthington Rd | Millersville |
| 7/1/2015 18:55 | Minniss | Regina | 6 W Mount Vernon Pl Apt 301 | Baltimore |
| 7/1/2015 15:12 | Chisholm | Jeanne | 6301 Wynkoop Blvd | Bethesda |
| 7/1/2015 14:28 | Lentz | Mike | 1505 Featherwood St | Silver Spring |
| 7/1/2015 16:40 | Neimark | S. | 12908 Ruxton Rd | Silver Spring |
| 7/1/2015 14:46 | Schokman | Rowena | 13130 Diamond Hill Dr | Germantown |
| 7/1/2015 19:00 | Knopf | Brad | 1018 Magothy Park Ln | Annapolis |
| 7/1/2015 18:54 | Bernson | Kathryn | 1313 Hollins St | Baltimore |
| 7/2/2015 14:19 | Del Toro | Inghard | 13303 Dovedale Way Apt J | Germantown |
| 7/1/2015 21:32 | Zeng | Miyako | 7370 Hilltop Dr | Frederick |
| 7/1/2015 15:29 | Doerr | Helena | 1401 Poplar Run Dr | Silver Spring |
| 7/1/2015 14:46 | Sedon | Douglas | 19935 Beallsville Rd | Beallsville |
| 7/2/2015 16:05 | O'Leary | David | 500 Albany Ave | Takoma Park |
| 7/1/2015 15:41 | Johnson | Rheta | 8033 Cobble Creek Cir | Potomac |
| 7/1/2015 19:24 | Frankowski | Ann | 9465 Black Velvet | Columbia |
| 7/1/2015 14:27 | Braham | Brenda | 12217 Peach Crest Dr Apt C | Germantown |
| 7/2/2015 15:49 | Cook | Kristin | 9408 Jongroner Ct | Potomac |
| 7/1/2015 14:06 | Lertch | Elizabeth | 607 Somerset Rd Apt 5 | Baltimore |
| 7/2/2015 10:44 | Dennis | Michael | 137 Timberbrook Ln Apt 301 | Gaithersburg |

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|---|---|---|---|---|
| 7/4/2015 12:56 | Martin Bail | Maryanne | 18 Marshs Victory Ct | Catonsville |
| 7/1/2015 14:32 | Derrickson | Elissa And I | 11 Kitzbuhel Rd | Parkton |
| 7/3/2015 15:57 | Krichevsky | Evan | 9205 Copenhaver Dr | Potomac |
| 7/1/2015 14:00 | Moyer | Heather | 2002 Grinnalds Ave | Baltimore |
| 7/1/2015 21:31 | Ferguson | Vicki | 7117 Garland Ave | Takoma Park |
| 7/2/2015 9:45 | O'Leary | Theresa | 5113 Crossfield Ct Apt 15 | Rockville |
| 7/1/2015 17:02 | Meoni | Anthony | 14125 Clarksville Pike | Highland |
| 7/4/2015 15:57 | Oliva | John | 2900 Shipmaster Way Apt 305 | Annapolis |
| 7/1/2015 15:58 | Komisarof | Jeff | 9033 Rouen Ln | Potomac |
| 7/3/2015 20:22 | Donnelly | Russell | 2114 Oak Rd | Baltimore |
| 7/3/2015 21:50 | Rizzo | Rosetta | 7 Foxleigh Grn | Lutherville Timonium |
| 7/2/2015 9:46 | Allison | Kathy | 1704 McAuliffe Dr | Rockville |
| 7/1/2015 19:08 | Murbach | Randy | 4010 Macalpine Rd | Ellicott City |
| 7/2/2015 0:19 | O'Connor | Myrene | 14654 Good Hope Rd | Silver Spring |
| 7/1/2015 14:01 | Murtagh | Joan | 7115 Garland Ave | Takoma Park |
| 7/5/2015 15:31 | Beach | Craig | 417 Cockeys Mill Rd | Reisterstown |
| 7/1/2015 14:49 | Woods | Robert | 112 Weber St | Havre DE Grace |
| 7/1/2015 14:37 | Lotfi | Jamshid | 3 Houndstooth Ct | Owings Mills |
| 7/1/2015 14:03 | Morsberge | Grace | 4826 Langdrum Ln | Chevy Chase |
| 7/1/2015 15:18 | White | Robbie | 1401 Billman Ln | Silver Spring |
| 7/1/2015 15:45 | Kenney | Jo Anne | 26 Capricorn Ct | Rockville |
| 7/3/2015 19:51 | Englehart | Leslie | 5200 Kalmia Dr | Dayton |
| 7/4/2015 12:46 | Penczek | Alan | 19 Jonathans Ct | Cockeysville |
| 7/1/2015 17:43 | Welch | Laura | 7118 Cedar Ave | Takoma Park |
| 7/1/2015 14:53 | Cashen | Richard | 1 W Conway St Apt 1414 | Baltimore |
| 7/1/2015 16:26 | Candler | Wilfred | 1514 Winchester Rd | Annapolis |
| 7/2/2015 8:06 | Shenot | Christine | 183 Doncaster Rd | Arnold |
| 7/4/2015 21:26 | Whalen | Virginia | 2401 Forest Edge Ct Unit 103l | Odenton |
| 7/1/2015 15:27 | Olson | Mary | 9100 Chanute Dr | Bethesda |
| 7/1/2015 18:20 | Langelan | M J | 7215 Chestnut St | Chevy Chase |
| 7/1/2015 14:05 | Gole | Robert | 9400 Ewing Dr | Bethesda |
| 7/1/2015 14:10 | Freeman | Toni | 2804 Southbrook Rd | Dundalk |
| 7/1/2015 15:41 | Iacovelli | Anthony | 234 Canfield Ter | Frederick |
| 7/2/2015 8:33 | Jordahl | Dave | 317 S Church St | Middletown |
| 7/1/2015 18:47 | Siddique | Omar | 4517 Rebecca Ct | Ellicott City |
| 7/2/2015 13:06 | Kunze | Jennifer | 1402 Hollins St | Baltimore |
| 7/2/2015 12:49 | Bannister | Susan | 5418 High Tor Hl | Columbia |
| 7/2/2015 4:44 | Plaxico | Nancy | 3303 Shore Dr | Annapolis |
| 7/3/2015 13:50 | Dorf | Sigrid | 79 Milburn Cir | Pasadena |
| 7/5/2015 15:53 | Brown | Robert | 2315 Salem Village Rd Apt F | Baltimore |
| 7/10/2015 14:55 | Mohnasky | Corrine | 360 Dameron S | Laurel |
| 7/1/2015 14:25 | Berte | Stephen | 201 Ali Dr | Middletown |
| 7/1/2015 14:29 | Almond | Maryann | 8040 Quarterfield Rd | Severn |
| 7/1/2015 14:42 | Allen | Philip | 3463 Rockway Ave | Annapolis |
| 7/1/2015 17:37 | Nylen | Eric | 4800 Auburn Ave Apt 1102 | Bethesda |
| 7/1/2015 20:20 | Bakalian | Sima | 5012 Cloister Dr | Rockville |
| 7/1/2015 15:51 | Snively | James | 13522 John Kline Rd | Smithsburg |

| | | | | |
|---|---|---|---|---|
| 7/1/2015 14:37 | Brekke | Pamela | 9 Bush Chapel Rd | Aberdeen |
| 7/1/2015 15:36 | Somer | Lawrence | 9116 Sudbury Rd | Silver Spring |
| 7/1/2015 16:49 | Gregg | Louise | 5701 Chinquapin Pkwy Apt D | Baltimore |
| 7/6/2015 14:10 | Fahlman | Cheryl | 9224 Sandy Lake Cir | Gaithersburg |
| 7/5/2015 17:03 | Subramani | Erin | 613 Joppa Farm Rd | Joppa |
| 7/2/2015 11:09 | Alexander | Charles | PO Box 4752 | Lutherville Timonium |
| 7/1/2015 14:35 | Wright | Sydney | 12 Stoneridge Ct | Baltimore |
| 7/1/2015 14:07 | Shaffer | Barbara | 4900 Bangor Dr | Kensington |
| 7/2/2015 18:25 | Krebs | Jim | 2002 Stockton Rd | Phoenix |
| 7/3/2015 20:33 | Ireland | Andrew | 7525 Hampden Ln | Bethesda |
| 7/1/2015 16:51 | Bowser | Zach | 12386 Boncrest Dr | Reisterstown |
| 7/1/2015 20:03 | Van Wely | J B | 2210 E Lombard St | Baltimore |
| 7/2/2015 4:50 | Howard | Lucy | 2400 Castleton Rd | Darlington |
| 7/3/2015 14:53 | Dean | Carol | 925 Bowleys Quarters Rd | Baltimore |
| 7/1/2015 15:01 | Young | L | 1121 Pipestem Pl | Potomac |
| 7/1/2015 16:03 | Hobson | Kelvin | 4 Crosswall Ct | Nottingham |
| 7/1/2015 18:02 | Krause | Doug | 31 Battleford Bay | fargo |
| 7/1/2015 17:06 | Stoddard | David | 3316 Kilkenny St | Silver Spring |
| 7/1/2015 17:29 | Handwerge | Norman | 7023 Concord Rd | Pikesville |
| 7/5/2015 22:19 | Dalnekoff | Cecilia | 2532 Carrollton Rd | Annapolis |
| 7/1/2015 16:43 | Fary | Jim | 2836 Blue Spruce Ln | Silver Spring |
| 7/1/2015 14:47 | Misra | Sunil | 7025 Flintfeet Ln | Columbia |
| 7/2/2015 4:43 | Land | David | 821 Malibu Dr | Silver Spring |
| 7/1/2015 14:40 | Place | Laura | 8711 Bradford Rd | Silver Spring |
| 7/1/2015 15:44 | Woodward | Ellis | 3422 Seneca St | Baltimore |
| 7/1/2015 16:11 | Freeman | Brenda | 1220 Dale Dr | Silver Spring |
| 7/1/2015 14:40 | Novotny | Sandra | 11407 Cam Ct | Kensington |
| 7/3/2015 14:22 | Fein | Elliott & Ac | 5 Carter Ct | Rockville |
| 7/1/2015 15:01 | Poole | Kathy | 6101 Blackburn Ln | Baltimore |
| 7/1/2015 20:04 | Wilson | Molly | 2439 Old National Pike | Middletown |
| 7/2/2015 9:29 | Lippy | Diana | 2728 Waldor Dr | Baltimore |
| 7/4/2015 5:38 | Pavlinic | Margaret | 2108 Lang Dr | Crofton |
| 7/2/2015 14:38 | Milligan | Eleanor | 228 Jefferson Pike | Knoxville |
| 7/4/2015 17:37 | Schley | Marta | 4522 Middleton Ln | Bethesda |
| 7/2/2015 9:17 | Lough | Ed | 4600 Roland Ave | Baltimore |
| 7/2/2015 14:32 | Mosley | Rebecca | 303 Jody Way | Lutherville Timonium |
| 7/1/2015 14:09 | Luksenburg | Lillian | 609 Kemp Mill Forest Dr | Silver Spring |
| 7/1/2015 19:15 | Malghan | Suhas | 2411 Everton Rd | Baltimore |
| 7/3/2015 15:42 | Straight | Wayne | 961 Day Rd | Sykesville |
| 7/4/2015 18:09 | Virga | Michael | 12225 Stardrift Dr | Germantown |
| 7/1/2015 17:22 | Gousha | Debbie | 3315 Willoughby Rd | Parkville |
| 7/1/2015 21:45 | Lyon | Nancy | 4911 Crescent St | Bethesda |
| 7/1/2015 22:08 | Macmillan | Paulette | 5106 Maple Park Ave | Gwynn Oak |
| 7/1/2015 15:37 | Marzban | Karina | 237 Jay Dr | Rockville |
| 7/1/2015 15:42 | Rosen | Steven | 809 Hope Ct | Gaithersburg |
| 7/1/2015 14:03 | Casey | Carol | 2213 Canary Ct | Baltimore |
| 7/3/2015 1:21 | Gilbert | Katherine | 7105 Georgia St | Chevy Chase |

| | | | | |
|---|---|---|---|---|
| 7/2/2015 9:51 | Pollock | Robin | 12510 Eastbourne Dr | Silver Spring |
| 7/1/2015 14:19 | Stauske | Anette | 1087 Wayson Way | Davidsonville |
| 7/1/2015 14:07 | Pearsall | Lorraine | 7708 Takoma Ave | Takoma Park |
| 7/1/2015 22:12 | Carpenter | Kathryn | 2708 Fenimore Rd | Silver Spring |
| 7/1/2015 16:18 | Clancy | Jason | 307 Meares Ct | Annapolis |
| 7/1/2015 14:09 | Torchenot | Ferold | 7080 Cradlerock Way | Columbia |
| 7/1/2015 17:16 | Oresky | Alan | 15620 Aitcheson Ln | Laurel |
| 7/1/2015 14:03 | Jacobsen | Frode | 7721 Paddock Way | Windsor Mill |
| 7/3/2015 18:38 | Dempsey | Kelley | 5342 Saint James Pl | Frederick |
| 7/6/2015 18:26 | Ramsey | Lezlie | 8641 Pete Wiles Rd | Middletown |
| 7/3/2015 7:30 | Skeen | Cynthia | 9330 Wild Grass Ct | Jessup |
| 7/1/2015 16:12 | Soffen | Patricia | 5310 Honey Ct | Ellicott City |
| 7/3/2015 5:47 | Davis | Allan | 8304 Brookmere Blvd | Frederick |
| 7/2/2015 7:52 | O'Connor | Jim | 14654 Good Hope Rd | Silver Spring |
| 7/1/2015 16:46 | Arent | Raymond | 1 Belleview Dr | Severna Park |
| 7/4/2015 10:28 | Wolfe | Linda | 11307 Empire Ln | Rockville |
| 7/3/2015 22:33 | Levitt | Mary | 6708 Bonnie Ridge Dr | Baltimore |
| 7/1/2015 16:40 | Togashi | James | 3959 Wendy Ct | Silver Spring |
| 7/3/2015 18:19 | Mount | Debby | 6842 Boyers Mill Rd | New Market |
| 7/4/2015 10:14 | Burch | Lilian | 7111 Woodmont Ave Apt 504 | Bethesda |
| 7/2/2015 8:31 | Reynolds | Jessica | 8011 Hollow Reed Ct | Frederick |
| 7/1/2015 14:04 | Hickey | Frances | 7701 Winterberry Pl | Bethesda |
| 7/1/2015 22:03 | Chemai | Beverly | 13316 Waterside Cir | Germantown |
| 7/2/2015 10:55 | Parr | Sarah | 1602 Twin Maple Ave | Baltimore |
| 7/1/2015 17:32 | Douglas | Kenneth | 9669 Devedente Dr | Owings Mills |
| 7/3/2015 11:13 | Tevelow | Carla | 10205 Wincopin Cir Apt 308 | Columbia |
| 7/1/2015 14:01 | Oliver | Rebecca | 23 Loring Ct | Sparrows Point |
| 7/5/2015 1:44 | Gage | Colm | 18781 Nathans Pl | Montgomery Village |
| 7/2/2015 10:53 | Douglass | Scott | 301 Hart Rd | Gaithersburg |
| 7/2/2015 2:20 | Watkins | Derek | 205 Pauline Ct | Arnold |
| 7/1/2015 19:00 | Smith | Carl | 8412 Each Leaf Ct | Columbia |
| 7/1/2015 16:25 | Wolfe | Stacey | 8225 Bodkin Ave | Lake Shore |
| 7/2/2015 21:41 | Baker | K.R. | 319 Double Eagle Dr | Linthicum |
| 7/1/2015 17:03 | Knox | Harry | 9900 Georgia Ave Apt 615 | Silver Spring |
| 7/2/2015 23:19 | Conelley | B. | No Way | Frederick |
| 7/7/2015 14:32 | Kumar | Naomi | 19213 Bonmark Ct | Germantown |
| 7/1/2015 14:49 | Black | Robert | 16912 Glen Oak Run | Derwood |
| 7/1/2015 23:33 | Wagner | Art | 200 Oak Dr | Pasadena |
| 7/1/2015 18:00 | Konig | Sean | 8500 16th St | Silver Spring |
| 7/1/2015 14:46 | Jones | Thomas | 913 Beaverbank Cir | Towson |
| 7/1/2015 14:48 | Upton | Charles | 11414 Cedar Ridge Dr | Potomac |
| 7/1/2015 20:15 | Sawyer | Gillian | 10930 Little Sparrow Pl | Columbia |
| 7/3/2015 21:28 | Scott | Catherine | 4309 Maryland Ave | Bethesda |
| 7/1/2015 16:09 | Carey | Kathy | 6692 Hillandale Rd | Chevy Chase |
| 7/1/2015 16:14 | Lundquist | John | 237 S Ellwood Ave | Baltimore |
| 7/3/2015 14:34 | Moran | Mike | 10660 Greenbough Ct | Columbia |
| 7/2/2015 20:37 | Fu | Sabrina | 9817 Madelaine Ct | Ellicott City |

| | | | | |
|---|---|---|---|---|
| 7/1/2015 16:17 | Dall | Frank | PO Box 86467 | Montgomery Village |
| 7/1/2015 15:32 | Walstrum | Joseph | 9106 Covered Bridge Rd | Parkville |
| 7/1/2015 14:04 | Schlesinger | Ronald | 5801 Nicholson Ln | Rockville |
| 7/2/2015 3:23 | Padula | Cristoforo | 5257 Buckeystown Pike | Frederick |
| 7/1/2015 14:06 | Schafer | Wayne | 719 Maiden Choice Ln Apt Br421 | Catonsville |
| 7/1/2015 18:26 | Mantovani | Pier | 9039 Sligo Creek Pkwy Apt 503 | Silver Spring |
| 7/2/2015 11:49 | Miller | Laurie | 8224 Brandon Dr | Millersville |
| 7/2/2015 3:31 | Ecker | Christophe | 9737 Lake Shore Dr | Gaithersburg |
| 7/1/2015 14:43 | Perera | Elizabeth | 4605 Chestnut St | Bethesda |
| 7/1/2015 14:02 | Roberts | Rob | 1908 Forest Dr | Annapolis |
| 7/7/2015 15:41 | Rohrback | Russell | 155 Allendale Ave | Aberdeen |
| 7/4/2015 16:52 | Brewster | Richard | 10 Oakwood Rd | Baltimore |
| 7/3/2015 0:37 | Walsh | Jacqueline | 1015 N Calvert St Apt 2 | Baltimore |
| 7/5/2015 15:26 | David | James | 14220 Bradshaw Dr | Silver Spring |
| 7/1/2015 16:13 | Shipp | Michele | 22 Anna Ct | Gaithersburg |
| 7/3/2015 19:25 | Story | Marilyn | 906 Palladi Dr | Baltimore |
| 7/1/2015 14:43 | Kriescher | Kevin | 4 E 32nd St Apt 106 | Baltimore |
| 7/1/2015 14:06 | Zimmerly | Eileen | 116 Fairview Ave. N | Bethesda |
| 7/2/2015 6:22 | Tran | Que | 9502 Curran Rd | Silver Spring |
| 7/3/2015 14:54 | Childress | Lisa | 5302 Quail Creek Ct | Ijamsville |
| 7/2/2015 10:05 | Comfort | Marianne | 8218 Roanoke Ave | Takoma Park |
| 7/1/2015 19:10 | Baruch | Jacqueline | 3040 Barclay St | Baltimore |
| 7/4/2015 16:10 | Bowyer | Sharon | 632 Harvey St | Baltimore |
| 7/2/2015 21:13 | Chapin | Mark | 1160 Green Holly Dr | Annapolis |
| 7/1/2015 14:23 | Wine | Jordann | 8500 Meadowlark Ln | Bethesda |
| 7/1/2015 21:18 | Lassow | Dina | 16 Hesketh St | Chevy Chase |
| 7/1/2015 16:19 | Balder | James | 2124 Freeland Rd | Freeland |
| 7/3/2015 17:19 | Kramer | George | 1720 Elkridge Dr | Edgewater |
| 7/1/2015 20:17 | Loomis | Margaret | 10206 Day Ave | Silver Spring |
| 7/1/2015 20:25 | Rodrigues | Gracinda | 7831 Clark Station Rd | Severn |
| 7/1/2015 15:12 | Baldwin | Julie | 1501 Rainbow Dr | Silver Spring |
| 7/1/2015 16:06 | Daugherty | Amy | 1407 Parker Rd | Baltimore |
| 7/1/2015 14:21 | Bauer | Bobby | 10422 Inwood Ave | Wheaton |
| 7/1/2015 14:16 | Weber | Nicole | 356 Nature Walk Ln | Pasadena |
| 7/2/2015 13:01 | Vishio | Alex | 6717 Glenkirk Rd | Baltimore |
| 7/6/2015 8:52 | Zink | Wayne | 805 Quincy Rd | Baltimore |
| 7/1/2015 18:28 | Mcnaught | Anna | 742 E Lake Ave | Baltimore |
| 7/1/2015 19:08 | Dolina | Amy | 1114 Charing Cross Dr | Crofton |
| 7/1/2015 17:48 | Milster | Amanda | 6216 Quebec Pl | Berwyn Heights |
| 7/1/2015 14:36 | Cohen | Sue | 14403 Butternut Ct | Rockville |
| 7/1/2015 14:03 | Bastian | Anne | 1523 Enyart Way Unit 303 | Annapolis |
| 7/11/2015 12:51 | Agarwal | Nitin | 348 Market St E | Gaithersburg |
| 7/6/2015 20:08 | Peltier | Laurel | 4 Bellemore Rd | Baltimore |
| 7/2/2015 10:36 | Raschiator | Lorraine | 3034 Brandt Ct Unit A | Fort Meade |
| 7/1/2015 16:31 | Troffkin | Rhea | 7808 Ivymount Ter | Potomac |
| 7/3/2015 23:11 | Q | Izzy | 9641 Reach Rd | Potomac |
| 7/1/2015 15:38 | Smith | Douglas | 1333 Tall Timbers Dr | Crownsville |

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|---|---|---|---|---|
| 7/5/2015 22:06 | Grauer | David | 111 Park Dr | Catonsville |
| 7/4/2015 15:51 | Mackenzie | Rolyn | 5019 Norrisville Rd | White Hall |
| 7/1/2015 19:09 | Grahe | Mary | 538 Millshire Dr | Millersville |
| 7/3/2015 9:26 | White | Alexa | 1000 Hilltop Cir | Baltimore |
| 7/1/2015 14:31 | Hervey | Thomas | 360 Old Trail Rd | Baltimore |
| 7/4/2015 11:18 | Carr | Ruth | 9707 Old Georgtwn Rd Apt 2519 | Bethesda |
| 7/1/2015 14:51 | Martin | St John | 635 Shore Rd | Severna Park |
| 7/1/2015 14:46 | Hurley | David | 2010 Elm St | Bel Air |
| 7/1/2015 16:21 | Ostrach | Louis | 9303 Chanute Dr | Bethesda |
| 7/1/2015 23:34 | Spicer | Vivi | 629 Ritchie Ave | Silver Spring |
| 7/11/2015 9:51 | Peck | Joel | 3011 Rices Ln | Windsor Mill |
| 7/1/2015 17:23 | Russell | Mary | 107 S Clinton St | Baltimore |
| 7/1/2015 14:19 | Amari | Kristine | 10338 Sixpence Cir | Columbia |
| 7/1/2015 20:57 | Katz | Marian | 2420 Evans Dr | Silver Spring |
| 7/1/2015 14:36 | Peraza | Jessica | 8830 Piney Branch Rd | Silver Spring |
| 7/1/2015 22:49 | Perry | Michiko | 6286 Wild Swan Way | Columbia |
| 7/1/2015 15:27 | Meyerhard | Lisa | 600 Jasper St | Baltimore |
| 7/3/2015 9:48 | Rafferty | Cynthia | 804 Redwood Trl | Crownsville |
| 7/4/2015 0:46 | Jenkins | Marsha | 9494 Greco Garth | Columbia |
| 7/1/2015 15:19 | Tapp | Eveline | 2357 Ballard Way | Ellicott City |
| 7/1/2015 20:16 | Schrad | Anna | 11001 Old Court Rd | Woodstock |
| 7/2/2015 8:37 | Hovatter | William | 3742 Roland Ave | Baltimore |
| 7/6/2015 14:37 | Compton | Stephanie | 107 W 29th St Apt 3 | Baltimore |
| 7/4/2015 12:59 | Schropp | Joann | 840 South River Landing Rd | Edgewater |
| 7/10/2015 9:43 | Anderson | Abby | W 3rd St | Frederick |
| 7/2/2015 10:58 | Holt | Kendra | 1111 University Blvd W | Wheaton |
| 7/1/2015 16:26 | Lambe | Jill | 720 Bayfield St | Takoma Park |
| 7/1/2015 20:52 | Burton | Pat | 17109 Qn Victoria Ct Apt 101 | Gaithersburg |
| 7/1/2015 17:32 | Tait | Erika | Watkins Rd | Germantown |
| 7/2/2015 23:02 | Valiga | Susan | 1616 Marshall Ave | Rockville |
| 7/7/2015 19:29 | Berman | Christy | 4503 Araby Church Rd | Frederick |
| 7/3/2015 6:45 | Zimmerma | Philip | 4105 Sweet Air Rd | Baldwin |
| 7/2/2015 6:40 | Konig | Judith | 2916 Louise Ave | Baltimore |
| 7/4/2015 19:31 | O'Brien | Pat | 15 Clarion Ct | Cockeysville |
| 7/4/2015 12:33 | Yost | Sally | 6303 Blenheim Rd | Baltimore |
| 7/1/2015 14:08 | Spittel | Richard | 5506 Rockleigh Dr | Halethorpe |
| 7/1/2015 19:37 | Wilhite | Ellen | 5225 Pooks Hill Rd Apt 1106n | Bethesda |
| 7/1/2015 16:13 | Canning | Andriana | 2415 Arapaho Way | Gambrills |
| 7/1/2015 21:36 | Czerny | Mai | 8126 Sommerville Drive | Gaithersburg |
| 7/1/2015 15:43 | Johnson | James | 15010 Athey Rd | Burtonsville |
| 7/3/2015 9:24 | Ichikawa | Tazuko | 2609 Fenimore Rd | Silver Spring |
| 7/2/2015 8:03 | Alford | Jennifer | 2537 W Baltimore St | Baltimore |
| 7/1/2015 15:37 | Betteridge | Donna | 14707 Winthrop Dr | Silver Spring |
| 7/1/2015 15:54 | Hughes | Karan | 3210 N Leisure World Blvd | Silver Spring |
| 7/1/2015 14:38 | Roberts | Barbara | 6079 Melbourne Ave | Deale |
| 7/1/2015 16:40 | Krier | Betty | 6612 Poplar Ave | Takoma Park |
| 7/2/2015 7:55 | Hovav | Adam | 7209 Willowdale Ave | Baltimore |

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|---|---|---|---|---|
| 7/1/2015 14:18 | Goodson | Geoffrey | TOWSON University | Towson |
| 7/2/2015 9:10 | Todman | Gloria | 5804 Hamlin Ave | Baltimore |
| 7/1/2015 17:46 | Jomo | Angela | 1922 Wilkens Ave # 1 | Baltimore |
| 7/2/2015 14:12 | Brosius | Robert | 3010 Fallstaff Manor Ct | Baltimore |
| 7/1/2015 14:03 | Judson | Timothy | 7333 New Hampshire Ave | Takoma Park |
| 7/2/2015 0:45 | Greene | Anne | 17219 Quaker Ln | Sandy Spring |
| 7/2/2015 0:50 | Chambers | Patricia | PO Box 212 | Abingdon |
| 7/7/2015 15:24 | Inman | Daniel | 7073 Gresham Ct W | Frederick |
| 7/3/2015 9:43 | Thomas | Trisha | 3334 Arundel On The Bay Rd | Annapolis |
| 7/1/2015 22:16 | Teuscher | Alfred | 6004 Ryland Dr | Bethesda |
| 7/1/2015 14:04 | Johnson | Kaleena | 5055 Clifford Rd | Perry Hall |
| 7/1/2015 14:25 | Sharp | Birgit | 585 Fairhaven Rd | Tracys Landing |
| 7/2/2015 15:47 | Stein | Alan | 10 Glenamoy Rd Unit 301 | Timonium |
| 7/8/2015 10:26 | Thayer | Derek | 2552 Carrington Way | Frederick |
| 7/2/2015 9:10 | Gousha | Laura | 3314 Keswick Rd | Baltimore |
| 7/1/2015 14:17 | Borlo | Ann | 4100 Byeforde Ct | Kensington |
| 7/1/2015 16:57 | Pollock | Sarah | 6413 Lochridge Rd | Columbia |
| 7/1/2015 18:11 | Woodfield | Joy | 1123 Baldwin Mill Rd | Jarrettsville |
| 7/1/2015 14:39 | Mcgarrity | John | 10402 Gardiner Ave | Silver Spring |
| 7/8/2015 16:03 | Pirtle-Conn | Nancy | 1803 Winans Ave | Baltimore |
| 7/1/2015 15:06 | Rakowski | William | 3431 Woodstock Ave | Baltimore |
| 7/4/2015 21:35 | Cafiero | Joanne | 14112 Castaway Dr | Rockville |
| 7/1/2015 14:56 | Gore | Linda | 60 Oak Shade Rd | Gaithersburg |
| 7/2/2015 0:51 | Schmidt | Malgorzata | 244 Dill Ave | Frederick |
| 7/1/2015 15:08 | Welsh | Mark | 3737 Harmony Church Rd | Havre DE Grace |
| 7/5/2015 8:50 | Taylor | Craig | 433 Essexwood Ct | Essex |
| 7/6/2015 22:04 | Joyner | Stephanie | 406 Harwood Rd | Catonsville |
| 7/1/2015 14:17 | Borel | Corinna | 5717 Oakshire Rd | Baltimore |
| 7/3/2015 18:30 | Seewagen | Linda & Jar | 9925 Whitworth Way | Ellicott City |
| 7/1/2015 16:12 | De Chirico | Antonia | Via Del Bosco 12 | Mezzago |
| 7/4/2015 6:52 | Poklemba | Veronica | 11209 Jon Ct | Ijamsville |
| 7/1/2015 14:02 | Friedel | Kristen | 1703 E West Hwy Apt 618 | Silver Spring |
| 7/1/2015 20:14 | Langworthy | James | 3114 Gracefield Rd Apt 112 | Silver Spring |
| 7/3/2015 16:36 | Thomason | Rick | 20133 Laurel Hill Way | Germantown |
| 7/1/2015 19:43 | Maurer | Jeff | 6629 Commodore Ct | New Market |
| 7/1/2015 14:58 | Mcgovern | Kristin | 9863 Greenbriar Way | Middle River |
| 7/1/2015 15:38 | Wolford | John | 515 S Washington St | Baltimore |
| 7/1/2015 14:21 | Clark | Eugene | 5829 Winding Oaks Ct | Frederick |
| 7/1/2015 17:43 | Haendiges | Donald | 1158 Annis Squam Harbour | Pasadena |
| 7/4/2015 10:30 | Felton | Stephanie | 14 E F St | Brunswick |
| 7/1/2015 14:12 | Cooke | Kim | 708 Northwest Dr | Silver Spring |
| 7/2/2015 8:21 | Shireman | Thomas | 601 Robinhood Rd | Havre DE Grace |
| 7/1/2015 14:31 | Pirrone | Martha | 1 N Church St | Middletown |
| 7/2/2015 9:07 | Miller | Elizabeth | 13308 Wye Oak Dr | Darnestown |
| 7/1/2015 14:06 | Leyden | Terren | 4 Stag Horn Ct | Cockeysville |
| 7/1/2015 15:30 | Schaefer | Connie | 3500 Pear Tree Ct Apt 34 | Silver Spring |
| 7/2/2015 8:00 | Robbins | Ellie | 5719 Ridgway Ave | Rockville |

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|---|---|---|---|---|
| 7/2/2015 7:32 | Morrison | Debra | 7843 E Shore Rd | Pasadena |
| 7/1/2015 22:36 | Kinge | Heloisa | 5411 McGrath Blvd Apt 501 | Rockville |
| 7/1/2015 14:40 | Nolan | Emily | 321 Lynn Manor Dr | Rockville |
| 7/5/2015 9:15 | Cording | Harry | 530 Meadow Hall Dr | Rockville |
| 7/1/2015 19:29 | Smolar | Laura | 6640 Sanzo Rd | Baltimore |
| 7/1/2015 14:12 | Hart | Ana | 2909 Gibbons Ave | Baltimore |
| 7/2/2015 12:19 | Johnson | Lynn | 5409 Bishops Head Ct | Columbia |
| 7/4/2015 12:01 | Combs | John | 15316 Delphinium Ln | Rockville |
| 7/1/2015 14:14 | Wagner | Sienna | 7101 Marlborough Dr | Baltimore |
| 7/7/2015 8:40 | Wojtalik | Nikki | 3723 Green Oak Ct | Baltimore |
| 7/4/2015 15:26 | Holmes | Mary Ellen | 3449 Falls Rd | Baltimore |
| 7/2/2015 14:47 | Dunnell | David | 11215 Dewey Rd | Kensington |
| 7/1/2015 15:06 | Mintz Urqu | Rosa Shosh | 8722 Leonard Dr | Silver Spring |
| 7/7/2015 15:25 | Mebane | Natalie | 13818 Notley Rd | Silver Spring |
| 7/4/2015 16:08 | Shapiro | Steve | 3007 Westfield Ave | Baltimore |
| 7/1/2015 15:46 | Dunlap | Dianne | 8814 Washington St | Savage |
| 7/3/2015 22:53 | Dudek | Maxwell | 5014 Hampden Ln | Bethesda |
| 7/1/2015 21:59 | Rynasiewic | Robert | 329 Hopkins Rd | Baltimore |
| 7/7/2015 10:59 | Miotto | Angela | 3142 Gracefield Rd Apt 604 | Silver Spring |
| 7/5/2015 21:44 | Shread | Paul | 12180 Flowing Water Trl | Clarksville |
| 7/1/2015 14:02 | Garcia-Ron | Albert | 231 S Wolfe St | Baltimore |
| 7/1/2015 14:12 | Mott | Ashleigh | 28 Oak Shade Rd | Gaithersburg |
| 7/1/2015 18:31 | Bucklin | Dave | 613 S Streeper St | Baltimore |
| 7/2/2015 15:26 | Page | Ahmand | 1619 Winding Brook Way | Windsor Mill |
| 7/1/2015 15:40 | Moreno | Ruth | 18025 Lafayette Dr | Olney |
| 7/1/2015 14:03 | Person | Kristin | 3621 Roland Ave | Baltimore |
| 7/2/2015 7:06 | Kim | Tom | 12431 Loft Ln | Silver Spring |
| 7/1/2015 22:39 | Belsley | Cheryl | 6887 Sanderling Ct | New Market |
| 7/2/2015 9:05 | Jackman | Louise | 128 Post Rd | Aberdeen |
| 7/2/2015 9:40 | Martinez | Erick | 6314 Greenspring Ave | Baltimore |
| 7/1/2015 18:06 | Phillips | Susannah | 864 Stonehurst Ct | Annapolis |
| 7/1/2015 15:18 | Magruder | Christi | 10428 Edgewood Ave | Silver Spring |

| HOME_STA | HOME_ZIP | PRIMARY_EMAIL | HOME_PHONE |
|---|---|---|---|
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| MD | 20902-3357 | marayuud@gmail.com | |
| MD | 21703-7551 | christinekatz@hotmail.com | 3015096936 |
| MD | 21403-5510 | patriciaijames@yahoo.com | 4102806287 |
| MD | 20886-1410 | williamderge@yahoo.com | 3019266079 |
| MD | 21152-9444 | dkd@jhu.edu | 4104722004 |
| MD | 20852-4868 | petesa05@gmail.com | 2403993890 |
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| MD | 21046-2073 | kenclark7@live.com | 3017253306 |
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| MD | 21409-5300 | bdknopf@gmail.com | 4107577992 |
| MD | 21223-2415 | kbernson@yahoo.com | |
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| MD | 20912-4140 | dave.oleary@mdsierra.org | 3015882990 |
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| MD | 21046-2016 | frankows@umbc.edu | 3014981292 |
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| MD | 21210-2733 | jazzinat00@yahoo.com | 4107189580 |
| MD | 20878-2878 | michael_3919@hotmail.com | 3019474303 |

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|---|---|---|---|
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| MD | 20777-9524 | tmeoni@yahoo.com | 3018540777 |
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| MD | 21042-5325 | randymurbach@gmail.com | 2405650030 |
| MD | 20905-6018 | myreneo@msn.com | 3013844243 |
| MD | 20912-6421 | padlr2@hotmail.com | |
| MD | 21136-5111 | crbclub@hotmail.com | 4108333573 |
| MD | 21078-3910 | bwoods423@msn.com | 4109394936 |
| MD | 21117-1503 | jlotfi60@gmail.com | 4103631042 |
| MD | 20815-5413 | morsbergerg@gmail.com | 3016562724 |
| MD | 20902-1413 | robbinewhite@gmail.com | 3019497223 |
| MD | 20855-2566 | jkenney@palladianpartners.com | 3016508660 |
| MD | 21036-1232 | leslietutor@comcast.net | 3019226004 |
| MD | 21030-1419 | apenczek@verizon.net | 4102525720 |
| MD | 20912-4252 | laurawelch123@gmail.com | 3015654399 |
| MD | 21201-6402 | richardepc@yahoo.com | 4439613303 |
| MD | 21409-5848 | wcandler1@gmail.com | 4107575626 |
| MD | 21012-1040 | cshenot@yahoo.com | 4102416887 |
| MD | 21113-2841 | virginiawhalen@comcast.net | 4107446674 |
| MD | 20814-3941 | olsonmk1@aol.com | |
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August 25, 2015

Maryland Commission on Climate Change
Maryland Department of Environment
1800 Washington Boulevard
Baltimore, MD 21230-1720
climate.change@maryland.gov

Dear Maryland Commission on Climate Change;

Please accept the included comments on Maryland's Greenhouse Gas Reduction Plan from Sierra Club's Maryland members and supporters. Given that many of the comments were identical, I have attached the comment language along with a spreadsheet that includes the information for all signers. I have also attached 36 unique comments in a separate document.

Thank you,

Seth Bush
Maryland Organizing Representative
Sierra Club

Lillian Luksenburg
609 Kemp Mill Forest Dr
Silver Spring, MD 20902-1566

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food. We owe it to future generations to protect these precious resources!

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

With more than 3,000 miles of tidal shoreline, Maryland is the third most vulnerable state to sea level rise -- one of the major consequences of climate change. Large swaths of the state along the Chesapeake Bay, including Baltimore's Inner Harbor, are already experiencing higher incidence of flooding each year due to rising seas. As previously found by Maryland scientists, a continued increase in greenhouse gas emissions would mean sea level rise more than 5 feet by the end of the century. To put that in perspective, 5 feet of sea level rise would put 3,700 miles of road underwater and cost taxpayers billions of dollars.

Furthermore, the GGRA Plan is helping to clean up the air we breathe by investing in clean renewable energy instead of polluting fossil fuels. The National Academy of Sciences estimates that illness caused by polluting energy sources costs Maryland households an average of $73 per month. Replacing dirty energy sources with more clean energy will improve our health and save Maryland money.

On the other hand, current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal would result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,

Lillian Luksenburg

Nicole Weber
356 Nature Walk Ln
Pasadena, MD 21122-1181
(410) 571-7960

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am very committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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On the other hand, current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal would result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Nicole Weber

Corinne Borel
5717 Oakshire Rd
Baltimore, MD 21209-4217
(443) 690-3402

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

Maryland has more to gain and to lose than most should we not address fossil fuel emissions and climate change. The rise of the Chesapeake could submerge this state's capitol as well as Baltimore and numerous coastal communtiies. Tourist economies along the EAstern shore could be devastated.

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Sincerely,
Corinne Borel

Mike Lentz
1505 Featherwood St
Silver Spring, MD 20904-6653

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Sincerely,
Mike Lentz

Sydney Wright
12 Stoneridge Ct
Baltimore, MD 21239-1339

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

PLEASE make sure the GGRA Plan is renewed in 2016 for Maryland, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

Estimated economic benefits include $1.6 billion and support over 37,000 Maryland jobs.

Please submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Thank you!

Sincerely,
Sydney Wright

Laura Place
8711 Bradford Rd
Silver Spring, MD 20901-4003

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

What we do now matters so much to our near future, not just generations ahead - and there's no reason it can't be a win-win-win, for our health, the health of the rest of our ecosystem, and our economy.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Sincerely,
Laura Place

Philip Allen
3463 Rockway Ave
Annapolis, MD 21403-4849

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

Whatever you do to protect our world or leave it to flood and desiccate will test your courage, for the consequences of your action will be realized by generations that come after the end of your (and my) professional lives. Please show the courage to protect those generations to come.

Short of the optimal step a carbon tax or fee the Greenhouse Gas Reduction Act (GGRA) Plan is the best legal framework for Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy.

Furthermore, the GGRA Plan is helping to clean up the air we breathe by investing in clean renewable energy instead of polluting fossil fuels.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Philip Allen

L Young
1121 Pipestem Pl
Potomac, MD 20854-5550

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!WORK TO BE DONE; SOCIAL JUSTICE IN GREAT DANGER!

Dear Maryland Commission on Climate Change,

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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. I am here to join the Union of Concerned Scientists and other civic groups to support the Clean Air Act, Performance Standards, and other plans that EPA would take to reduce significantly harmful emissions, pollution, and global warming from power plants and petroleum refineries, etc,; to improve government function; and to protect people, families and communities from such harmful damages.

The dirty emissions are harmful and dangerous, which affect people's health, productivity, medical expenditures, family and social lives, from both private and social cost-benefits points of view. Besides, serious scientists and environmentalists have urged swift and significant reduction of these dangerous emissions and global warming to avoid the adverse effects of worse climate change.

Currently, power plants and refineries are producing carbon emission and pollution without meaningful restraints. It harms our people and communities, while taxpayers and general public have to pay the costs. Further, the adverse impacts of unfairness, irresponsibility, unfair election and market mechanism, and unjust influences of corporations, entities or networks cause serious social- political problems, and thus cost our society tremendously. To help you understand the social problems as I have identified, see my candidate statements as attached, or see relevant candidate/election websites. I have run for public offices, local- federal, since 1994. *

It would be appreciated if the EPA would take necessary actions to protect people and reduce significantly dangerous pollution from power plants and petroleum refineries, etc.; and make government function more meaningfully.

Sincerely,
L Young

Eveline Tapp
2357 Ballard Way
Ellicott City, MD 21042-1781

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

Personal note:
Reading "The Little Ice Age: Climate Change 1300-1850" should be mandatory reading for your department. It covers not only the Little Ice Age but the Medieval Warm Period that preceded it. This book impressively combines scientific research with the historical accounts of what happened in both eras. The warming climate we are experiencing now parallels the accounts of violent weather, droughts, and famine that occurred during the Medieval Warm Period. We really need to pay attention to the historical record, especially as we are adding human industrial production into the natural cycle.

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Eveline Tapp

James Snively
13522 John Kline Rd
Smithsburg, MD 21783-9111
(301) 416-0767

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

CONTROL OF HARMFUL EMISSIONS SHOULD BE A NO-BRAINER, AND IN A LESS CORRUPT, LESS CORPORATIST COUNTRY IT WOULD BE.

Sincerely,
James Snively

Brenda Freeman
1220 Dale Dr
Silver Spring, MD 20910-1609

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

Please renew Maryland's Greenhouse Gas Reduction Plan. Frankly, I am at a loss as to why in these days of climate havoc the public has to lobby its government to build a future on clean, renewable energy. This should be a given.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy.

Though the GGRA requires carbon reductions by 2020, it's paramount we should stay the course so that we can continue reducing carbon emissions, by at least 90% by the year 2050.

Maryland is vulnerable to sea level rise -- one of the major consequences of climate change. The Chesapeake Bay, including Baltimore's Inner Harbor, are already experiencing higher incidence of flooding each year due to rising seas.

As previously found by Maryland scientists, a continued increase in greenhouse gas emissions would mean sea level rise more than 5 feet by the end of the century.

Furthermore, the GGRA Plan is helping to clean up the air we breathe by investing in clean renewable energy instead of polluting fossil fuels.

This is of the utmost importance to a senior like me who must often stay indoors during "red alert" days caused by the combination of air pollutions and heat.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Brenda Freeman

S. Neimark
12908 Ruxton Rd
Silver Spring, MD 20904-5278
(301) 384-9347

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

It's so important, and that's why I'm committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Sincerely,
S. Neimark

Jim Fary
2836 Blue Spruce Ln
Silver Spring, MD 20906-3166
(301) 460-1565

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond. Our families and our future need clean air and protection from climate change.

Sincerely,

Jim Fary

S. Neimark
12908 Ruxton Rd
Silver Spring, MD 20904-5278
(301) 384-9347

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Please Renew Maryland's Greenhouse Gas Reduction Plan!

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It's so important, and that's why I'm committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
S. Neimark

Kenneth Douglas
9669 Devedente Dr
Owings Mills, MD 21117-5424

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy: values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

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Sincerely,
Kenneth Douglas

Joy Woodfield
1123 Baldwin Mill Rd
Jarrettsville, MD 21084-1936
(410) 557-7948

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

Increasing numbers of children suffer from asthma and related respiratory diseases because of polluted air. We cannot expect them to become healthy, hardworking adults if they are unable to grow up under these conditions.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Joy Woodfield

Sarah Peters
6070 California Cir Apt 308
Rockville, MD 20852-4868

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Please Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

As a lifelong Maryland resident, I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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I urge you to take a closer look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Thank you for your time and consideration.

Sincerely,
Sarah Peters

Donald & Anita Cowan
600 Hawkesbury Ln
Silver Spring, MD 20904-6310

Jul 1, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

We are committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

With more than 3,000 miles of tidal shoreline, Maryland is the third most vulnerable state to sea level rise -- one of the major consequences of climate change. Large swaths of the state along the Chesapeake Bay, including Baltimore's Inner Harbor, are already experiencing higher incidence of flooding each year due to rising seas. As previously found by Maryland scientists, a continued increase in greenhouse gas emissions would mean sea level rise more than 5 feet by the end of the century. To put that in perspective, 5 feet of sea level rise would put 3,700 miles of road underwater and cost taxpayers billions of dollars.

Furthermore, the GGRA Plan is helping to clean up the air we breathe by investing in clean renewable energy instead of polluting fossil fuels. The National Academy of Sciences estimates that illness caused by polluting energy sources costs Maryland households an average of $73 per month. Replacing dirty energy sources with more clean energy will improve our health and save Maryland money.

On the other hand, current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal would result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Donald & Anita Cowan

Jeanette Parker
308 Audrey Ave
Brooklyn, MD 21225-2823

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollination out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Sincerely,
Jeanette Parker

Barbara Wasserman
13200 Triadelphia Rd
Ellicott City, MD 21042-1143
(301) 854-0033

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Furthermore, the GGRA Plan is helping to clean up the air we breathe by investing in clean renewable energy instead of polluting fossil fuels. The National Academy of Sciences estimates that illness caused by polluting energy sources costs Maryland households an average of $73 per month. Replacing dirty energy sources with more clean energy will improve our health and save Maryland money. The existing fossil-fuel fired electrical generating plants contribute tremendously to the poor air we breathe in the Baltimore-Washington area. With the recent Supreme Court ruling that allows these plants to continue to pour mercury into the air we breathe, it is critical that the Maryland Department of the Environment do everything possible to reduce greenhouse gases and give the citizens less polluted air.

On the other hand, current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal would result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

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Sincerely,
Barbara Wasserman

Marianne Comfort
8218 Roanoke Ave
Takoma Park, MD 20912-3209
(518) 860-8538

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Please Renew Greenhouse Gas Reduction Plan

Dear Maryland Commission on Climate Change,

I have been inspired by Pope Francis' call to people around the world to connect care for the environment with care for persons who are poor. We have an opportunity here in Maryland to live that out by renewing the Greenhouse Gas Reduction Act Plan.

A renewed commitment to clean, renewable energy not only will address climate change, but also alleviate the pollution that disproportionately impacts our low-income, minority residents.

Therefore, we need to make sure that the Greenhouse Gas Reduction Act Plan is renewed in 2016 to maintain this legal framework for cutting carbon emissions well into the future.

Maryland is the third most vulnerable state to sea level rise due to climate change, with the Chesapeake Bay, including Baltimore's Inner Harbor, already experiencing higher incidences of flooding. Additionally, the National Academy of Sciences estimates that illness caused by polluting energy sources costs Maryland households an average of $73 per month. Replacing dirty energy sources with more clean energy will improve our health and save Maryland money.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Marianne Comfort

Charles Alexander
PO Box 4752
Lutherville Timonium, MD 21094-4752
(443) 519-6324

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

With more than 3,000 miles of tidal shoreline, Maryland is the third most vulnerable state to sea level rise -- one of the major consequences of climate change.  Large swaths of the state along the Chesapeake Bay, including Baltimore's Inner Harbor, are already experiencing higher incidence of flooding each year due to rising seas. As previously found by Maryland scientists, a continued increase in greenhouse gas emissions would mean sea level rise more than 5 feet by the end of the century. To put that in perspective, 5 feet of sea level rise would put 3,700 miles of road underwater and cost taxpayers billions of dollars.

Furthermore, the GGRA Plan is helping to clean up the air we breathe by investing in clean renewable energy instead of polluting fossil fuels. The National Academy of Sciences estimates that illness caused by polluting energy sources costs Maryland households an average of $73 per month. Replacing dirty energy sources with more clean energy will improve our health and save Maryland money.

On the other hand, current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal would result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

This is the most important goal, the most important program Maryland MUST undertake to be responsible to it's citizens as well as the greater community of people worldwide.

Sincerely,
Charles Alexander

Susan Bannister
5418 High Tor Hl
Columbia, MD 21045-2440

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

A strong future for Maryland depends on clean, renewable energy that leaves more money in our pockets and keeps pollution out of our air, water, and soil.

The Greenhouse Gas Reduction Act (GGRA) is the legal framework that suports Maryland's carbon reducing efforts. It is critical that it be renewed in 2016 or Maryland will lose its legal mandate to effectively cut the carbon emissions that cause climate change and threaten our economy.

Maryland's 3,000+ miles of tidal shoreline make us the third most vulnerable state to sea level rise, a major consequences of climate change. Areas of the state along the Chesapeake Bay, including Baltimore's Inner Harbor, are experiencing higher incidence of flooding each year from rising seas. A continued increase in greenhouse gas emissions will mean a sea level rise of over 5 feet by the end of the century. 5 feet of sea level rise will put 3,700 miles of road underwater, costing billions of dollars.

The GGRA Plan helps clean the air by investing in clean renewable energy instead of polluting fossil fuels. According to the National Academy of Sciences illness caused by polluting energy sources cost Maryland households an average of $73 per month. Replacing dirty energy sources with clean energy improves public health and saves money. Current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal will result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can enjoy the benefits in 2020 and beyond.

Sincerely,
Susan Bannister

Alex Vishio
6717 Glenkirk Rd
Baltimore, MD 21239-1411
(410) 828-9161

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to cut effectively carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions by at least 90% by the year 2050.

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan and submit a report to the General Assembly that compels it to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Alex Vishio

Rebecca Mosley
303 Jody Way
Lutherville Timonium, MD 21093-2920
(410) 252-3972

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food. I do not want my children and grand children to say that we were part of a generation too selfish and short-sighted to change our destructive ways.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Sincerely,
Rebecca Mosley

Rebecca Mosley
303 Jody Way
Lutherville Timonium, MD 21093-2920
(410) 252-3972

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food. I do not want my children and grand children to say that we were part of a generation too selfish and short-sighted to change our destructive ways.

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Sincerely,
Rebecca Mosley

David Dunnell
11215 Dewey Rd
Kensington, MD 20895-1319

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep excess pollutants out of the air we breathe, the water we drink, and the soils we till. These are the true measures of wealth in our country.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Sincerely,
David Dunnell

Sabrina Fu
9817 Madelaine Ct
Ellicott City, MD 21042-4918
(410) 418-8694

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

Dear MD Dept. of the Environment,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.   It is the right thing to do for Maryland's future.

Sincerely,
Sabrina Fu

B. Conelley
No Way
Frederick, MD 21701-9129

Jul 2, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am a biologist, and I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Sincerely,
B. Conelley

Debby Mount
6842 Boyers Mill Rd
New Market, MD 21774-6930

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Thank you very much.

Sincerely,
Debby Mount

Mary Levitt
6708 Bonnie Ridge Dr
Apt 201
Baltimore, MD 21209-2864
(410) 878-7887

Jul 3, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am a voter, and I'm committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,

Mary Levitt

Margaret Pavlinic
2108 Lang Dr
Crofton, MD 21114-2127
(410) 721-5371

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

You are entrusted to protect Maryland's residents, air, land and water. Please take this issue seriously. Your children and grandchildren are inheriting a different America than we envisioned. We need to do whatever it takes to clean things up for them.

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

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Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General

Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Margaret Pavlinic

Stephanie Felton
14 E F St
Brunswick, MD 21716-1423
(301) 834-3770

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

With more than 3,000 miles of tidal shoreline, Maryland is the third most vulnerable state to sea level rise -- one of the major consequences of climate change. Large swaths of the state along the Chesapeake Bay, including Baltimore's Inner Harbor, are already experiencing higher incidence of flooding each year due to rising seas. As previously found by Maryland scientists, a continued increase in greenhouse gas emissions would mean sea level rise more than 5 feet by the end of the century. To put that in perspective, 5 feet of sea level rise would put 3,700 miles of road underwater and cost taxpayers billions of dollars.

Furthermore, the GGRA Plan is helping to clean up the air we breathe by investing in clean renewable energy instead of polluting fossil fuels. The National Academy of Sciences estimates that illness caused by polluting energy sources costs Maryland households an average of $73 per month. Replacing dirty energy sources with more clean energy will improve our health and save Maryland money.

On the other hand, current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal would result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.YES,RENEW!

Sincerely,
Stephanie Felton

John Combs
15316 Delphinium Ln
Rockville, MD 20853-1727
(301) 929-3316

Jul 4, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.

The Greenhouse Gas Reduction Act (GGRA) Plan is the legal framework that drives Maryland's carbon reducing efforts. We need to make sure it is renewed in 2016 or Maryland will lose its legal mandate to effectively cut carbon emissions that cause climate change and threaten our economy. Plus, even though GGRA requires carbon reductions by 2020, it's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

With more than 3,000 miles of tidal shoreline, Maryland is the third most vulnerable state to sea level rise -- one of the major consequences of climate change. Large swaths of the state along the Chesapeake Bay, including Baltimore's Inner Harbor, are already experiencing higher incidence of flooding each year due to rising seas. As previously found by Maryland scientists, a continued increase in greenhouse gas emissions would mean sea level rise more than 5 feet by the end of the century. To put that in perspective, 5 feet of sea level rise would put 3,700 miles of road underwater and cost taxpayers billions of dollars.

Furthermore, the GGRA Plan is helping to clean up the air we breathe by investing in clean renewable energy instead of polluting fossil fuels. The National Academy of Sciences estimates that illness caused by polluting energy sources costs Maryland households an average of $73 per month. Replacing dirty energy sources with more clean energy will improve our health and save Maryland money.

On the other hand, current analyses project that fully implementing the carbon reduction and clean energy policies needed to achieve the GGRA goal would result in estimated economic benefits of $1.6 billion and support over 37,000 Maryland jobs.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Let's also redouble our efforts to conserve all our resources by making all our homes and business structures more energy efficient and conserving our water and other natural resources.

Sincerely,
John Combs

Derek Thayer
2552 Carrington Way
Frederick, MD 21702-5973

Jul 8, 2015

Maryland Commission on Climate Change

Subject: Renew Maryland's Greenhouse Gas Reduction Plan!

Dear Maryland Commission on Climate Change,

I am committed to a stronger future for Maryland built on clean, renewable energy -- values that will leave more money in our pockets and keep pollution out of the air we breathe, the water we drink, and the soil in which we grow our food.
It's paramount that we put Maryland on a trajectory to continue reducing carbon emissions, by at least 90% by the year 2050.

Please take a close look at the clean energy programs that are facilitated by the GGRA Plan, and submit a report to the General Assembly that compels them to renew and fortify the plan and programs so we can reap the benefits in 2020 and beyond.

Sincerely,
Derek Thayer

**Table C-1.** Strategy Assigned Reductions.

| Program I.D. | Program | Lead Agency | Potential GHG Emission Reductions ($MMtCO_2e$) Revised for 2015 |
|---|---|---|---|
| **ENERGY** | | | |
| **A** | **EmPOWER Maryland** | **-** | **7.24** |
| A.1 | EmPOWER Maryland: Energy Efficiency in the Residential Sector | MEA | Included in A |
| A.2 | EmPOWER Maryland: Energy Efficiency in the Commercial and Industrial Sectors | MEA | Included in A |
| A.3 | EmPOWER Maryland: Energy Efficiency in Appliances and Other Products | MEA | Included in A |
| A.4 | EmPOWER Maryland: Utility Responsibility | MEA | Included in A |
| A.5 | Combined Heat and Power | MEA | Included in A |
| **B** | **The Maryland Renewable Energy Portfolio Standard (RPS)** | **-** | **4.13** |
| B.1 | The Maryland Renewable Energy Portfolio Standard (RPS) Program | MEA | 4.13 |
| B.2 | Fuel Switching | MEA | Included in B |
| B.3 | Incentives and Grant Programs to Support Renewable Energy | MEA | Included in B |
| B.4 | Offshore Wind Initiatives to Support Renewable Energy | MEA | Included in B |
| **C** | **The Regional Greenhouse Gas Initiative (RGGI)** | **MDE** | **3.60** |
| **D** | **Other Energy Programs** | **-** | **0.14** |
| D.1 | GHG Power Plant Emission Reductions from Federal Programs | - | - |
| D.1.A | Boiler Maximum Achievable Control Technology (MACT) | MDE | 0.07 |
| D.1.B | GHG New Source Performance Standard | MDE | Included in D.1 |
| D.1.C | GHG Prevention of Significant | MDE | Included in D.1 |

| | | | |
|---|---|---|---|
| | Deterioration Permitting Program | | |
| D.2 | Main Street Initiatives | DHCD | 0.05 |
| D.3 | Energy Efficiency for Affordable Housing | DHCD | 0.02 |
| | **TRANSPORTATION** | | |
| **E** | **Transportation Technologies** | **-** | **6.88** |
| E.1 | Motor Vehicle Emission and Fuel Standards | - | 5.57 |
| E.1.A | Maryland Clean Cars Program | MDE | Included in E.1 |
| E.1.B | Corporate Average Fuel Economy Standards (CAFÉ): Model Years 2008 – 2011 | MDOT | Included in E.1 |
| E.1.C | National Fuel Efficiency and Emission Standards for Medium and Heavy-Duty Trucks | MDE | Included in E.1 |
| E.1.D | Federal Renewable Fuels Standards | MDOT | Included in E.1 |
| E.2 | On Road, Airport, Port and Freight/Freight Rail Technology Initiatives | - | 1.06 |
| E.2.A | On Road Technology | MDOT | Included in E.2 |
| E.2.B | Airport Initiatives | MDOT | Included in E.2 |
| E.2.C | Port Initiatives | MDOT | Included in E.2 |
| E.2.D | Freight and Freight Rail Programs | MDOT | Included in E.2 |
| E.3 | Electric and Low Emitting Vehicle Initiatives | MDOT/ MEA | 0.25 |
| **F** | **Public Transportation** | **-** | **1.85** |
| F.1 | Public Transportation Initiatives | MDOT | 1.85 |
| F.2 | Intercity Transportation Initiatives | MDOT | Included in F.1 |
| **G** | **Pricing Initiatives** | **MDOT** | **1.99** |
| **H** | **Other Innovative Transportation Strategies/Programs** | **-** | **Included in F.1** |
| H.1 | Evaluating the GHG Emissions Impact of Major New Transportation Projects | MDE | Included in F.1 |
| H.2 | Bike and Pedestrian Initiatives | MDOT | Included in F.1 |
| | **AGRICULTURE AND FORESTRY** | | |
| **I** | **Forestry and Sequestration** | **-** | **4.55** |
| I.1 | Managing Forests to Capture Carbon | DNR | 1.80 |
| I.2 | Planting Forests in Maryland | DNR | 1.79 |
| I.3 | Creating and Protecting Wetlands | DNR | 0.43 |

| | | | |
|---|---|---|---|
| | and Waterway Borders to Capture Carbon | | |
| I.4 | Biomass for Energy Production | DNR | 0.33 |
| I.5 | Conservation of Agricultural Land for GHG Benefits | MDA | 0.18 |
| I.6 | Increasing Urban Trees to Capture Carbon | DNR | 0.02 |
| I.7 | Geological Opportunities to Store Carbon | DNR | Included in I |
| **J** | **Ecosystems Markets** | **-** | **0.68** |
| J.1 | Creating Ecosystems Markets to Encourage GHG Emission Reductions | DNR | 0.11 |
| J.2 | Nutrient Trading for GHG Benefits | MDA | 0.57 |
| **BUILDING** | | | |
| **K** | **Building and Trade Codes in Maryland** | **DHCD** | **3.15** |
| **RECYCLING** | | | |
| **L** | **Zero Waste** | **MDE** | **1.48** |
| **MARYLAND'S INNOVATIVE INITIATIVES** | | | |
| **M** | **Leadership-By-Example** | **-** | **1.78** |
| M.1 | Leadership-By-Example: State of Maryland Initiatives | DGS | 0.56 |
| M.2 | Leadership-By-Example: Maryland Colleges and Universities | MDE | 0.56 |
| M.3 | Leadership-By-Example: Federal Government | MDE | 0.41 |
| M.4 | Leadership-By-Example: Local Government | MDE | 0.25 |
| **N** | **Maryland's Innovative Initiatives** | **-** | **0.21** |
| N.1 | Voluntary Stationary Source Reductions | MDE | 0.17 |
| N.2 | Buy Local for GHG Benefits | MDA | 0.02 |
| N.3 | Pay-As-You-Drive® Insurance in Maryland | MIA | 0.02 |
| N.4 | Job Creation and Economic Development Initiatives Related to Climate Change | COMMERCE | Included in N |
| **O** | **Future or Developing Programs** | **-** | **0.02** |
| O.1 | The Transportation and Climate | MDE/ | 0.02 |

| | | | |
|---|---|---|---|
| | Initiative | MDOT | |
| O.2 | Clean Fuels Standard | MDE | 0.00 |
| | **LAND USE** | | |
| **P** | **Land Use Programs** | **-** | **0.64** |
| P.1 | Reducing Emissions through Smart Growth and Land Use/Location Efficiency | MDP | Included in P |
| P.2 | Priority Funding Area (Growth Boundary) Related Benefits | MDP | Included in P |
| | **PUBLIC** | | |
| **Q** | **Outreach and Public Education** | **MDE** | **0.03** |
| | **TOTAL EMISSIONS REDUCTIONS** | | |
| **TOTAL** | | | **38.37** |
| **GGRA 2020 GOAL** | | | **34.66** |
| **2020 REDUCTIONS** | | | **3.71** |

# The Energy Sector

**Table C-2.** Energy Sector GHG Reduction Programs.

| ENERGY | | |
|---|---|---|
| **Program I.D.** | **Program** | **Potential GHG Emission Reductions ($MMtCO_2e$) Revised for 2015** |
| A | EmPOWER Maryland | 7.24 |
| B | The Maryland Renewable Energy Portfolio Standard (RPS) | 4.13 |
| C | The Regional Greenhouse Gas Initiative (RGGI) | 3.60 |
| D | Other Energy Programs | 0.14 |
| **Total** | | **15.11** |

# A. EmPOWER Maryland

**Revised 2015 Estimate of GHG Emissions Reduction**

The emission reduction of 10.52 MMT from EmPOWER Maryland as stated in the 2012 GGRA Plan contained a mathematical error that overstated the emissions reductions by about 7%, or 0.73 MMT. The correct 2020 emission reduction that corresponded to the policy scenario embedded in the 2012 Plan should have been reported as 9.79 MMT.

The Maryland Energy Administration (MEA) is currently investigating the EmPOWER surcharge and wishes to better understand the costs needed to maintain or increase the level of EmPOWER savings. An analysis is currently underway to determine what level of cost-effective savings may be available and at what cost. Based on the information that is currently available, MEA estimates the 2020 target for EmPOWER Maryland program savings and the corresponding emission reductions to be 7.2 MMT.

# B. Renewable Portfolio Standard (RPS)

**Revised 2015 Estimate of GHG Emissions Reduction**

The current Administration has yet to finalize the necessary legislative changes that would be required to increase the RPS to 25% or to remove qualifying biomass. As such, the projected emission reductions from this program are reflective of the Energy Sector Overlap Analysis previously conducted.

## C. The Regional Greenhouse Gas Initiative (RGGI)

Lead Agency: MDE

**Revised 2015 Estimate of GHG Emissions Reduction**

RGGI provides a framework by which emission reductions are implemented under the EmPOWER and RPS programs. The potential emission reductions from the RGGI program in 2020 are estimated to be 3.60 MMt$CO_2$e.

Following a 2012 Program Review, RGGI states implemented a new 2014 RGGI cap of 91 million short tons. The RGGI $CO_2$ cap then declines 2.5 percent each year from 2015 to 2020. Additionally, the RGGI program was potentially strengthened by the federal Clean Power Plan which was finalized in 2015. It is not unreasonable to assume that an additional 10 percent to 15 percent emission reduction could be achieved by 2020. By 2030, 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

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 tons. 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.

## D. Other Energy Programs

This policy contains various other energy programs which, when fully implemented, will provide further potential emissions reductions by 2020 and will create and retain jobs and increase the State gross domestic product.

### *D.1. GHG Power Plant Emission Reductions from Federal Programs*

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

## ***D.1.A. Boiler Maximum Achievable Control Technology (MACT)***

Lead Agency: MDE

## GHG Emission Reductions in 2020

### Revised 2015 Estimate of GHG Emissions Reduction

The potential emission reductions from the Boiler MACT program in 2020 are estimated to be 0.07 $MMtCO_2e$.

### 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.[1] 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.[2] 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.

## ***D.1.B. GHG New Source Performance Standard***

[1] 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.
[2] A 15 percent capacity factor chosen to approximate typical boiler based on COMAR 26.11.09.08F.

Lead Agency: MDE

## GHG Emission Reductions in 2020

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the GHG New Source Performance Standard program has been aggregated with the estimated emission reductions from the GHG Power Plant Emissions Reductions Federal Programs bundle.

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

**Revised 2015 Estimate of GHG Emissions Reduction**

Though no potential emissions reductions have been quantified at this time, this program will assist in further GHG reductions occurring in the future. The benefit has been aggregated with the estimated emission reductions from the GHG Power Plant Emissions Reductions Federal Programs bundle.

## *D.2. Main Street Initiatives*

Lead Agency: DHCD

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Main Street Initiatives program in 2020 are estimated to be 0.05 $MMtCO_2e$

**MDE Quantification**

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

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 $CO_2$e, with conversion factors provided by MDE, with the final values reported in the table below.

These calculations are performed for each of the six scenarios. The results are presented in the summary table below.

D. Results

**Table C-3.** Energy-15 Low Estimate Summary.

| | $MMtCO_2e$ | | |
|---|---|---|---|
| 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** |

**Table C-4.** Energy-15 High Estimate Summary.

| | $MMtCO_2e$ | | |
|---|---|---|---|
| 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** |

## ***D.3. Energy Efficiency for Affordable Housing***

Lead Agency: DHCD

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Energy Efficiency for Affordable Housing program in 2020 are estimated to be 0.02 $MMtCO_2e$

**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 table 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.

**Table C-5.** 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 table 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 Table C-6.

**Table C-6.** 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** |

# Updated Expenditures and GHG Reductions from DHCD Programs

**Weatherization Assistance Program**

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| Units | 250 | 3349 | 5087 | 3262 | 94 | 9 |
| Dollars (1) | $1,071,127 | $18,010,674 | $208,872,58 | $14,440,208 | $369,963 | $47,481 |
| Savings (2) | 7625 | 102144 | 155153 | 99491 | 2867 | 274 |

**Energy Efficiency for Affordable Housing**

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| Units | 28 | 285 | 177 | 351 | 3197 | 5263 |
| Dollars (1) | $107,491 | $2,815,222 | $1,166,403 | $1,585,055 | $19,232,791 | $29,107,504 |
| Savings (4) | - | - | - | 617 | 15833 | 14922 |

(1)Program dollars are benefit only and do not include administrative costs
(2)Savings for DOE WAP ARRA are estimates based on DOE's calculation for energy savings in MBtus
(3)Funding sources include U.S. DOE WAP, EmPOWER LIEEP and MEEHA, RGGI and MEAP
(4)Savings are provided on EmPOWER units only and are calculated using MWhs
Source: DHCD

# The Transportation Sector

**Table C-7.** Transportation Sector GHG Reduction Programs.

| TRANSPORTATION | | |
|---|---|---|
| **Program I.D.** | **Program** | **Potential GHG Emission Reductions ($MMtCO_2e$) Revised for 2015** |
| E | Transportation Technologies | 6.88 |
| F | Public Transportation | 1.85 |
| G | Pricing Initiatives | 1.99 |
| H | Other Innovative Transportation Programs | Included in F |
| **Total** | | **10.72** |

# E. Transportation Technologies

MDOT's approach to developing revised greenhouse gas (GHG) emissions estimates for the transportation sector are as follows:

1. Emissions baseline (2006),
2. Business-as-usual (2020) emissions estimate, and
3. Emissions benefits resulting from the implementation of transportation policies, plans and programs (2020).

MDOT updated the Maryland Department of Transportation Draft Implementation Plan (the Green Book), which will contain more details regarding background, transportation sector GHG emissions trends and progress, technical approach, and the transportation sector's contribution to Maryland's climate goals

MDOT continues to work across its modal agencies and with the Washington Area Metropolitan Transit Authority (WMATA) to aggregate details on internal operations, programs, and any initiatives that are already generating GHG emission reductions and may lead to greater reductions over the long-term.

MDE and MDOT also continuously coordinate activities with Maryland's metropolitan planning organizations (MPOs) to support short and long-range transportation planning and the federal transportation conformity process. In addition, MDOT continues to chair the Electric Vehicle Infrastructure Council (EVIC), working with MDE and Maryland Energy Administration (MEA), as well as other public and private stakeholders to plan and develop policy regarding electric vehicles.

MDOT also works with external partners, including CSX Transportation and Norfolk Southern regarding the National Gateway and Crescent Corridor initiatives as well as studies, in cooperation with Amtrak and the Federal Railroad Administration, that over the long-term will greatly improve operations on the Northeast Corridor.

**Technical Approach**

The 2015 technical approach utilizes the latest planning assumptions, approved by MDE, which reflect the current state of the practice for GHG emissions analysis in the transportation sector. Beyond the GGRA's 2015 legislative requirement, the motivating factors driving updates to MDOT's technical approach include:

1. Release of and updates to EPA MOVES2014 which includes enhanced data and assumptions reflecting updated mobile source emission characteristics, and refined information on final Federal fuel economy and GHG emissions standards, as well as the Tier 3 standards.

2. Continuation of Maryland's transportation planning, programming, and implementation process. Actions that have moved the process forward include finalization of the Maryland Transportation Plan in 2013 and passage of the Transportation Infrastructure Investment Act of 2013. In addition, recent major project completions (e.g. the Intercounty Connector and I-95 Express Toll Lanes), investment priority changes, a continued uncertain federal funding environment, and emergence of new programs have changed the structure of greenhouse gas beneficial projects in the 6-year Consolidated Transportation Program (CTP).

3. Vehicle miles traveled in Maryland has continued to remain steady, with minimal increase annually since 2010 - and total statewide VMT remains below the high-point in 2008.

4. A 2014 update to the EPA's State Inventory Tool (SIT) used to estimate off-road GHG emissions in the baseline and business as usual (BAU) scenarios.

2006 Baseline and 2020 Business as Usual (BAU) Emission Inventories

The updated 2006 baseline and 2020 BAU transportation sector GHG emissions forecast are summarized in Table C-8. The on-road analyses were performed using MOVES2014 and include data, methods, and procedures approved by MDE. Off-road analyses utilized the SIT tool and the Projection Tool.

**Table C-8.** Maryland 2006 and 2020 Transportation Sector GHG Emissions

| GHG Emissions (mmt $CO_2e$) | 2006 Baseline | 2020 BAU Forecast |
|---|---|---|
| Light Duty Vehicles | 23.34 | 30.77 |
| Medium/Heavy Duty Trucks & Buses | 7.38 | 9.36 |
| Total On-Road | 30.72 | 40.13 |
| Off-Road | 4.34 | 4.13 |
| **TOTAL GHG Emissions** | **35.06** | **44.26** |

Transportation Sector Contribution to Maryland's Climate Change Goals

The revised transportation sector GHG reduction estimates are based on updated planning assumptions and the new MOVES2014 modeling results. The transportation sector exceeds the 2013 GGRP initial reductions and achieves over 80 percent of the 2013 GGRP enhanced reductions that were representative of unfunded strategies. Table C-9 compares the 2013 initial and enhanced emission reductions (using prior modeling tools and assumptions documented in the MDOT Green Book) to the funded 2015 reductions (using the tools and assumptions documented above).

**Table C-9.** 2020 Transportation Sector Emission Reductions Summary.

| **GGRA Policy ID** | | **GGRA Policy Name** | **2013 (Initial)** | **2013 (Enhanced)** | **2015 (Funded)** |
|---|---|---|---|---|---|
| E.1 | | Motor Vehicle Emissions & Fuel Standards | 7.72 | 7.72 | 5.57 |
| E.1.A | | Maryland Clean Car | 4.33 [2] | 4.33 | 5.06 [4] |
| E.1.B | | CAFE 2008-2011 | 2.27 | 2.27 | NA |
| E.1.C | | National Medium and Heavy Duty Standards | 0.88 [3] | 0.88 | 0.28 [5] |
| E.1.D | | Federal Renewable Fuel Standards | 0.24 | 0.24 | 0.23 |
| E.2 | | On-Road, Airport, Port and Freight/Freight Rail | 0.38 | 0.62 | 1.06 |
| E.2.A | | On Road Technology | Included in E.2.A | Included in E.2.A | 1.00 |
| E.2.B | | Airport Initiatives | Included | Included in | 0.04 |

| | | | | | |
|---|---|---|---|---|---|
| | | | in E.2.A | E.2.A | |
| E.2.C | | Port Initiatives | Included in E.2.A | Included in E.2.A | 0.03 |
| E.2.D | | Freight & Freight Rail Programs | Included in E.2.A | Included in E.2.A | Included in E.2.A |
| E.3 | | Electric & Low Emitting Vehicle Initiatives | 0.00 | 0.27 | 0.25 |
| F.1* | | Public Transportation Initiatives | 2.00 | 2.89 | 1.61 |
| F.2 | | Intercity Transportation Initiatives | Included in F.1 | Included in F.1 | 0.16 |
| G | | Pricing Initiatives | 0.43 | 2.30 | 1.99 |
| H.2 | | Bike & Pedestrian Initiatives | Included in F.1 | Included in F.1 | 0.07 |
| | | TOTAL | 13.29 | 16.58 | 10.72 |

1. The "True-Up" represents a reforecasting of the 2020 BAU based on actual VMT through 2014.
2. The Maryland Clean Car Program includes the Maryland Clean Car and National Fuel Economy (2012-2025) Program.
3. 2014-2018 National Medium and Heavy Duty Vehicle Standards.
4. The Maryland Clean Car Program includes the Maryland Clean Car, Tier 3 (fuels only), and 2007-2025 National Fuel Economy Programs.
5. 2014-2018 and proposed 2019-2025 National Medium and Heavy Duty Vehicle Standards.

# The Agriculture and Forestry Sector

**Table C-10.** Agriculture and Forestry Sector GHG Reduction Programs.

| **AGRICULTURE AND FORESTRY** | | |
|---|---|---|
| **Program I.D.** | **Program** | **Potential GHG Emission Reductions ($MMtCO_2e$) Revised for 2015** |
| I | Forestry and Sequestration | 4.55 |
| J | Ecosystem Markets | 0.68 |
| **Total** | | **5.23** |

# I. Forestry and Sequestration

## *I.1. Managing Forests to Capture Carbon*

Lead Agency: DNR

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Managing Forests to Capture Carbon program in 2020 are estimated to be 1.80 $MMtCO_2e$

## Estimated GHG Emission Reductions

**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.

**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 table 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.

**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 table below.

**Data and Data Sources**

*Explanation of Table 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.

**Table C-11**. 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.

## ***I.2. Planting Forests in Maryland***

Lead Agency: DNR

## GHG Emission Reductions in 2020

### Revised 2015 Estimate of GHG Emissions Reduction

The potential emission reductions from the Planting Forests in Maryland program in 2020 are estimated to be 1.79 $MMtCO_2e$

**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.

**Table C-12.** Potential Carbon Sequestration from Reforestation.

| **MMtCO$_2$e Reforestation** | | | | | | |
|---|---|---|---|---|---|---|
| | **Private Lands** | | **Public Lands** | | | |
| | Loblolly Pine[3,4,5,6] | Mixed Upland Hardwood[133,134,136,7] | Loblolly Pine[133,134,135,136] | Mixed Upland Hardwood[133,134,136,8] | 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** |

**Table C-13.** Potential Carbon Sequestration from Afforestation.

| MMtCO$_2$e Afforestation | | | | |
|---|---|---|---|---|
| | Loblolly | Mixed Upland | | |

[3] Includes soil carbon estimate of 34.51 tonnes per acre
[4] Assumes constant rate of reforestation annually, based on median acreage planted years 2006-2010.
[5] From Carbon On Line Estimator report for Maryland
[6] U.S. Dept of Agriculture Forest Service-NRS GTR NE-343
[7] Assumes 90 percent reforestation post-harvest is pine. See Table above
[8] Assumes 90 percent reforestation post-harvest is pine. See Table above

| | Pine[9,10,11,12] | Hardwood[13,140,142,14] | 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 | |
| 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** | **$MMtCO_2e$** |

## ***I.3. Creating and Protecting Wetlands and Waterway Borders to Capture Carbon***

Lead Agency: DNR

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Creating and Protecting Wetlands and Waterway Borders to Capture Carbon program in 2020 are estimated to be 0.43 $MMtCO_2e$.

**DNR Quantification**

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

9 Includes soil carbon average of 26.17 tonnes per acre per year.
10 Assumes constant rate of afforestation annually, as based on median acreage planted years 2006-2010
11 From Table 4, Carbon On Line Estimator report for Maryland. Based on U.S. Dept of Agriculture Forest Service-NRS GTR NE-343
12 Assumes 80 percent of all afforestation is mixed hardwood.
13 Includes soil carbon average of 17.93 tonnes per acre per year.
14 From Table above.

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 participant in the protocol development and it is anticipated that protocol demonstration projects will occur in the State.

Estimates of carbon sequestration for the potential wetland restoration projects in Dorchester County are shown in the Table C-14.

**Table C-14.** 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 |

Estimates of the potential for carbon sequestration in future wetlands created by sea level rise has yet to be determined.

## *I.4. Biomass for Energy Production*

Lead Agency: DNR

## GHG Emission Reductions in 2020

### Revised 2015 Estimate of GHG Emissions Reduction

The potential emission reductions from the Biomass for Energy Production program in 2020 are estimated to be 0.33 $MMtCO_2e$

**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 Table C-15.

**Table C-15.** 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$_2$e** | |

## ***I.5. Conservation of Agricultural Land for GHG Benefits***

Lead Agency: MDA

## GHG Emission Reductions in 2020

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Conservation of Agricultural Land for GHG Benefits program in 2020 are estimated to be 0.18 MMtCO$_2$e

The Maryland Agricultural Land Preservation Foundation (MALPF) has permanently preserved land in each of Maryland’s 23 counties. As of June 30, 2014, 2,154 farms had been protected, representing a cumulative public investment of over $645 million and increasing total acres preserved to 292,357 or 30% of the ambitious 2020 goal. MALPF’s purchases are funded by dedicated percentages of the Real Estate Transfer Tax and the Agricultural Transfer Tax, along with county and state allocations.

Since 2009 the General Assembly has diverted monies from the program and partially replaced them with bond funds. Because of these decreases, the program has combined its acquisition years over four cycles in order to have enough funding in each cycle to make at least one offer in each participating county. For the current cycle, 2015/2016, MAPF has received 156 applications covering 21,285 acres and expects to be able to fund about 1/3 of them. At the present pace, it is estimated that MALPF will reach 40% of its target by 2020.

The monies in CREP vary with authorized funding and participation levels. Currently Maryland landowners can receive five types of payments: a one-time signing bonus, annual rental payments that include a per-acre incentive, cost-share assistance, a one-time practice incentive payment, and maintenance payments. USDA funds rental payments and a percentage of cost-shares and incentives through its Farm Service Agency. MACS grants, which are financed by state bond funds, provide up to 87.5% of the costs to install eligible best management practices. Bonus payments are funded through grants from the

Chesapeake and Atlantic Coastal Bays 2010 Trust Fund. CREP enrollments have generally been declining and have averaged less than 70,000 acres for the past five years. Given the recent history of commodity prices, this downward trend is unlikely to be reversed soon, and the achievement of 69% of goal may represent a peak for the program.

## *I.6. Increasing Urban Trees to Capture Carbon*

Lead Agency: DNR

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Increasing Urban Trees to Capture Carbon program in 2020 are estimated to be 0.02 $MMtCO_2e$

**DNR Quantification**

**Table C-16.** 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 Table C-17.

**Table C-17.** 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:

Step 1: Identify a Representative Sample of Maryland Trees:

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.

Step 2: Determine Carbon Sequestration Per Calendar Year:

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 table 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 table below. Future years used the average number of trees planted between 2006 and 2010, or 837,070 trees.

Step 3: Determine Annual Number of Trees to be Planted

**Table C-18.** 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:

**Table C-19.** 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 | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Trees Planted | | | | | | | | | | | | | | | | | Convert to | TOTAL | TOTAL |
| Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | TOTAL lbs. C | Metric Tonne | MTCO2e | 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 | |
| | Metric Tonnes C/yr | 120 | 259 | 360 | 426 | 735 | 1,077 | 1,355 | 1,571 | 1,858 | 2,991 | 4,258 | 5,259 | 6,007 | 7,044 | 9,118 | | 42,438 | | |

| Tree Mendous and Marylanders Plant Trees Tree Planting Carbon Calculations | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Trees Planted | | | | | | | | | | | | | | | | | Convert to | TOTAL | TOTAL |
| Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | TOTAL lbs. C | Metric Tonne | $MTCO_2e$ | $MMTCO_2e$ |
| 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 |

### *I.7. Geological Opportunities to Store Carbon*

Lead Agency: DNR

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Geological Opportunities to Store Carbon program have been aggregated with the estimated emission reductions from the Forestry and Sequestration bundle.

## J. Ecosystems Markets

### *J.1. Creating Ecosystems Markets to Encourage GHG Emission Reductions*

Lead Agency: DNR

## GHG Emission Reductions in 2020

**Revised 2015 Estimate of GHG Emissions Reduction**

GHG reductions for nutrient trading, under Maryland's Nutrient Trading Program, are treated separately in this plan because this market has been established as an administratively funded and staffed program. The GHG reduction benefits from the remaining ecosystem markets cannot be quantified until an active set of markets has been established and protocols to assess GHG benefits have been developed.

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 the Nutrient Trading for GHG Benefits program.

The potential emission reductions from the Creating Ecosystems Markets to Encourage GHG Emission Reductions program in 2020 are estimated to be 0.11 $MMtCO_2e$

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.

### *J.2. Nutrient Trading for GHG Benefits*

Lead Agency: MDA/ MDE

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Nutrient Trading for GHG Benefits program in 2020 are estimated to be 0.57 $MMtCO_2e$

**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.

Unlike many trading programs across the county which supply compliance credits for existing wastewater treatment plants, Maryland’s program was designed since inception to provide offsets for new growth and development. The lack of progress in finalizing Accounting for Growth policies and regulations has left the program without the necessary driver for trading although several recent proposals to meet reduction requirements may offer a much needed alternative. A public and private stakeholder advisory group started meeting in November 2009 to assess carbon mitigation activities, determine a menu of eligible practices, and develop the policies and guidelines to implement a carbon trading program, but that effort was discontinued in 2012 with the worldwide collapse in carbon credit prices.

MDA plans to re-convene the carbon advisory group when the nutrient marketplace is fully functioning, and while the timing is uncertain, it is still possible that 10% of Maryland's farms could be generating nutrient, sediment, and carbon credits in an active environmental market through either intra or inter-state trading by 2020. Also, a new multi-state trading platform has been completed using the Maryland model as the template and this platform already has the embedded capacity to calculate carbon credits. Work has begun, too, on the development of a complementary online offset assessment tool for use by the urban sector, and a prototype should be available for testing soon.

## The Buildings Sector

**Table C-20.** Building Sector GHG Reduction Program.

| BUILDINGS SECTOR | | |
|---|---|---|
| **Program I.D.** | **Program** | **Potential GHG Emission Reductions ($MMtCO_2e$) Revised for 2015** |
| K | Building and Trade Codes in Maryland | 3.15 |

## K. Building and Trade Codes in Maryland

Lead Agency: DHCD

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Building and Trade Codes in Maryland program in 2020 are estimated to be 3.15 $MMtCO_2e$

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.[15] 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.

[15] Annotated Code of Maryland, Public Safety, Title §12–503 Maryland Building Performance Standards.

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. 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.

The Maryland Building Performance Standards adopted most recently (January 1, 2015) includes the 2012 International Energy Conservation Code, which is the latest energy code published by the International Code Council. Local jurisdictions were required to adopt the 2015 standard within six months (July 1, 2015).

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.
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.

## The Recycling Sector

**Table C-21.** Recycling Sector GHG Reduction Program.

| RECYCLING | | |
|---|---|---|
| **Program I.D.** | **Program** | **Potential GHG Emission Reductions ($MMtCO_2e$) Revised for 2015** |
| L | Zero Waste: Maryland's Long-Term Strategy to an 85% Reduction in the Generation of Solid Waste by 2030 | 1.48 |

## L. Zero Waste: Maryland's Long-Term Strategy to an 85% Reduction in the Generation of Solid Waste by 2030

Lead Agency: MDE

The potential emission reductions from the Zero Waste program in 2020 are estimated to be 1.48 MMtCO2e

**Method for Revised Estimate of GHG Emissions Reductions in 2013**

Tons generated for the materials listed in the WARM model are calculated using the total tons generated in Maryland and the portion of each material in the U.S. waste stream, according to EPA reports. The 2006 EPA report was used for the 2006 baseline scenario and the 2012 report (most recent available) was used for 2013.

Tons recycled for each material in the WARM model are obtained from MDE's database of recycling tonnages by material, as reported by the counties annually. Materials not clearly fitting in one WARM category are divided among relevant categories (e.g. "mixed metals" are divided between WARM's aluminum cans and steel cans. There is also a catchall category of other materials that is distributed among the all the recyclable material types.)

The tons disposed for each material are calculated by subtracting tons recycled from tons generated. Disposal is broken down between landfilling and combustion according to the portion of all waste landfilled versus combusted, as reported annually to the Department. Decreases and increases in generation between 2006 and 2013 are entered in the source reduction column.

**Method for Revised Projection of GHG Emissions Reductions in 2020**

The per capita waste generation in 2013 is assumed to remain constant in 2020 at 1.096 tons per person per year. Note that this low compared to past data. However, in previous projections we used a historical multi-year average that ended up being too high in recent years.

The population projection for 2020 is 6,224,550 (Maryland Dept. of Planning).The recycling rate is assumed to be 60% in 2020 (Zero Waste goal). These assumptions provide the total projected waste generation and the total projected recycling tonnage for 2020.

Waste generation in 2020 is broken down by material using the same proportion of each material in the waste stream in 2013, e.g. PET was 8% of the waste stream in 2013, so the projected PET generation in 2020 is 8% of the total waste generated in 2020.

For recycling, the total additional tons recycled in 2020 relative to 2013 was first calculated. This additional recycling tonnage was then allocated to each material by its portion of the waste stream. For example, 1.3 million tons more recycling is expected in 2020 than in 2013. PET is 8% of the waste stream, so 8% of the additional 1.3 million tons was added to the tons of PET recycled in 2013 to estimate the tons of PET recycled in 2020.
Limitations

The current version of WARM does not allow for source reduction of yard waste, so yard waste was modeled in a separate spreadsheet using the older WARM v.11. The older version contains different emissions factors for composting that may not be as accurate. Under v. 11, composting of yard waste is preferable to landfilling and combustion, but in the current version, it is actually better to combust or landfill yard waste than to compost it.

The revised method is more accurate to estimate overall changes in GHG emissions over time because it accounts for changes in both waste generation and recycling. However, it is not useful to measure the impacts of recycling programs specifically. The reduction in GHG emissions between 2006 and 2013 was due almost entirely to less waste generation, not more recycling. Fewer tons were recycled in 2013 than in 2006.

Waste generation in 2020 is difficult to predict. The per capita waste generation in 2020 was assumed to be the same as in 2013. Per capita waste generation has declined over the past several years, and was lower in 2013 than it has been in any year since at least 1999. If the recent trend reverses in the future and waste generation per capita returns to higher rates, the 2020 projection would be inaccurate.

## Maryland's Innovative Initiatives

**Table C-22.** Maryland's Innovative Initiatives GHG Reduction Programs.

| MARYLAND'S INNOVATIVE INITIATIVES | | |
|---|---|---|
| **Program I.D.** | **Programs** | **Potential GHG Emission Reductions ($MMtCO_2e$) Revised for 2015** |

| | | |
|---|---|---|
| M | Leadership-By-Example | 1.78 |
| N | Maryland's Innovative Initiatives | 0.21 |
| O | Future or Developing Programs | 0.02 |
| **Total** | | **2.01** |

# M. Leadership-By-Example

## *M.1. Leadership-By-Example: State of Maryland Initiatives*

Lead Agency: DGS

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emissions reductions from the Leadership-By-Example: State of Maryland Initiatives program in 2020 are estimated to be 0.56 $MMtCO_2e$.

## Estimated Greenhouse Gas Emission Reductions in 2020

**Table C-23.** Summary of Estimated Avoided GHG Emissions in 2020 ($MMtCO_2e$).

| Emissions Reductions | Enhanced |
|---|---|
| 1. eFootprint | 0.39 |
| 2. Local Government | 0.45 |
| 3. Schools | 0.20 |
| 4. DGS Environmental Performance Contracts and Public School Energy Efficiency Initiatives | 0.10 |
| 5. LEED | 0.26 |
| **Total** | **1.45** |

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 Table C-24.

**Table C-24.** Summary of GHG benefits for a 25 Percent Reduction.

| 2008 Base Year $MMtCO_2e$ | 25% Reduction | Low Estimate | 50% Reduction |
|---|---|---|---|
| 1.58 | 1.19 | 0.40 | 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.

**Table C-25.** Summary of County Data with a 25 Percent GHG Reduction.

| | | **Base Year Emissions** | | | |
|---|---|---|---|---|---|
| **County** | **Base Year** | **Metric tons of $CO_2$-equivalent** | **$MMtCO_2e$** | **25% Reduction from Base** | **Reduction Estimate** |
| Baltimore City | 2007 | 608,988 | 0.61 | 0.46 | 0.15 |
| Frederick | 2007 | 134,667 | 0.13 | 0.10 | 0.03 |
| Montgomery | FY2005 | | 0.45 | 0.34 | 0.11 |
| Howard | 2007 | 340,042 | 0.34 | 0.26 | 0.09 |
| Prince Georges | FY2007 | 95,877 | 0.10 | 0.07 | 0.02 |
| Baltimore County | 2006 | 142,701 | 0.14 | 0.11 | 0.04 |
| Annapolis | FY2006 | 11,991 | 0.01 | 0.01 | 0.00 |
| Chevy Chase | 2007 | 162 | 0.00 | 0.00 | 0.00 |
| Takoma Park | 1990 | 1,901 | 0.00 | 0.00 | 0.00 |
| | | | | | **0.45** |

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

**Table C-26.** 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.

**Table C-27.** Comparison of 25 Percent and 50 Percent GHG Reductions.

| | Base Year 2005 | 25% Reduction from Base 2020 | Reduction Estimate |
|---|---|---|---|
| **$MMtCO_2e$** | 0.80 | 0.6 | **0.20** |

4. Energy Performance Contracts

Estimates from work conducted by SAIC under contract to MDE.

**Table C-28.** 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,[16] 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 table is from the report:

**Table C-29.** Commercial Building GHG Emission Reductions due to Energy Efficiency.

| Approximate LEED Level | LEED NC Point Level | Metric Tons of GHG Reductions | |
|---|---|---|---|
| | | 2015 | 2020 |

[16] 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

| | | | |
|---|---|---|---|
| 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.

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

**Table C-30.** GHG Reductions from LEED certified Public School Projects.

| | | | | Metric Tons GHG Reductions | | Estimated Benefits Metric Tons | | Reduction 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** |

## *M.2. Leadership-By-Example: Maryland Colleges and Universities*

Lead Agency: MDE

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Leadership-By-Example: Maryland Colleges and Universities program in 2020 are estimated to be 0.56 $MMtCO_2e$.

**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 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.[17] 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 $MMtCO_2e$).[18]

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 Table C-31) 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 (Table C-32), 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 Table C-31. 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 (Table C-33), 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 Table C-33, 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 Table C-31. 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 $CO_2$-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 $MMtCO_2e$).

[17] 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)

[18] One school has not completed a GHG inventory at this time and therefore, was not included in this estimation.

C. Calculations

In Table C-31, 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 Tabless C-32 and C-33 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

**Table C-31.** 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 University | | | | 3,975 | 4,055 | 4,136 | 4,566 | **5,041** |
| 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 | 30,045 | 30,839 | 34,095 | 35,710 | 37,734 | 39,759 | 49,883 | **60,007** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| College | | | | | | | | |
| 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** |

**Table C-32.** 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** |

**Table C-33.** 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 GHG reduction 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.

## ***M.3. Leadership-By-Example: Federal Government***

Lead Agency: MDE

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Leadership-By-Example: Federal Government program in 2020 are estimated to be 0.41 $MMtCO_2e$.

## Estimated Greenhouse Gas Emission Reductions

**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 (Table C-34). MDE calculated Scopes 1, 2, and 3 reductions for each federal agency from this data.

**Table C-34.** 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) | Scope 3 Reductions (MMtCO2e) |
|---|---|---|---|---|---|---|---|---|
| Advisory Council on Historic Preservation | N/A | N/A | Blank | 44.3 | 36 | 1 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Commodity Futures Trading Commission | N/A | N/A | N/A | N/A | 669 | 4 | 0 | 0 |
| Court Services and Offender Supervision Agency | 30 | 21? | ? | 969.812 | ? | ? | 0 | 0 |
| Department of Agriculture | 21 | 7 | 616728 | 258765 | 110-115000 | 26026 | 129512.88 | 18113.55 |
| Department of Commerce | 1 | 6 | 0.3619284 | 0.1832843 | 43000 | 858 | 0.003619284 | 0.010997058 |
| Department of Defense | 34 | 13.5 | 78.4 | 7 | 2328937 | 211266 | 26.656 | 0.945 |
| Department of Education | 0 | 3 | 232 | 14965 | 4348 | 26 | 0 | 448.95 |
| Department of Energy | 28 | 13 | 4634 | 0.858 | 127376 | 19214 | 1297.52 | 0.11154 |
| Department of Health and Human Services | 15.2 | 3.3 | 0.96 | 0.29 | 83745 | 3983 | 0.14592 | 0.00957 |
| Department of Homeland Security | 25 | 7.2 | 1717333.5 | 1602912.6 | 237629 | 14190 | 429333.375 | 115409.7072 |
| Department of Housing and Urban Development | 47.4 | 16.2 | 17715 | 31726 | 9462 | 108 | 8396.91 | 5139.612 |
| Department of Justice | 16.4 | 3.8 | 1.61 | 0.62 | 112000 | 3861 | 0.26404 | 0.02356 |
| Department of Labor | 27.7 | 23.4 | 231403.1 | 86414.1 | 16404 | 4768 | 64098.6587 | 20220.8994 |
| Department of State | 20 | 2 | 139067 | 33652 | 14664 | 10 | 27813.4 | 673.04 |
| Department of the Interior | 20 | 9 | 0.8351128 | 0.3614084 | 70000 | 47518 | 0.16702256 | 0.032526756 |
| Department of the Treasury | 33 | 11 | 0.2633017 | 0.5100492 | 125881 | 697 | 0.086889561 | 0.056105412 |
| Department of Transportation | 12.3 | 10.9 | 857.9 | 309.5 | 58011 | 11594 | 105.5217 | 33.7355 |
| Department of Veterans Affairs | 29.6 | 10 | 2.991 | 1.077 | 284316 | 7186 | 0.885336 | 0.1077 |
| Environmental Protection Agency | 25 | N/A | 0.14078 | 0.067315 | 17208 | 171 | 0.035195 | 0 |
| Farm Credit Administration | N/A | 10 | 0 | 1921 | 287 | 0 | 0 | 192.1 |
| Federal Housing Finance Agency | 50 | 5 | 13.5 | 1135.2 | 455 | 3 | 6.75 | 56.76 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| General Services Administration | 28.7 | 14.6 | 2270645 | 156676 | 12827 | 9624 | 651675.115 | 22874.696 |
| Marine Mammal Commission | N/A | 35? | Blank | Blank | 23? | Blank | 0 | 0 |
| Millennium Challenge Corporation | N/A | 15 | 2.174 | 2.513 | 279 | 2 | 0 | 0.37695 |
| National Aeronautics and Space Administration | 18.3 | 12.6 | 1.356 | 0.171 | 18490 | 4884 | 0.248148 | 0.021546 |
| National Archives and Records Administration | 7 | 10 | 75.517 | 15.309 | 3611 | 68 | 5.28619 | 1.5309 |
| National Capital Planning Commission | N/A | 20 | N/A | 60.58 | 44 | 1 | 0 | 12.116 |
| National Endowment for the Humanities | N/A | 6.4 | N/A | 392.7 | 173 | 1 | 0 | 25.1328 |
| National Labor Relations Board | 20 | 5 | 124.5 | 2721.1 | 1740 | 56 | 24.9 | 136.055 |
| National Mediation Board | Blank | ? | Blank | Blank | 49 | 1? | 0 | 0 |
| Nuclear Regulatory Commission | 4.4 | 3 | 13800.4 | 21552.7 | 2752 | 2 | 607.2176 | 646.581 |
| Office of Personnel Management | 20 | 5 | 6547.18 | 21295.49 | 6568 | 73 | 1309.436 | 1064.7745 |
| Overseas Private Investment Corporation | ? | ? | Blank | Blank | 230 | 1 | 0 | 0 |
| Peace Corps | 20 | 20 | 64.8 | 1164.6 | 3200 | 461 | 12.96 | 232.92 |
| Pension Benefit Guaranty Corporation | Blank | 5 | 0 | 427.5 | 980 | 11 | 0 | 21.375 |
| Railroad Retirement Board | 27.2 | 6.2 | 4100 | 542 | 900 | 56 | 1115.2 | 33.604 |
| Small Business Administration | 28 | 9 | 291.3 | 11057 | 4740 | 190 | 81.564 | 995.13 |
| Social Security Administration | 21.2 | 13 | 126204.7 | 150103 | 70898 | 1649 | 26755.3964 | 19513.39 |
| Tennessee Valley Authority | 17 | 20.7 | 0.573 | 0.102 | 12457 | 2876 | 0.09741 | 0.021114 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| US Army Corps of Engineers | 23 | 5 | 338989 | 162274 | 35438 | 888 | 77967.47 | 8113.7 |
| United States Postal Service | 20 | 20 | 5.28 | 8.09 | 581775 | 33620 | 1.056 | 1.618 |
| | | | | | | | | |
| **Totals** | **690.4** | **344.8** | **5,488,921** | **2,561,118** | **4,291,579** | **405,947** | **1,420,149** | **213,962** |

The White House established a 2008 baseline of 68.9 MMt$CO_2$e 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 MMt$CO_2$e in 2020.

To obtain the GHG reduction estimate, 1.5/51 of the total federal reductions was assumed, resulting in 0.415 MMt$CO_2$e of reductions in 2020.

## *M.4. Leadership-By-Example: Local Government*

Lead Agency: MDE

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Leadership-By-Example: Local Government program in 2020 are estimated to be 0.25 MMt$CO_2$e.

**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.

**Table C-35.** 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** |

# N. Maryland's Innovative Initiatives

## *N.1. Voluntary Stationary Source Reductions*

Lead Agency: MDE

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Voluntary Stationary Source Reductions program in 2020 are estimated to be 0.17 $MMtCO_2e$.

**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

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Buy Local for GHG Benefits program in 2020 are estimated to be 0.02 $MMtCO_2e$.

The Maryland Farmers Market Association (www.marylandfma.org) was established in 2012 through a federal matching grant awarded to MDA in cooperation with the University of Maryland and Maryland's market managers. As of spring 2015, there were 145 farmers markets across the State, with at least one in every Maryland county and Baltimore City. This number represents 94% of the 2020 goal, but it is likely that the target of 155 markets has been achieved because there are always markets that are not included in the official count for a variety of reasons. MDA does not track direct sales tables, but if annualized participant numbers at the buyer/grower event held each spring since 2002 are used as a proxy, the event has grown by 93% in the last nine years. In addition, MDA participates in the USDA Farmers Market Nutrition Program (FMNP), which provides checks to low-income residents to purchase fresh produce. Last year 400 Maryland farmers joined in this effort and received over $500,000 through the program.

MDA was given legislative authority in the 2010 General Assembly session to regulate the use of the terms "locally grown" and "local" when advertising or identifying agricultural products. In 2014, the Maryland Department of Human Resources joined with the Farmers Market Association to install point-of-sale machines in farmers markets across that state so that purchases can be made by low-income residents on electronic benefit transfer cards. And this year, Maryland became the first state in the nation to pilot the Farmers Market Finder, a mobile website (http://farmersmarketfinder.ub.1.co/) that lists all farmers markets with vendors who accept FMNP checks.

## *N.3. Pay-As-You-Drive® Insurance in Maryland*

Lead Agency: MIA

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Pay-As-You-Drive® Insurance program in 2020 are estimated to be 0.02 $MMtCO_2e$

Pay-As-You-Drive® (PAYD) 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 driving, time-of-day, and driving style, which would characterize safe or risky driving behavior. PAYD technology that analyzes factors in addition to mileage has been successfully deployed in the commercial sector. However the methodology 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.

The methodology adjusts the assumptions as documented above, specifically:

- 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.

PAYD Insurance includes only light-duty VMT, and reduced this subtotal by 12 percent to exclude non-insured motorists. For the total GHG reduction potential, a 4 percent effectiveness rate was assumed and a cautiously increasing participation rate of only 5 percent by 2020 based on input from the Maryland Insurance Administration (MIA).

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 PAYD Insurance 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

### *N.4. Job Creation and Economic Development Initiatives Related to Climate Change*

Lead Agency: COMMERCE

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Job Creation and Economic Development Initiatives Related to Climate Change program have been aggregated with the estimated emission reductions from the Maryland's Innovative Initiatives bundle.

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.

## O. Future or Developing Programs

### *O.1. The Transportation and Climate Initiative*

Lead Agency: MDE/MDOT

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Transportation and Climate Initiative program in 2020 are estimated to be 0.02 $MMtCO_2e$

**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.

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.

### ***O.2. Clean Fuels Standard***

Lead Agency: MDE

The potential emission reductions from the Clean Fuels Standard program in 2020 are estimated to be 0.00 $MMtCO_2e$. This program is not projected to be operational by 2020 so not benefit has been attributed to it.

## Land Use

**Table C-36.** Land Use Sector GHG Reduction Program.

| **LAND USE** |
|---|

| Program I.D. | Program | Potential GHG Emission Reductions ($MMtCO_2e$) Revised for 2015 |
|---|---|---|
| P | Land Use Programs | 0.64 |

# P. Land Use Programs

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Land Use Programs in 2020 are estimated to be 0.64 $MMtCO_2e$

## *P1. Reducing Emissions through Smart Growth and Land Use/Location Efficiency*

Lead Agency: MDP

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Reducing Emissions through Smart Growth and Land Use/Location Efficiency program have been aggregated with the estimated emission reductions from the Land Use Programs bundle.

## *P2. Priority Funding Area (Growth Boundary) Related Benefits*

Lead Agency: MDP

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Reducing Emissions through Smart Growth and Land Use/Location Efficiency program have been aggregated with the estimated emission reductions from the Land Use Programs bundle.

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)

## The Public Sector

**Table C-37.** Public Sector GHG Reduction Program.

| PUBLIC | | |
|---|---|---|
| **Program I.D.** | **Program** | **Potential GHG Emission Reductions ($MMtCO_2e$) Revised for 2015** |
| Q | Outreach and Public Education | 0.03 |

## Q Outreach and Public Education

Lead Agency: A multi-agency effort coordinated by MDE

**Revised 2015 Estimate of GHG Emissions Reduction**

The potential emission reductions from the Outreach and Public Education program in 2020 are estimated to be 0.03 $MMtCO_2e$.

**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.

**Table C-38.** 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.

**Table C-39.** Middle Range GHG Reductions (MMt$CO_2$e).

| 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 MMt$CO_2$e emissions avoided.

**Table C-40.** Bike to Work Benefits.

| Year | People | GHG emissions avoided (pounds) | GHG emissions avoided (Metric Tons) | GHG emissions avoided (MMt$CO_2$e) |
|---|---|---|---|---|
| 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 |

# DRAFT: SUMMARY OF *AMERICAN CLIMATE PROSPECTUS* DATA DESCRIBING CLIMATE IMPACTS FOR MARYLAND

The *American Climate Prospectus* (ACP) served as the technical input to the Risky Business project, a broad-based effort to raise awareness about the potential costs of climate impacts in the United States during the 21st century.

In this paper, we summarize the information about the costs of climate impacts in ACP that are specific to the state of Maryland. The impacts examined include: increases in heat-related mortality, increases in the amount of coastal property exposed to flooding, declines in labor productivity, increases in energy expenditures, and declines in agricultural output. For the mortality impacts, annual costs could be several billion dollars by mid-century. Approximately $9 billion of Maryland's coastal property is likely to be below sea level in the coming decades; that estimate could exceed $20 billion for end-of-century sea levels. Other impacts are smaller in a monetary sense, generally on the order of millions of dollars annually. However, in all cases: 1) risks and costs grow with increasing warming, and 2) risks for substantial costs exist in the coming decades, even if significant reductions in global greenhouse gas emissions are achieved.

## About the American Climate Prospectus

*Overview and Methodology*

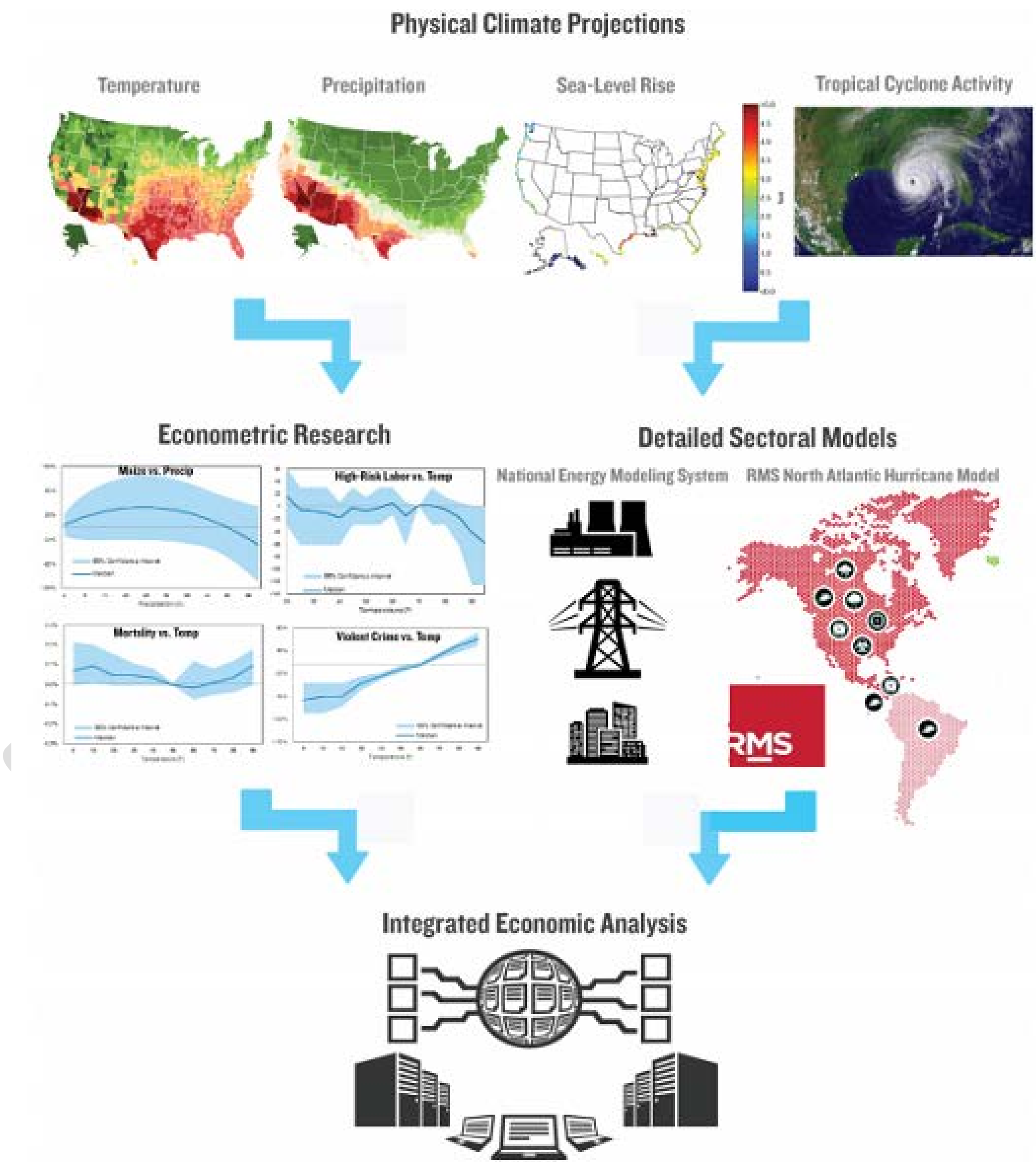
The *American Climate Prospectus* (ACP; http://www.climateprospectus.org) is an assessment of the economic risks associated with climate change in the United States, completed by the Rhodium Group (http://rhg.com/). The assessment was completed in 2014 and served as the technical input to the Risky Business Project (http://riskybusiness.org/).

ACP is novel in that it uses a consistent methodology to estimate the potential costs of climate impacts in the 21st century across a range of sectors and regions (see Figure 1). It takes advantage of some of the most recent projections for future climate, using a risk-based framework of analysis. The ACP analysis draws upon econometric relationships, linking these climate variables to impacts on human health, labor productivity, and agriculture.[1] The analysis also employs a sector-specific approach for estimating future energy demands and expenditures (i.e., the analysis draws on a model that links climate to domestic energy use), and for estimating the exposure and potential damage to coastal property. All the data regarding future climate conditions, impacts, and costs are publicly available at http://rhg.com/wp-content/uploads/2015/06/ACP-Science-data-tables.zip. More in-depth descriptions of the methodology for each type of impact is provided in the ACP report, and its associated Technical Appendices, all available online (http://www.climateprospectus.org).

[1] The report also explores the relationship between climate and crime. However, given the number of non-climate factors that affect the incidence of crime, these impacts have not been included in this summary.

This report is an independent interpretation of the data analysis conducted by the ACP team. Any additional information and discussion of these data included in this report is separate from the findings of the ACP team.

**Figure 1. A Schematic Depicting the Methodology Used in the American Climate Prospectus (SOURCE: ACP, Figure 1.1)**



*Time Periods, Scenarios, and Risk Framing*

In this paper, we draw upon three scenarios and three time periods presented in ACP for estimates of future impacts and costs. These time periods and scenarios span a relatively wide range of potential future climate conditions, demonstrating the difficulty in precisely predicting future choices regarding greenhouse gas emissions, as well as the pace and magnitude of the climate system's response to those emissions. These uncertainties reinforce the need to think about future impacts from the standpoint of *risk* – despite the lack of a "crystal ball," we can generate a range of plausible climate futures and examine the probability of different consequences and costs that are associated with those future climate conditions.

The three time periods examined can be interpreted as **near-term**, **mid-century**, and **end-of-century**. The near-term results have been compiled from averages of the 2020-2039 climate conditions (labelled as "2030" on most graphs); the mid-century results correspond to 2040-2059 climate conditions (labelled as "2050"); the end-of-century results correspond to 2080-2099 climate conditions (labelled as "2090").

The three scenarios are the same that were developed for the Fifth Assessment Report (AR5) from Intergovernmental Panel on Climate Change (IPCC). A brief description of each is as follows:

**RCP[2] 2.6** – This scenario assumes that the global community pursues immediate and significant action to reduce emissions, emissions peak in the first few decades of the 21st century, and that net emissions are close to zero during much of the second half of the 21st century. This scenario provides a likely chance (66 to 100 percent) of avoiding 2°C of warming[3], globally-averaged.

**RCP 4.5** – This scenario assumes that the global community pursues policies to reduce greenhouse gas emissions in the early part of the 21st century, and that emissions peak around mid-century. It is somewhat comparable to the B1 scenario from previous IPCC reports, but defines different drivers in achieving emissions reductions (e.g. socio-economic and technological advancements versus direct climate mitigation initiatives). This scenario provides a chance (33 to 66 percent) of avoiding 2°C of warming by the end of the 21st century.

**RCP 8.5** – This scenario can be loosely interpreted as "business as usual." Emissions continue to grow through most of the 21st century. Globally-averaged warming has a roughly 50-50 chance of exceeding 4°C by the end of the century.

## Climate Impacts for Maryland from ACP

The following graphs identify a range of potential physical impacts that may affect the state of Maryland through the end of this century. The colored rectangles in these graphs show a "likely range" for each scenario and time period. Statistically speaking, these ranges correspond to the 17th and 83rd percentiles of the distributions generated in the ACP analysis (i.e., greater than two-thirds of the projected values lies within one standard deviation above and below the mean). The lines extend to the 5th and 95th percentiles – impacts at these levels can be considered a 1-in-20 chance.

[2] Representative Concentration Pathways (RCP) are greenhouse gas concentration trajectories.
[3] The increase in warming is compared to the pre-industrial (1880) globally-averaged temperature.

It is important to note that the data presented within each graph result from a suite of 35 global climate models (GCM), downscaled to provide state-specific information on future trends in temperature, precipitation, and sea-level rise, and is interpreted within a framework that generates self-consistent probability distributions. These are the same GCMs used by the Intergovernmental Panel on Climate Change (IPCC) and the U.S. Government in their latest assessment reports – the AR5 and the 3rd National Climate Assessment, respectively.

For many of the physical and subsequent economic impact categories, the differences among scenarios are small in the near-term and around mid-century. This reflects the long lifetime (decades to centuries) of majority of greenhouse gases, as well as the slow turnaround time for the energy system. Most impacts for the next several decades are essentially “baked into” the climate system, arising from emissions occurring in past decades. However, at the end of the 21st century, the choices made regarding the world’s energy systems will have a significant influence on the severity of impacts.

*Temperature*

Under all RCP scenarios average seasonal temperatures rise throughout the course of the 21st century.

Figures 2 and 3 show the ranges for increases in the average summer and winter temperature during the 21st century compared to the 1981-2010 climatological average. A thirty-year average is used in place of a yearly average to minimize any potential effects of natural variation. In the early part of the 21st century, increases in the median average temperature range between 2°F and 3°F above the climatological average for both summer and winter. By mid-century, the median values begin to increase more sharply, especially for the RCP 8.5 scenario. By the end of the century, median temperatures range between 2.5°F and 9°F above the current average. The 1-in-20 chance associated with RCP 8.5 corresponds to an average summer temperature of 90.0°F and an average winter temperature of 48.1°F. This is 15.5°F and 12.6°F above the current climatological average, respectively.

**Figure 2. Projected Changes in Average Summer Temperature in Maryland in the 21st Century**

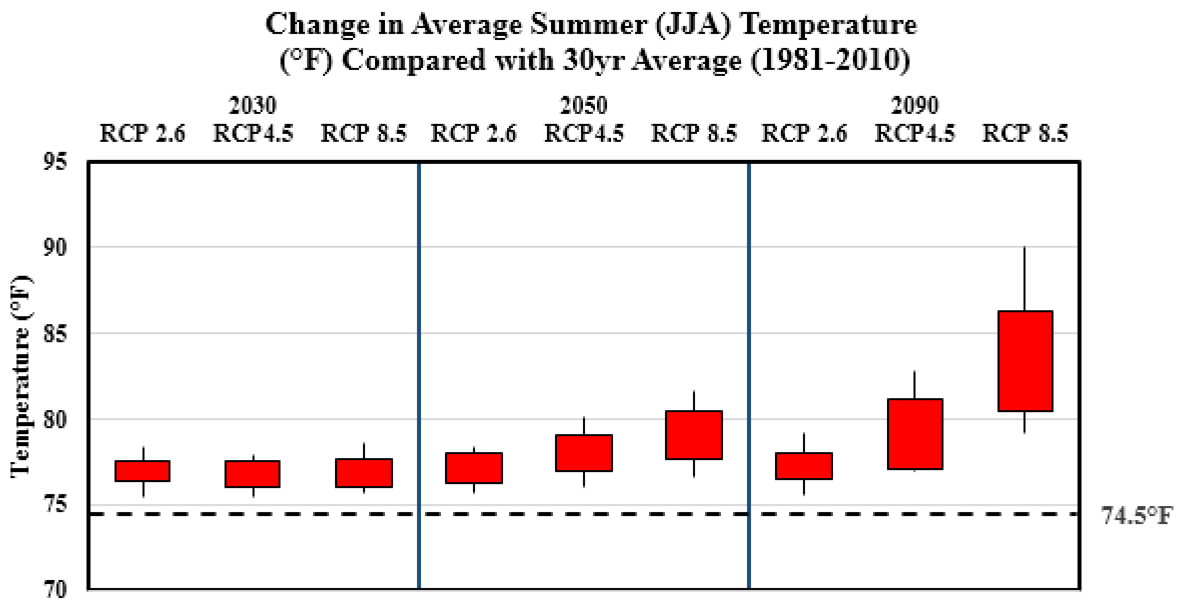



**Figure 3. Projected Changes in Average Winter Temperature in Maryland in the 21st Century**

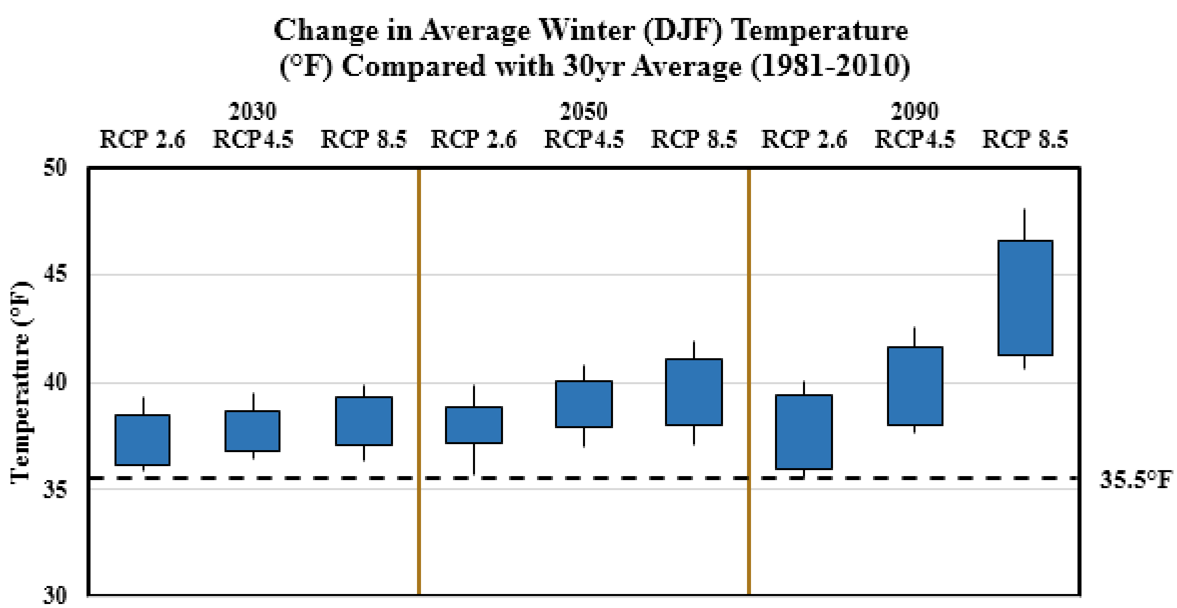



Figure 4 shows the ranges for increases in the number of days above 95°F compared to the 1981-2010 climatological average of 6.4 days. Under the RCP 8.5 scenario, the expected number of days above 95°F increases to 16 days by 2030, with a likely range of 11 to 17 days. By 2050, the expected number of days above 95°F increases to 27 days, with a likely range of 16 to 35 days. By the end of the century, this value increases to 62 days, with a likely range of 33 to 85 days. Also under the RCP 8.5 scenario, there is a 1-in-20 chance of 111 days above 95°F by the end of the century.

**Figure 4. Projected Changes in Number of Days above 95°F in Maryland in the 21st Century**

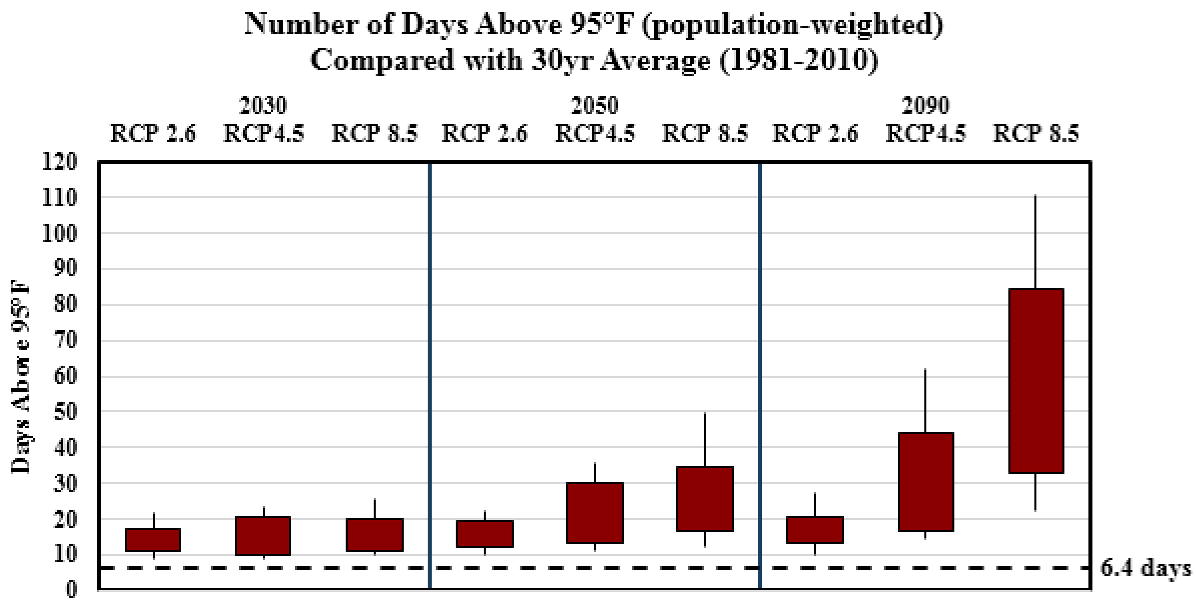
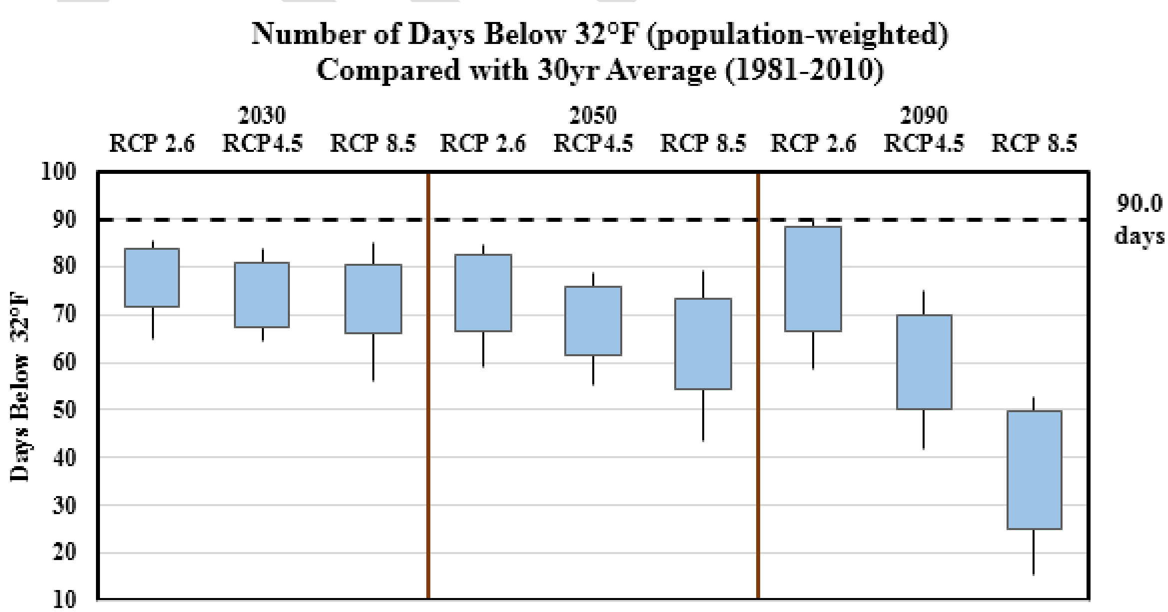



Figure 5 shows the ranges for increases in the number of days below 32°F compared to the 1981-2010 climatological average of 90 days. Under the RCP 8.5 scenario, the expected number of days below 32°F decreases to 56 days by 2030, with a likely range of 66 to 80 days. By 2050, the expected number of days below 32°F decreases to 43 days, with a likely range of 55 to 73 days. By the end of the century, this value increases to 38 days, with a likely range of 25 to 50 days. Also under the RCP 8.5 scenario, there is also a 1-in-20 chance of 15 days below 32°F by the end of the century.

**Figure 5. Projected Changes in Number of Days below 32°F in Maryland in the 21st Century**



*Heat and Humidity*

Figures 6 and 7 identify the range of increases in the number of Humid Heat Stroke Index (HHSI) days compared to the 1981-2010 climatological average. The HHSI developed for the ACP takes into account not only ambient air temperature, but an evaporative measurement known as a wet-bulb temperature. This measurement is made by wrapping the bulb of a thermometer in wet cloth and allowing the moisture to evaporate. Evaporation is a cooling process, and as such the temperature of the cloth decreases. The wet-bulb temperature is the lowest temperature achieved by this process. The higher the wet-bulb temperature, the more moisture in the air. The more moisture in the air, the higher the humidity, and the more difficult it is to regulate body temperature by sweating.

ACP has defined four categories of HHSI (Table 1). Category I reflects the typical uncomfortable conditions experienced in the Southern U.S. during the summer months. Category II reflects the most humid conditions experienced in the Southern U.S. and expanding into the Midwest and along the East Coast during the hottest periods of the summer season. Category III reflects the most dangerous conditions experienced during record events such as the 1995 heatwave in the Midwest. Category IV reflects extreme events that have exceeded current U.S. records.

**Table 1. Categories of ACP Humid Heat Stroke Index**

| ACP Humid Heat Stroke Index | Peak Wet-Bulb Temperature | Characteristics of the hottest part of day |
|---|---|---|
| I | 74°F to 80°F | Uncomfortable. Typical of much of summer in the Southeast. |
| II | 80°F to 86°F | Dangerous. Typical of the most humid parts of Texas and Louisiana in hottest summer month, and the most humid summer days in Washington and Chicago. |
| III | 86°F to 92°F | Extremely dangerous. Comparable to Midwest during peak days of 1995 heat wave. |
| IV | >92°F | Extraordinarily dangerous. Exceeds all US historical records. Heat stroke likely for fit individuals undertaking less than one hour of moderate activity in the shade. |

Under the RCP 8.5 scenario, the expected number of HHSI I days by the end of the century in Maryland increases from the climatological average of 37 days to 78 days, with a likely range of 69 to 84 days. The expected number of HHSI II days increases from the climatological average of 1 day to 43 days, with a likely range of 25 to 57 days. There is also a 1-in-20 chance of 88 HHSI I days and 71 HHSI II days. Although not graphed, the number of occurrences for category III and IV days also increases. By 2090, the expected number of HHSI III days increases from zero to 8. The number of HHSI IV days increases from zero to 1.

**Figure 6. Projected Changes in the Number of HHSI I Days in Maryland in the 21st Century**

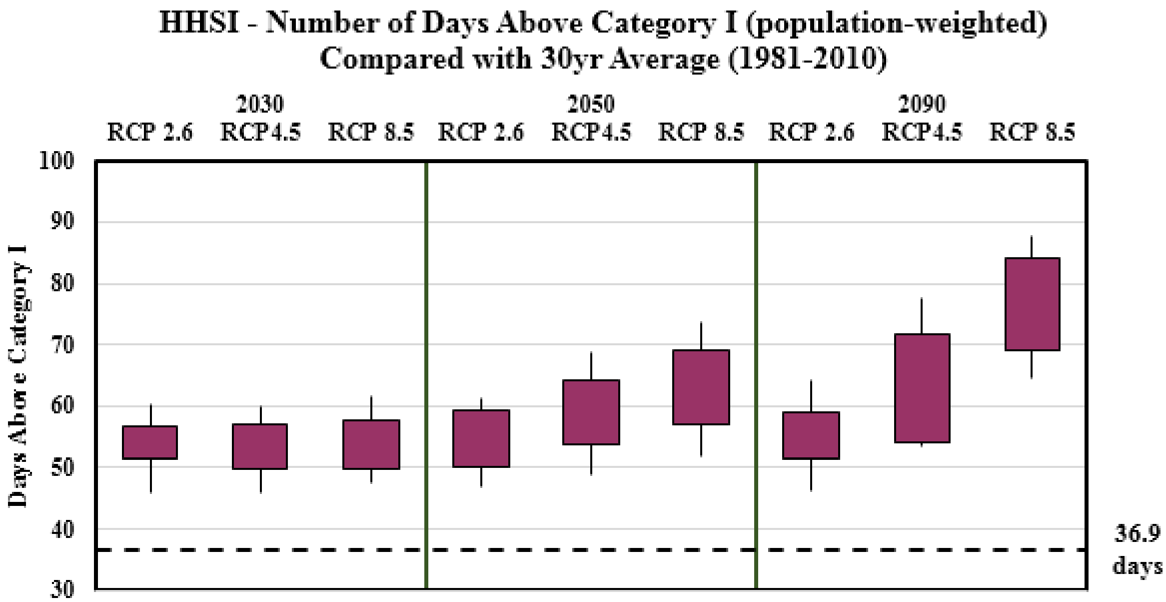
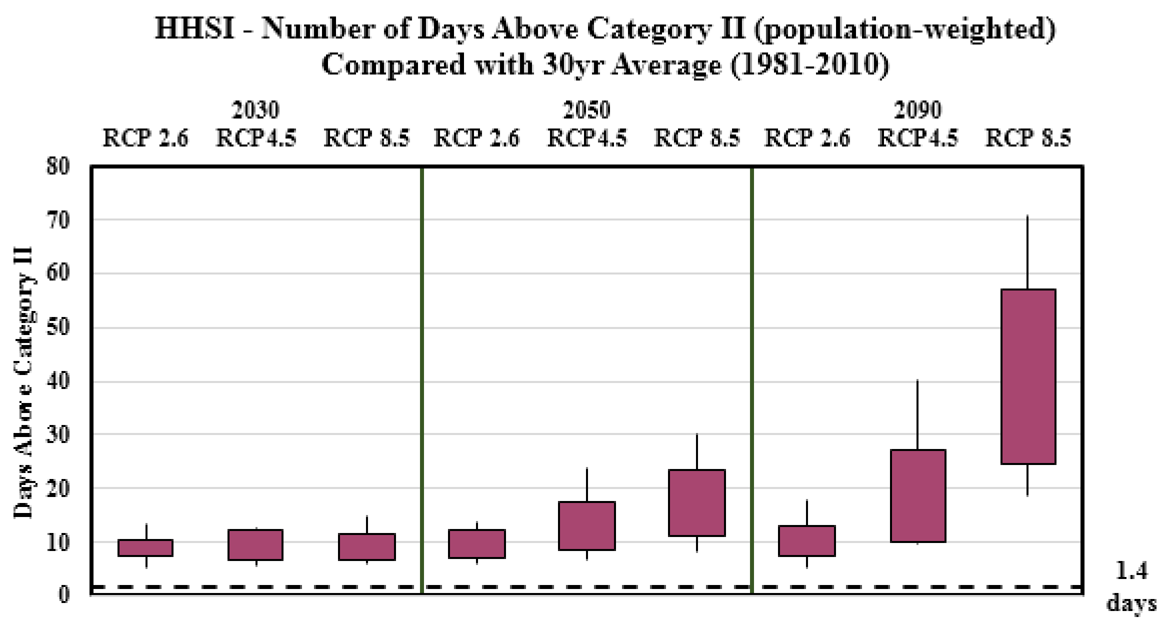



**Figure 7. Projected Changes in the Number of HHSI II Days in Maryland in the 21st Century**




*Precipitation*

Figure 8 shows the probability of change in precipitation when compared to the climatological average by the end of the 21st century. In Maryland, both seasonal and annual precipitation amounts are likely to increase under all three scenarios, with the highest likelihood of increased precipitation (>66%) occurring in the spring season and the RCP 8.5 scenario.

**Figure 8. Projected Changes in Annual and Seasonal Precipitation in Maryland in the 21st Century**

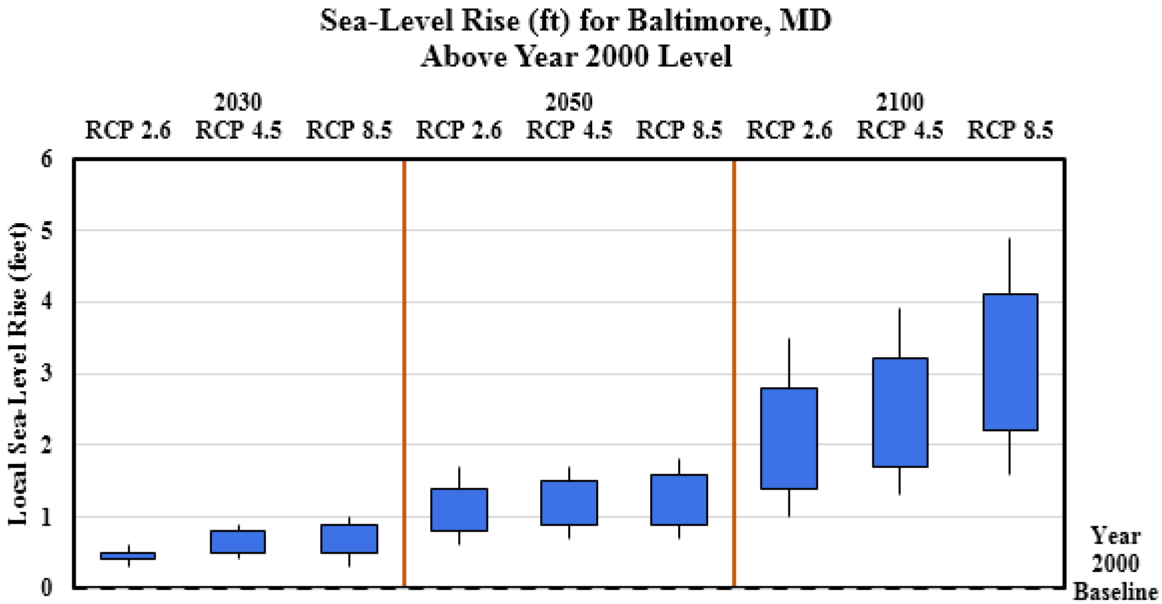
| PRECIPITATION CHANGE<br>*Probability of change (area-weighted)* | | | | | |
|---|---|---|---|---|---|
| | **Annual** | **Winter** | **Spring** | **Summer** | **Fall** |
| **RCP 8.5, 2080-2099** | | | | | |
| MD - (Northeast Region) | ++ | + | ++ | (+) | + |
| **RCP 4.5, 2080-2099** | | | | | |
| MD - (Northeast Region) | + | (+) | + | + | (+) |
| **RCP 2.6, 2080-2099** | | | | | |
| MD - (Northeast Region) | (+) | ? | + | (+) | (+) |

| | |
|---|---|
| *Very likely* (90% probability) increase | ++ |
| *Likely* increase (more than 67% probability) | + |
| Increase *more likely than not (more than 50% probability)* | (+) |
| Decrease *more likely than not* (more than 50% probability) | (-) |
| *Likely* decrease (more than 67% probability) | - |
| Ambiguous - Difference in sign between simple and probability weighted ensembles | ? |

*Sea-Level Rise*

Figure 9 shows ranges for increases in sea level above the 2000 level by 2100 for the city of Baltimore, MD. In the early part of the 21st century, increases in the median sea level range between 0.4ft and 0.9ft above the 2000 baseline. The median sea level range continues to increase to between 0.8ft and 1.6ft above the 2000 baseline, but displays little to no dependence on RCP scenario. However, by 2100 the range of sea level increases dramatically and is dependent on RCP scenario. Median values range from 1.4ft to 4.1ft, with an RCP 8.5 1-in-20 chance increase of 4.9ft and a 1-in-100 chance increase of 6.8ft.

**Figure 9. Projected Changes in Sea-Level Rise for Baltimore, MD in the 21st Century**




*Combined Effects*

In 2014, the total value of grain crops exceeded $680 million[4]. While a warming climate may increase the growing season and some crop yields, especially those harvested more than once per year, extended periods of extreme warmth above critical growth temperatures will limit yields (Porter et al., 2005). Additionally, increases in surface ozone levels due to warmer temperatures will also stunt crop growth and limit yields (Ainsworth et al., 2012). Furthermore, warmer temperatures may favor different crop varieties, causing farmers to switch less economically viable crops (Mercer & Perales, 2010).

Additionally, warmer air temperatures will translate to elevated surface water temperatures for the Chesapeake Bay region, affecting a fishing industry contributing over $600 million (2014) to the state's economy[5]. For some species – Brown shrimp, Spotted seatrout, and Black drum – warmer water may be more favorable. For others – Winter flounder, Soft-shelled clam, and Eastern oyster, the warmer temperatures could exceed their habitable range (Glick et al., 2007). Warmer water temperatures in the presence of an abundance of nutrients can also lead to harmful algal blooms (HAB) and hypoxia (Paerl & Huisman, 2009). A decrease in oxygen within the marine environment would prove detrimental to aquatic species.

Furthermore, likely increases in precipitation will affect the agricultural and fisheries sectors. Higher precipitation rates and amounts will likely lead to increased agricultural runoff, including fertilizers. This may result in increased amounts of fertilizer use by farmers and increased fertilizer in coast waterways, providing a favorable ingredient for the development of HABs.

[4] MD State Archives – Agriculture 2014.
[5] MD State Archives – Seafood 2014.

Impacts on public health are also contingent on these climatological factors. Heat-related and respiratory illness will increase due to warmer temperatures and resultant increased pollution (Shea et al., 2008). Rates of vector- borne and waterborne disease will also increase as warmer winter temperatures and increased spring and summer precipitation produce optimal breeding conditions for mosquitos and bacteria such as cryptosporidium and giardia (Hunter, 2003). In Maryland, asthma rates have increased 5.5% in Baltimore and 1.8% throughout the state between 2000 and 2009[6]. Eighty-eight cases of West-Nile Virus have been reported since 2011[7].

Coastal regions are not immune to climate change impacts. Maryland's coastal counties account for over two thirds of the state's population and attract two thirds the state's tourists. In 2013, Maryland's tourist sector was valued at $15.4 billion, bringing in over $2.1 in tax revenue for the state[8]. Rising sea-levels place the coastal infrastructure in jeopardy, potentially reducing residential and tourist traffic and adversely affecting valuable coastal communities.

These climatological impacts are multi-faceted and inter-connected, and will significantly affect Maryland's agricultural resources, coastal environment, and air quality – all factors intimately tied to the state's economic well-being.

## Impacts and Costs for Maryland from ACP

The following graphs show how climate change may affect health, coastal property, energy expenditures, labor productivity, and agriculture in Maryland. These categories represent a starting point for understanding the economic magnitude of *some* potential impacts. For example, no estimates are provided in ACP of how climate change might affect water resources, ecosystems, or aspects of human health beyond heat-related mortality (e.g., respiratory ailments associated with lower air quality, changes in the ranges of disease vectors).[9]

It is also critical to understand that the ACP modelling applies no assumptions about future changes in the economy. In other words, the estimates of impacts assume that the future climate conditions are affecting the population and economy of today. In the "real world," there will certainly be changes in many factors that are economically important between now and 2100 (e.g., patterns of land use; age-distribution of the population; location of communities; new technologies that affect labor, energy, agriculture, and health). As such, the impact estimates can be viewed as an indication of what is at stake if our economy was suddenly subject to a future climate, or what might happen if communities did nothing to prepare for the increases in risk over the coming decades.

All cost estimates are in 2011 U.S. Dollars.

[6] MD Dept. of Health and Mental Hygiene Baltimore City Asthma Report, August 2011. Asthma and other respiratory ailments are not solely dependent on air quality.
[7] MD Dept. of Health and Mental Hygiene Arbovirus Surveillance Reports 2011-2014. The spread of water- and vector-borne illnesses are not limited to the degree of climate change impacts presented in this report.
[8] MD Dept. of Tourism 2014 Annual Report.
[9] We will explore available information for these other impacts in a subsequent paper. But it is unlikely that precise, comparable ranges for future costs will be available for many of these other types of impacts.

*Increases in Heat-Related Mortality*

Figure 10 shows the ranges for increases in the mortality rate during the 21st century. In the early part of the 21st century, decreases in cold-related deaths may potentially offset increases in heat-related mortality, as the “likely” ranges include both positive and negative values. However, by mid-century, the median values for each of the three scenarios are all positive, indicating that it is more likely that increases in heat-related deaths would exceed reductions in cold-related deaths. By the end of the century, benefits become less likely. The 1-in-20 chance associated with RCP 8.5 corresponds to an increase in mortality of over 30 deaths per 100,000 people.

Costs associated with heat-related mortality are shown in two different ways (Figures 11 and 12). In Figure 11, the costs are based on the “Value of a Statistical Life” (VSL), which is commonly used in economic analysis to estimate potential costs and benefits related to mortality. The VSL estimate ($7.9 million per person) used in ACP[10] is based on values used by U.S. the Environmental Protection Agency (EPA). These estimates track the changes in mortality – costs or benefits may be on the order of several billion dollars per year in the early part of the century. The likely range for near-term and mid-century impacts range from approximately $2 billion in benefits to $3.4 billion in costs. At the end of the century, costs are projected to exceed benefits – the median values for all scenarios are all greater than zero. And all scenarios have increasingly large “tail risks.” For example, with the RCP 8.5 scenario there is a 1-in-20 chance for additional annual costs to exceed $15 billion.

“Market” costs (Figure 12) reflect the changes in labor productivity related to the loss of workers and their income. These costs are much smaller than the VSL estimates; in the near-term and at mid-century, the likely ranges begin around $20-50 million in annual benefits and go up to nearly $200 million in annual costs (note the difference in scale of the y-axis). However, unlike the VSL estimates, in all time periods the median cost estimates are greater than zero. At the end-of-century, the RCP 8.5 scenario has a 1-in-20 chance for additional annual costs to exceed $1 billion.



[10] ACP, p. 108

**Figure 10. Projected Changes in Mortality in Maryland in the 21st Century**

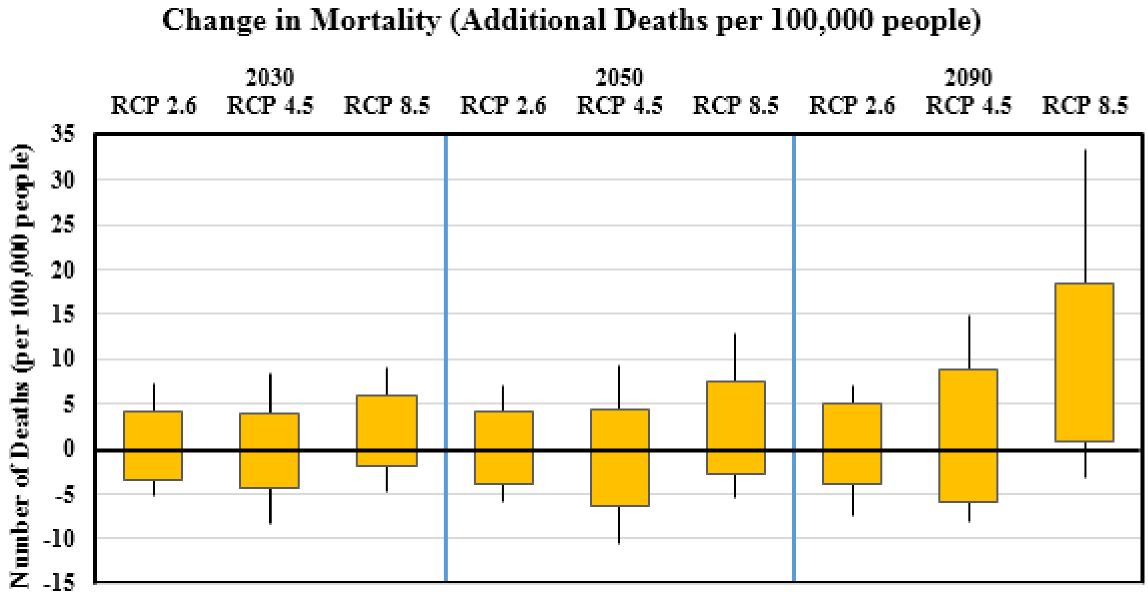



**Figure 11. Costs Associated with Changes in Mortality in Maryland in the 21st Century**

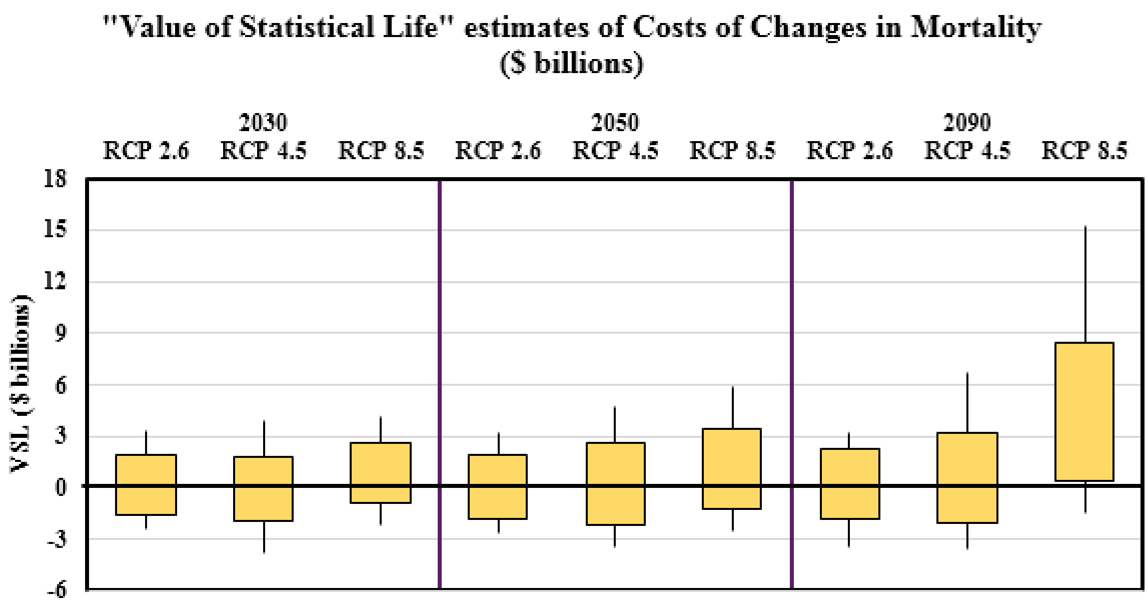
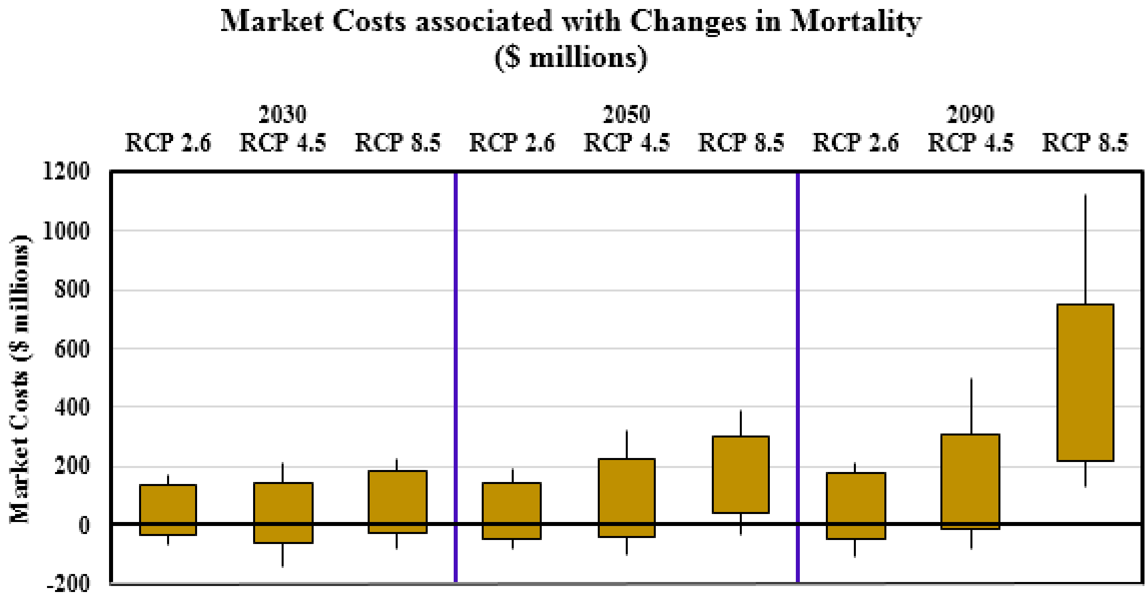


**Figure 12. "Market" Costs Associated with Changes in Mortality in Maryland in the 21st Century**

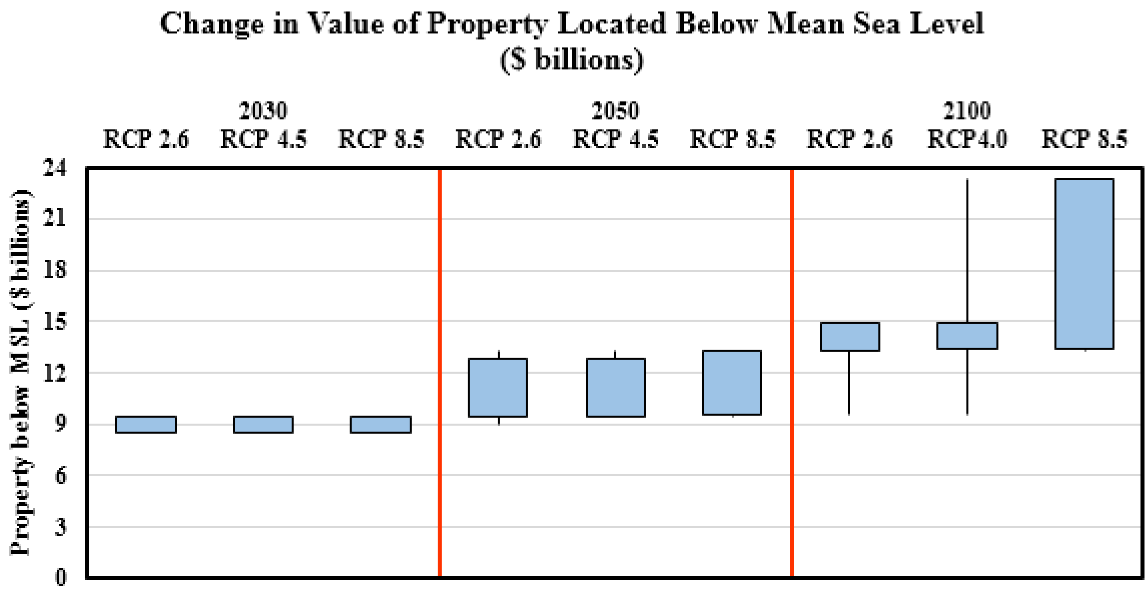



*Increases in Risks to Coastal Property*

Anticipated increases in sea level will expose a significant number of homes and businesses to more frequent flooding. Much of the newly exposed area will be on the east side of the Chesapeake Bay, in Queen Anne and Talbot counties[11]. As shown in Figure 13, in the near-term, an additional $9 billion in property value[12] is likely to be below sea level. For mid-century, this range grows to $9 to $13 billion. For the end-of-century, the likely range for the RCP 8.5 scenario extends to over $23 billion. Throughout the 21st century, only 4 states exhibit a greater increase in coastal property: Florida, Louisiana, California, and Texas. Unlike other impact estimates discussed in this paper, the future coastal exposure information is not based on a two decade average of future sea levels, but rather a "snapshot" of future sea level in 2030, 2050, and 2100.

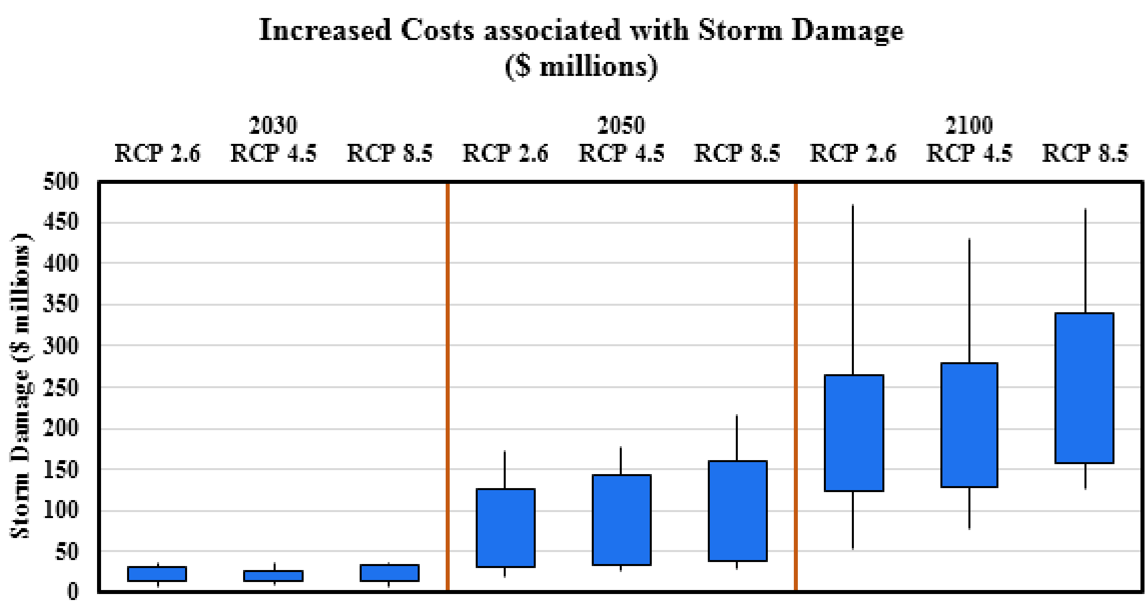
[11] ACP, p.89
[12] Risk to coastal property is based on current (2014) distribution of property and economic activity.

**Figure 13. Increases in Coastal Property at Risk of Inundation in Maryland for 2030, 2050, and 2100**




Current damages from coastal storms in Maryland average approximately $200 million annually. As shown in figure 14, future damages estimated in ACP exhibit modest increases prior to mid-century (likely ranges for 2030 are increases of $7-30 million annually; for 2050, increases of $20-160 million annually). By 2100, the median damage estimates are approximately double current damages, and the likely range extends to around $340 million in additional annual damages.

**Figure 14. Increases in Costs associated with Storm Damage in Maryland for 2030, 2050, and 2100**

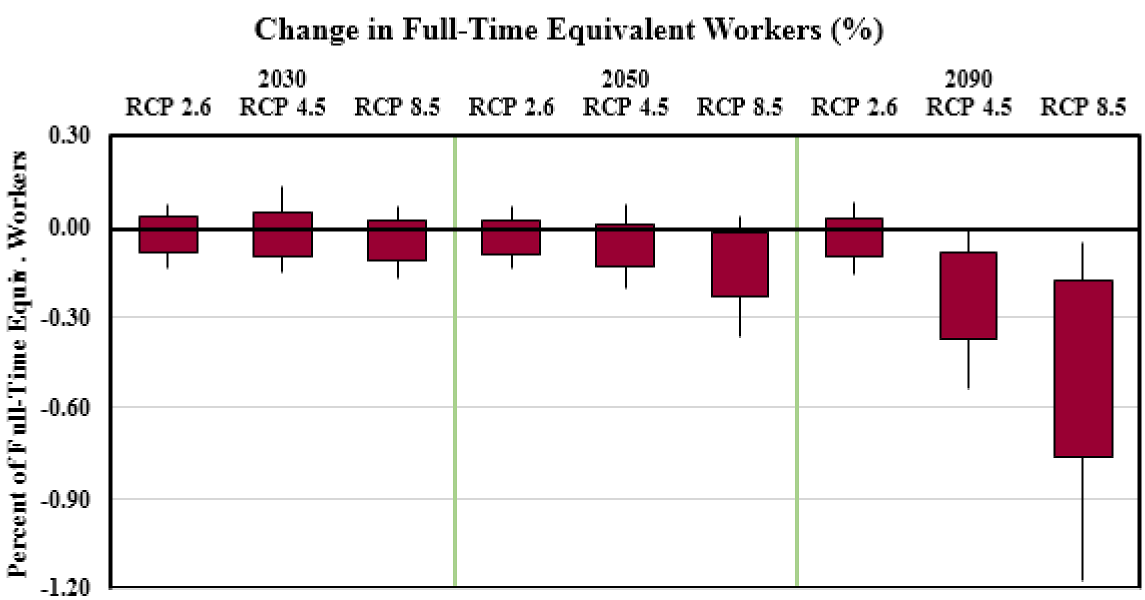


It should also be noted that the ACP scenarios draw upon sea level rise estimates that may be conservative. ACP sea level data situated within the likely range is in agreement with IPCC's sea level rise projections, which have a likely range of 2-3.3 feet through 2100. By comparison, the National Climate Assessment (NCA) (http://nca2014.globalchange.gov/) has a likely range for future global sea level extending up to 4 feet by 2100.

*Decreases in Labor Productivity*

Temperature can influence labor productivity, especially in sectors where outdoor work is required, such as agriculture, construction, utilities, and manufacturing.[13] ACP's estimates for changes in labor productivity are predominantly negative through the 21st century, with the likely range for lost productivity equivalent to about 0.2% to nearly 0.8% of all full-time equivalent workers in the state (Figure 15).

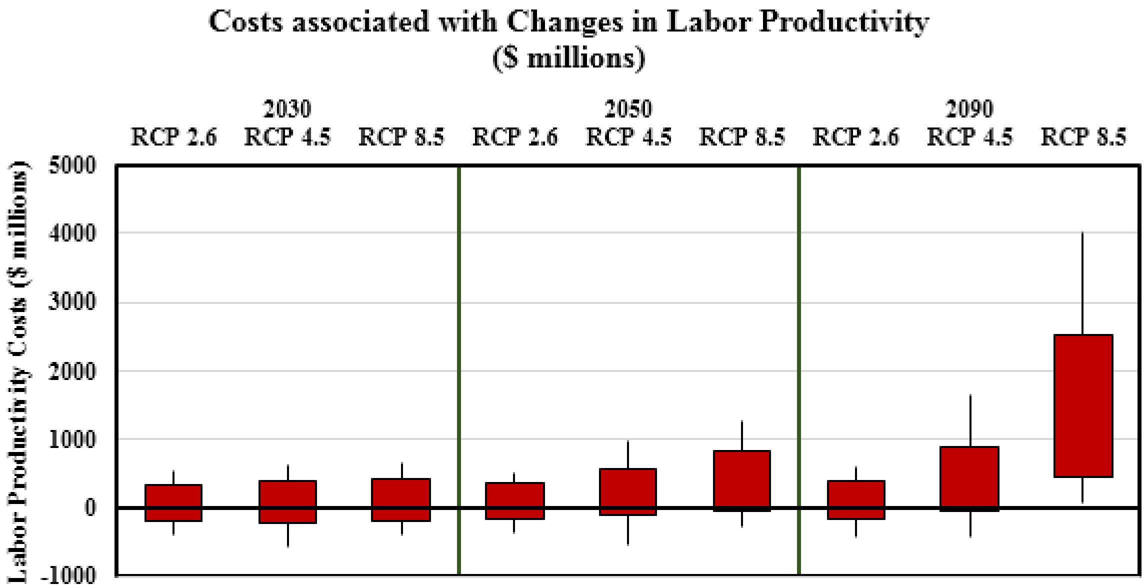
**Figure 15. Changes in Labor Productivity in Maryland in the 21st Century**




Although the likely ranges for the costs associated with changes in labor productivity show the potential for net benefits prior to mid-century, all the median estimates are greater than zero and correspond to costs (Figure 16). In the near-term, the median costs associated with the decline in labor productivity range between $70-110 million annually. This grows to $110-360 million by mid-century. By the end-of-century, the median estimate for RCP 8.5 is approximately $1.3 billion, with a 1-in-20 chance for costs to reach $4 billion annually.

**Figure 16. Costs Associated with Changes in Labor Productivity in Maryland in the 21st Century**

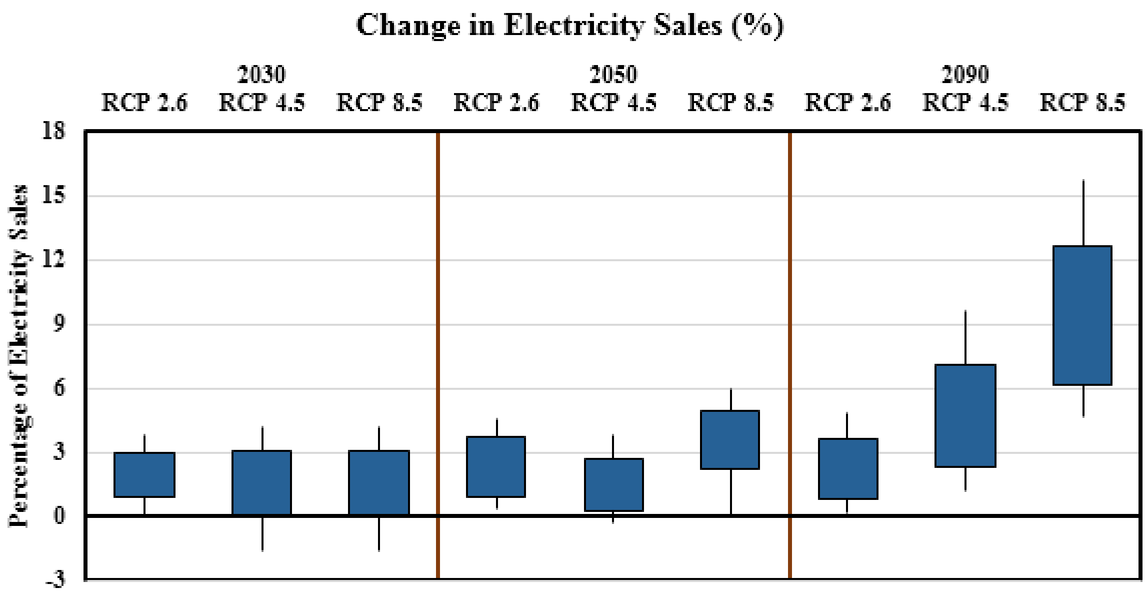
[13] ACP, p.54


Costs associated with Changes in Labor Productivity
($ millions)
2030
2050
2090
RCP 2.6
RCP 4.5
RCP 8.5
RCP 2.6
RCP 4.5
RCP 8.5
RCP 2.6
RCP 4.5
RCP 8.5
Labor Productivity Costs ($ millions)
5000
4000
3000
2000
1000
0
-1000

*Increases in Energy Expenditures*

Warming is likely to reduce energy required for heating in the winter, but boost energy demands in the summer for cooling. As the 21st century progresses, the increases in summer demands are likely to outpace reduced demands in the winter. More importantly, increases in the cost of energy are likely to accompany this shift. The increase in summer energy demands will drive up peak electricity demand (Figure 17), which is often a key factor in determining electricity prices, since it is connected to large capital investments associated with building and maintaining generation capacity[14].

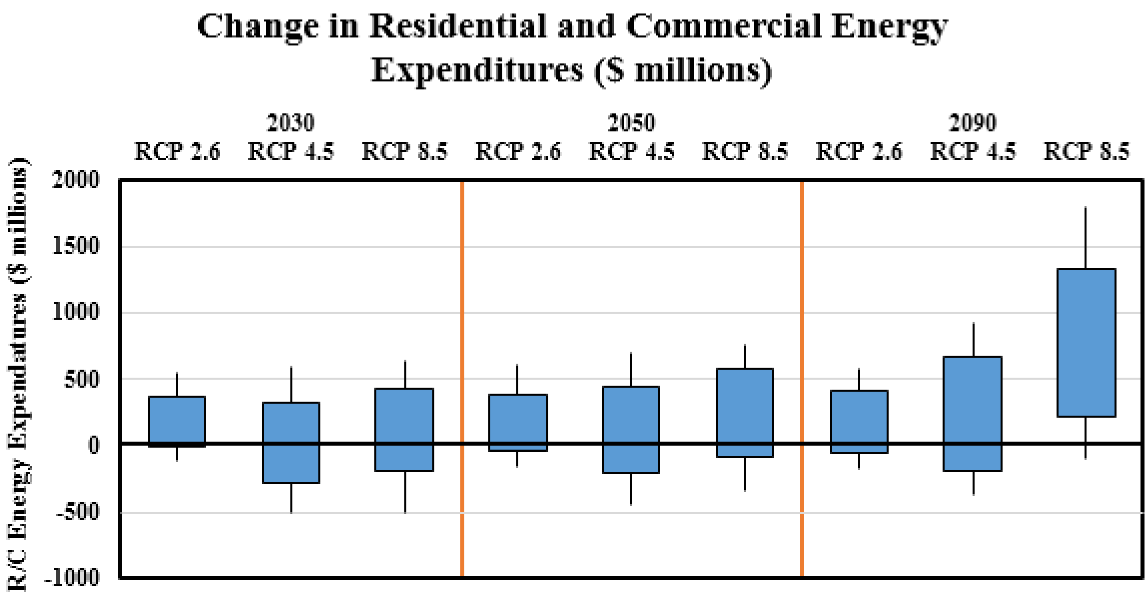
**Figure 17. Changes in Electricity Sales in Maryland in the 21st Century**




ACP provides estimates for future energy expenditures. In the near-term, the likely ranges for impacts span zero, beginning at approximately $300 million in benefits and extending to $400 million in additional costs (Figure 18). By mid-century, the chances for a net benefit shrinks and the range for likely costs grow to approximately nearly $600 million for the RCP 8.5 scenario. By the end-of-century, costs grow: median costs for even the most optimistic emissions scenario (RCP 2.6) exceed $160 million. For RCP 8.5, the likely range extends to $1.3 billion in additional costs, with a 1-in-20 chance for costs of $1.8 billion.

[14] ACP, p.80-81

**Figure 18. Changes in Energy Expenditures in Maryland in the 21st Century**



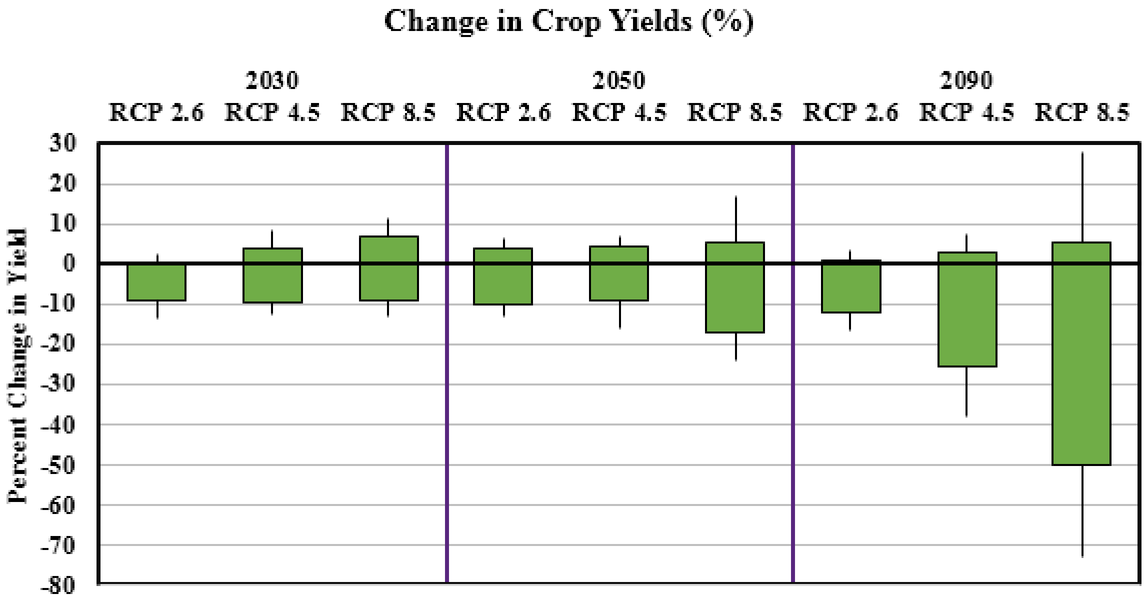

*Declines in Agricultural Output*

ACP provides estimates of the impacts of future temperature and precipitation on the yields of maize, wheat, and soybeans.[15] We have included the combined estimates for all three crops in the following figures. The estimates shown here also include the potential for carbon dioxide fertilization (that increases in concentrations of carbon dioxide facilitate crop growth), and can be thought of as conservative.

In Maryland, it is likely that yields for wheat would improve, while yields for maize and soybean would decline. The net effect of these changes are likely to lead to modest declines in agricultural yield prior to mid-century (Figure 19). Likely ranges for the near-term range from a 9% decline to a 7% improvement; all the median estimates indicate a decline of 2-4%. For mid-century, the likely ranges extend from a 17% decline to a 5% improvement. At the end-of-century, the potential exists for significant declines in crop yields – for the RCP 8.5 scenario, the likely range extends from a 50% decline to a 5% improvement, with a median estimate of a nearly 25% decline.

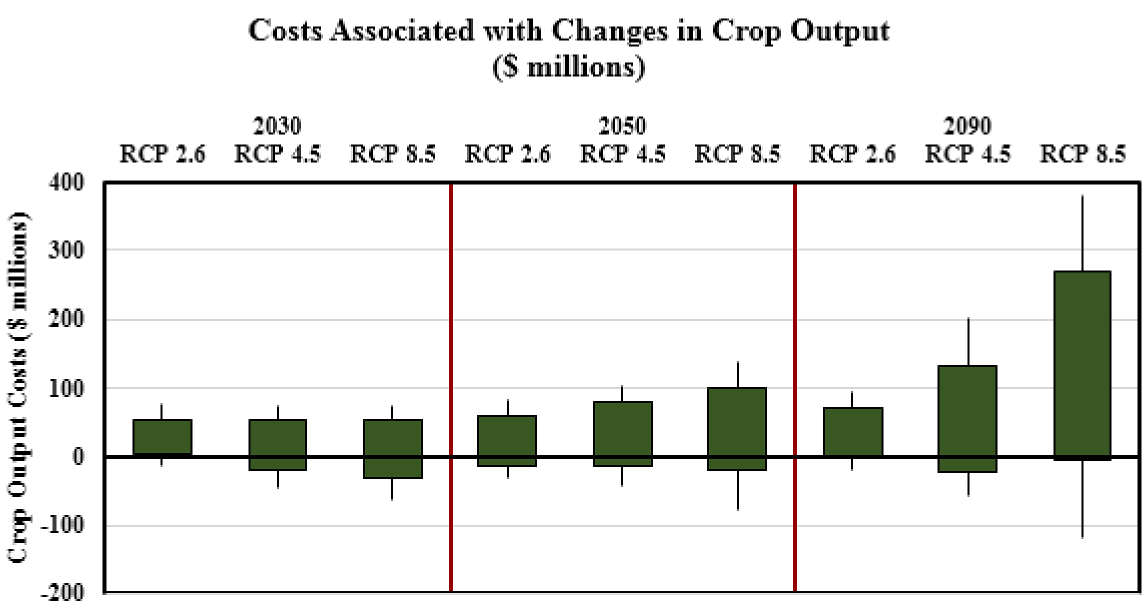
[15] ACP also includes estimates for cotton, but these estimates were not applicable to Maryland.

**Figure 19. Changes in Crop Yields in Maryland in the 21st Century**




Relative to the other impact categories, the costs associated with future declines in crop yields are relatively small (Figure 20). Costs or benefits are unlikely to exceed $50 million in the near-term, and are unlikely to exceed $100 million at mid-century. For the end-of-century, the likely range for costs extends from near zero to just over $260 million. The 1-in-20 chance for impacts equates to costs of approximately $380 million annually.

**Figure 20. Costs Associated with Changes in Crop Yields in Maryland in the 21st Century**



## Adaptation Efforts

Given the extent of potential risks due to climate change, it is clear that remaining on a path of increased greenhouse gas emissions will only increase Maryland's exposure. While reducing emissions can mitigate much of the climate risk to Maryland, some climatic changes are already "baked in" as result of past business decisions that increased the level of greenhouse gas emissions. Furthermore, decision-makers at all levels may have limited ability to directly influence attempts to limit or reduce emissions. Understanding the limitations of action toward mitigation, decision-makers can instead choose to focus on reducing risk through behavioral change and "defensive investments" – two general forms of adaptation practice[16].

Potential gains from adaptation measures, however, are generally unknown and are not included in the Risky Business Project report or incorporated into the ACP cost analyses. Farmers benefiting from longer growing seasons due to increased temperatures may have to invest in improved irrigation infrastructure or crop varieties better suited for warmer climates. People opting to utilize air conditioning will reduce heat-related risks, but at the consequence of higher energy costs. Utilities may be forced to invest in infrastructure upgrades to keep up with changes in demand. Governments may be forced to invest in developing or improving infrastructure to protect economic interests.

Decision-makers may also choose not to partake in adaptive measures. This may be due to high investment costs, scale of action, and a general lack of information and awareness of the climate change issue. Because of these non-quantifiable variables and uncertainty in future changes in behavior, adaptation should not be seen as a substitute for mitigation efforts, but rather as a complement to mitigation polices focusing on reducing greenhouse gas emissions and minimizing risks associated with climate change.

## Summary

The physical and economic impact data supplied by ACP identify not only the potential risks associated with climate change, but also the costs of climate change to specific sectors of Maryland's economy through the 21st century. These data examine not only the most likely physical and economic scenarios, given all three future emissions reduction tracks, but also the scenarios that, while less likely, could have greater impacts. Notably, no estimates are provided in the ACP of how climate change might affect water resources, ecosystems, or aspects of human health beyond heat-related mortality. And, potential gains from adaptation measures are not included in the Risky Business Project report or incorporated into the ACP cost analyses.

By continuing down the BAU path, it is likely that the number of days above 95°F will increase tenfold, the number of days below 32°F will decrease by half, and sea-level in the Chesapeake Bay region will increase an additional 3 feet. Moreover, there is a 90% likelihood of increased precipitation, especially during the spring and summer months. These climatological impacts translate to likely annual economic costs of over $5.5 billion dollars within the labor, health, and energy sectors by 2100 with an additional $15 billion dollars in property value at risk due to rising sea levels. However, opting for a scenario that

[16] ACP, p. 163

incorporates a mix of policy and technology to reduce greenhouse gas emissions would significantly limit the costs associated with climate change. A significant increase in sea level rise by 2100 under all three climate scenarios limits the reduction of economic risk to coastal property from BAU by 7 to 10 percent ($1 to $1.5 billion). Projected annual economic costs within the labor, health, and energy sectors decreases 79 to 89 percent or between $600 million to $1.1 billion by the end of this century. The magnitude of cost and risk reductions is directly dependent on the speed of policy and technology implementation.

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# 26. Consider Emerging Technologies and Other Important Policies

## 1. Introduction

The previous chapters offer a wide array of options to reduce greenhouse gas (GHG) emissions from the electric power sector through existing technology-based and policy-oriented solutions. The electricity sector is undergoing dramatic change, however, morphing from an analog unidirectional system to a digital multidirectional system. Traditional unidirectional systems are characterized by centralized electric generating units (EGUs) providing electricity to end-users through radial transmission and distribution grid networks. These systems have historically managed supply in order to meet demand. By contrast, currently emerging digital multidirectional systems will utilize distributed grid networks and manage both supply and demand through two-way communications and smart devices.

These changes will profoundly alter the electric power system as we have known it for the last century. Neither the form these changes take, nor their impacts and ramifications, are predictable or understandable at this point in any accurate or comprehensive way. However, several technology and policy trends and developments are increasingly evident. Although some may not achieve material penetration in the existing electric power system for a decade or more, many are already becoming widely commercialized. Because major air quality regulatory processes often operate on decadal timescales,[1] it is important to introduce several of these developments for regulators' awareness in air quality planning. The sections that follow do so, first for technology considerations and then for policy considerations.

It is also important to note that new technologies and new policy ideas regularly arise over the course of time. Those that follow do not represent a compilation of all such considerations, let alone a prediction of future ones. Furthermore, this list is intended to serve merely as an introduction to each of these developments rather than an exhaustive treatment of each.

## 2. Other Technology Considerations

Many new capabilities and increased efficiencies in the entire electric power system – from generation through end-uses – are being driven by the application of advanced digital and communications technologies. Others are emerging from enhanced data capture and analysis, better imaging and research capabilities, and new scientific discoveries and their application. Several of these technologically driven developments are covered in this chapter. Note that their order does not represent any kind of prioritization in terms of commercialization likelihood, time frame, or importance.

### 2.1. Energy Storage

Recent improvements in energy storage and power electronics technologies coupled with changes in the electricity marketplace are expanding opportunities for electricity storage as a cost-effective electric energy resource. Some analysts suggest, in fact, that we are nearing an inflection point in battery storage, with the economics of lithium-ion batteries unlocking new business opportunities that were unavailable just a few years ago. These in turn drive development efforts to, among other things, evaluate storage solutions as alternatives to future peaking needs. In conjunction with improving component costs, declining costs of capital, and the potential for utilities to rate-base the investment, factors are ripe for continued growth in storage as the market nears a tipping point on storage deployment.[2] Figures 26-1 and 26-2 illustrate the breadth

1 For example, the interval necessary for revising a National Ambient Air Quality Standard (NAAQS), adopting regulations to attain it, implementing and enforcing those regulations, and conducting the research necessary for the next periodic NAAQS review regularly exceeds ten years.

2 Dumoulin-Smith, J. (2014, December 8). *US Electric Utilities & IPPs: The Storage Inflection Point?* UBS.

*Figure 26-1*

**New Storage Opportunities Are Beginning to Proliferate in Front of the Meter**[3]

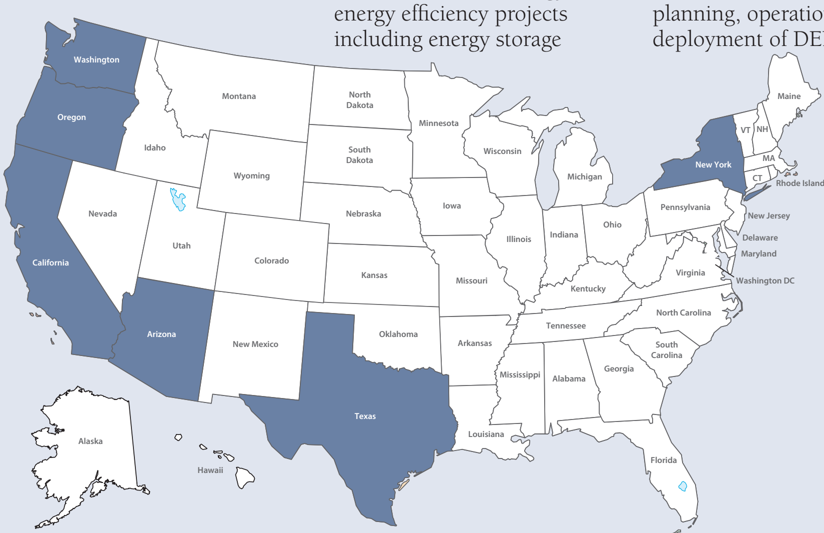
**Oregon:** Department of Energy sought comments to assist with development of storage demonstration RFP

**Washington:** Department of Energy awarded $15 million to three utilities for storage demonstration projects

**US:** DOE announced a $2.5 million solicitation (with additional funding up to $4 billion) in loan guarantees toward renewable energy and energy efficiency projects including energy storage

**New York:** Con Edison and PSEG Long Island procuring storage for T&D deferral; NYSERDA providing funding for storage technology startups in addition to microgrid projects; New York PSC reforming regulation to facilitate planning, operations, and market-based deployment of DERs, including storage

**California:** CPUC mandating 1.3 GW of storage by 2020; SCE, PG&E and SDG&E issued relevant RFOs; SCE also procured 100.5 MW through LCR and SDG&E issued LCR RFOs (which count toward the mandate), capacity requirements driving more procurements than the mandate so far; PG&E and SCE issued RPS RFOs for utility-scale renewables paired with storage; CPUC proceeding to improve utility distribution resource planning in 2015




**PJM:** Seeing consistent deployments for ancillary services; developing new capacity performance requirements for resources including storage

**Arizona:** APS to procure upward of 10 MW of storage; TEP to procure up to 10 MW

**Hawaii:** HECO considering three battery storage projects of 60 MW to 200 MW

**ERCOT:** Undertaking comprehensive redesign of ancillary service market to allow participation in the market and appropriately value fast-acting resources such as storage within three years; Oncor sponsored study showing value of utility-controlled distributed energy storage in Texas

of storage opportunities now being explored both "in front of the meter" and "behind the meter."[3]

Energy storage incorporates a variety of technology types that deliver four broad categories of energy services:

1. *Bulk energy services* (e.g., supply capacity, utility-scale time-shifting);
2. *Ancillary services* (e.g., regulation, spinning, non-spinning, and supplemental reserves, voltage support, black start, and the like);
3. *Transmission and distribution infrastructure services* (e.g., transmission/distribution upgrade deferral, avoided investments, reduced congestion); and
4. *Customer energy management services* (e.g., enhanced quality and reliability, retail time-shifting, and so forth).[4]

In what is known as stacked services, a single storage system can provide a combination of services, allowing it to become economically viable by capturing multiple revenue streams. These stacked configurations can be designed on a case-by-case basis, depending on location within the grid and the specific technology capabilities.[5]

Energy storage could be a key component of a comprehensive strategy to reduce GHG emissions from the power sector. Storage can reduce GHG emissions directly by providing bulk energy and ancillary services to replace

3 GTM Research and Energy Storage Association. (2015, February 20). *US Energy Storage Monitor: 2014 Year In Review: Executive Summary.* Available at: http://www.greentechmedia.com/research/us-energy-storage-monitor

4 Eyer, J., & Corey, G. (2010, February). SAND2010-0815 *Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide: A Study for the DOE Energy Storage Systems Program.* Sandia National Laboratories. Available at: http://www.sandia.gov/ess/publications/SAND2010-0815.pdf

5 See: California Public Utilities Commission. R.10-12-007, *Rulemaking to Consider the Adoption of Procurement Targets for Viable and Cost-Effective Energy Storage Systems.* Available at: http://www.cpuc.ca.gov/PUC/energy/electric/storage.htm

*Figure 26-2*

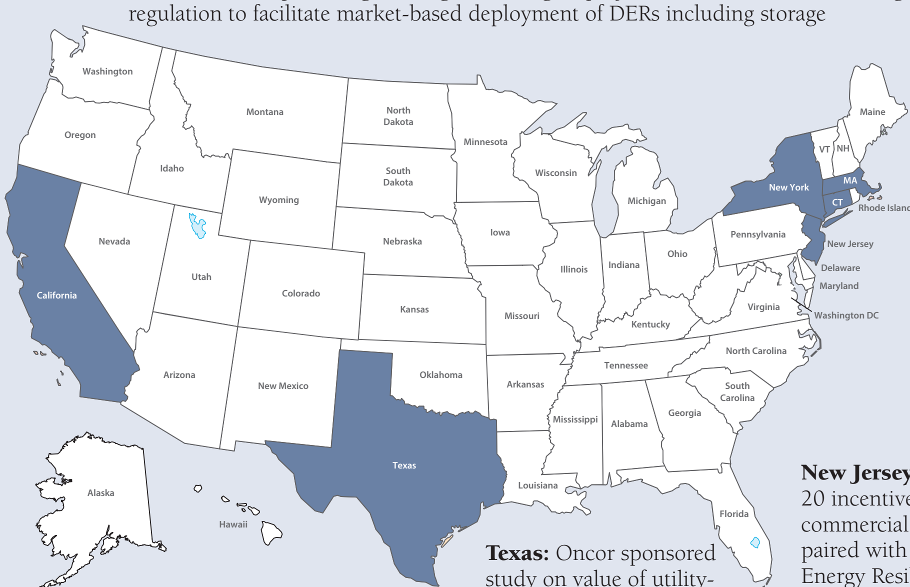
## New Storage Opportunities Are Beginning to Proliferate Behind the Meter[6]

**US:** DOE reviewing applications for $15 million funding opportunity targeting behind-the-meter PV and solar integration

**New York:** Con Edison soliciting 85 MW of load management including battery and thermal storage across two programs; PSEG Long Island may issue similar RFP; NYSERDA providing funding for microgrid projects; New York PSC reforming regulation to facilitate market-based deployment of DERs including storage

**Massachusetts:** $25.8 million grant awarded to various microgrid projects, many including battery storage; MassCEC awarded $150,000 for demonstration of utility-controlled residential battery systems

**California:** CPUC's SGIP program to continue through 2020 on $83 million annual budget, 4 MW of non-residential and 0.15 MW of residential projects have received upfront incentive; SCE procured 160.6 MW of behind-the-meter storage (135 MW battery storage) through LCR




**Connecticut:** $2.9 million grant awarded to municipal microgrid project including 100 kW of battery storage

**New Jersey:** BPU reviewing 20 incentive applications for commercial storage systems paired with renewable generation; Energy Resiliency Bank accepting applications for backup power systems for critical facilities

**Texas:** Oncor sponsored study on value of utility-controlled distributed (including behind-the-meter) energy storage in Texas

**Hawaii:** HECO contracted with Stem for 1 MW of storage for C&I customers with PV

high-emitting resources, such as fossil fuel peaking units and conventional load-following/ramping units. Storage can also help mitigate emissions indirectly by providing ancillary services to help integrate variable renewable energy resources into the grid. Storage can provide time-shifting services by charging devices when electricity prices are low – including when renewables are producing excess energy that would otherwise be curtailed – and discharging from them when prices are high. This can help reconcile the discrepancy between peak demand and peak renewable output, which can become an issue for portfolio managers at high penetrations of variable renewable generation.

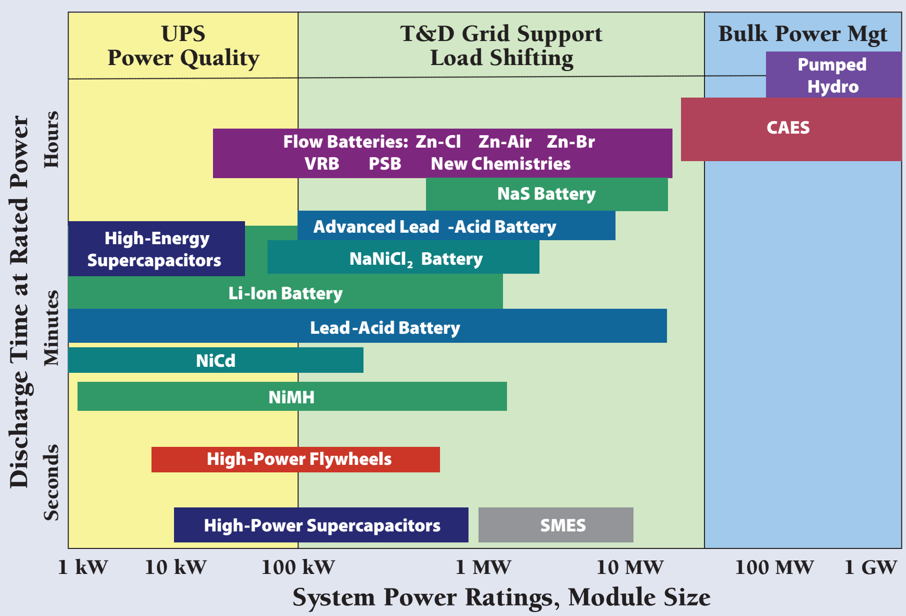
At present, viable storage opportunities have been primarily limited to pumped hydro and compressed air. Pumped hydro is a mature, utility-scale technology that takes advantage of off-peak electricity to pump water to a high elevation reservoir, from where it can be released and run through a hydroelectric turbine to generate electricity in peak hours. Compressed air energy storage (CAES) uses off-peak electricity to compress and store air, either belowground in manmade or natural caverns, or aboveground in tanks. When needed, the compressed air can be heated and expanded to generate electricity via an expansion turbine or in conjunction with a conventional gas turbine. To date, there are two existing commercial CAES plants, one in Germany and the second in Alabama. A number of second-generation facilities are currently planned or under development.

CAES and pumped hydro fit a similar profile of bulk storage services, capable of long discharge durations (>10 hours) at large sizes (15 to 1000 megawatts [MW]). Storage technologies can be classified according to this relationship between discharge time and power rating, as demonstrated conceptually in Figure 26-3, which shows that the majority of storage technologies (e.g., electrochemical batteries and flywheels) are better suited to shorter and rapid discharge times at lower power ratings.

6 Supra footnote 3.

***Figure 26-3***

**Power-Energy Relationship Across Energy Storage Technologies**[7,8]




Note that Figure 26-3 is intended as an illustration of this relationship and that many of the technology options shown can have broader applications than the figure characterizes.[9] Storage for utility-scale time-shifting (energy arbitrage) or storage tied to large variable power facilities (or groups of facilities) would fall in the upper right on Figure 26-3 at the higher end of the size and duration times. Alternatively, storage used for time-shifting smaller-scale wind farms or solar photovoltaic (PV) applications would fall on the left, at the lower end of size and duration times.

Bulk storage is especially complementary to solar generation. In a 2014 study examining strategies for integrating large amounts of variable energy resources, researchers at Lawrence Berkeley National Laboratory found that the value of PV and wind increase dramatically with availability of low-cost bulk power storage on the system.[10,11]

Discussion about "storage" often defaults to mean "storage of electricity," but electricity is used to provide energy services (heating, cooling, lighting, driving motors, and so on). Rather than storing electricity to provide such energy services

7 Sandia National Laboratories. (2013, July). *DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA*. Available at: http://www.sandia.gov/ess/publications/SAND2013-5131.pdf

8 CAES = Compressed Air Energy storage; Li-Ion = Lithium Ion battery; NaNiCl2 = Sodium Tetrachloroaluminate battery; NaS = Sodium Sulfur battery; NiCd = Nickel Cadmium battery; NiMH = Nickel Metal Hydride battery; PSB = Polysulfide Bromide battery; SMES = Superconducting Magnetic Energy Storage; T&D = Transmission and Distribution; UPS = Uninterruptible Power Supply; VRB = Vanadium Redox Battery; Zn-Air = Zinc Air battery; ZnBr = Zinc Bromine battery; ZnCl = Zinc Chloride battery.

9 For greater technical detail on storage technology types, see full report: supra footnote 7. See also: State Utility Forecasting Group. (2013, June). *Utility Scale Energy Storage Systems: Benefits, Applications, and Technologies*. Available at: http://www.purdue.edu/discoverypark/energy/assets/pdfs/SUFG/publications/SUFG%20Energy%20Storage%20Report.pdf

10 Wiser, R., & Mills, A. (2014, March). *Strategies for Mitigating the Reduction in Economic Value of Variable Generation With Increasing Penetration Levels*. Lawrence Berkeley National Laboratory. Available at: http://eetd.lbl.gov/sites/all/files/lbnl-6590e.pdf

11 Among other strategies considered (e.g., flexible conventional generation, real-time pricing, and variable resource diversity), low-cost bulk power storage was found to increase marginal values of PV by 80 percent at a 30-percent penetration level. The bulk power storage analyzed – modeled on pumped hydro storage with ten hours of storage capacity – would be charging during times with PV generation and have the effect of driving up prices during those times. Results for wind were positive but less substantial than solar. Lawrence Berkeley National Laboratory modeling found an 11-percent increase in the value of wind at a 40-percent penetration level, in comparison to a scenario without low-cost storage. The low-cost bulk storage mitigation measure assumes that pumped-hydro storage with ten hours of storage capacity can be built with a much lower investment cost than was assumed in the reference scenario, $700/kilowatts-year, based on the cost of new pumped-hydro storage from the Energy Information Administration (2011).

at a later time, electricity can be converted to an alternative energy carrier and then stored in that form for direct use later. One of the most promising opportunities along these lines is thermal storage (e.g., water heating) in homes and businesses to shift electricity use from peak periods and/or to capture and store solar and wind generation when it is available. With water heating responsible for more than 17 percent of residential energy demand, the tens of millions of electric water heaters across the country represent a large opportunity for load control.[12] As is already being done by many rural cooperatives and other utilities, grid operators can shift water heating from morning and evening peak demand times to mid-day and overnight, when wind and solar may be underutilized. Using existing capacity, water can be "supercharged" to higher temperatures during off-peak times, and moderated through blending valves to achieve desired temperatures.[13] One million electric water heaters are roughly equivalent to 4000 MW of dispatchable load, yielding as much as 10,000 megawatt-hours (MWh) per day that could be shifted as needed.[14]

Another promising load-shifting strategy involves thermal storage associated with air conditioning units under grid operator control. Central air conditioners and large cooling systems can incorporate two hours of thermal storage in the form of chilled water and ice. Commercially available and being deployed today, these units allow ice-making during the hours of maximum solar output to meet demand for cooling later in the evening.[15]

Over a longer-term horizon, electrical batteries will offer opportunities for storage, but at the 2014 cost of $700 to $3000 per kilowatt-hour (kWh) of installed electricity storage, they remain expensive.[16] Some analysts predict 50-percent declines in cost over the next three years; other analysts forecast even larger cost reductions.[17] Initial market transformation is being driven by activities at the state level, including notably a 2013 energy storage mandate by the California Public Utility Commission requiring the state's three investor-owned utilities to add 1.3 gigawatts (GW) of cost-effective energy storage to their grids by 2020.[18] In the first competitive procurement process by Southern California Edison, storage proposals exceeded expectations, with 264 MW of storage capacity selected, including a 100-MW lithium-ion battery (with four-hour output duration) to replace older conventional peaking units.[19]

12 US Department of Energy. (2011). *Residential Energy Consumption Survey 2009.* Available at: http://www.eia.gov/consumption/residential/

13 Lazar, J. (2015, February 15). *Thermal Energy Storage: A Low-Cost Option for Electricity Storage.* Presentation at NARUC's 2015 Winter Committee Meetings. Montpelier, VT: The Regulatory Assistance Project. Available at: http://www.narucmeetings.org/Presentations/Winter2015%20Lazar.pdf

14 Lazar, J. (2014, January). *Teaching the "Duck" to Fly.* Montpelier, VT: The Regulatory Assistance Project. Available at: http://www.raponline.org/document/download/id/6977

15 In accordance with CPUC D.13-02-015, Southern California Edison selected 25.6 MW offered through 16 contracts in the West Los Angeles Basin for behind-the-meter thermal energy storage from Ice Energy Holdings, Inc. Gross, D. (2015, January 9). Long May You Run. *Slate.* Available at: http://www.slate.com/articles/business/the_juice/2015/01/battery_and_storage_infrastructure_is_the_next_growth_area_for_energy_here.html

16 UBS Global Research. (2014, October 2). *US Electric Utilities & IPPs: The Storage Opportunity.* Available at: https://neo.ubs.com/shared/d1vn32UwCm8eh; Supra footnote 7.

17 Byrd, S., Radcliff, T., Lee, S., Chada, B., Olszewski, D., Matayoshi, Y., Gupta, P., Rodrigues, M., Jonas, A., Mackey, P. J., Walsh, P. R., Curtis, M., Campbell, R., & Gosai, D. (2014, July 28). *Morgan Stanley Blue Paper – Solar Power & Energy Storage: Policy Factors vs. Improving Economics.* Available at http://energystorage.org/resources/morgan-stanley-blue-paper-solar-power-energy-storage-policy-factors-vs-improving-economics

18 California Public Utilities Commission. (2013, October 17). *Decision 13-10-040: Decision Adopting Energy Storage Procurement Framework and Design Program.* Available at: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M079/K533/79533378.PDF

19 Southern California Edison. *Pursuant to D. 13-02-015, Local Capacity Requirements Request for Offers, Selected Resource List.* Available at: https://www.sce.com/wps/portal/home/procurement/solicitation/lcr/!ut/p/b1/rVTBcpswEP0VXzzTHmQtSIB0JDVjw3jsJqSTwMU-jZJnQAsJA4rhfX0zcyfQQ43Ssk3bn6Wn37ZvFMX7Ec-SleslS0mS5Ffoxjex34U9eYUdNf3RgeuKHPpt7cg3Bld-4CoA8AHx4Vz778tbPyAYxzLsq3aJxw1Uq2lLltVtmtVjuF-0H4MqVZ0eRlWt5XOtij7X6DyTWdtX2owh11LkIykq-0SUPo1rtnrM3aDP6ksv66_GjSmYbHBFBqLmRCbISCxA-1JEOcbAniwhaUc5IYpnFq7EzlA8L0jQ0w9ACDzdy5H4I-PzoKDf_P9zuP3nDCHnAB8Bt48WIE_u78l4JNbWIauSwD-MpxRP8Bxmuukn2TklglhKY5rtVW1qidPumnx436_n6Rap-7maSF3gqOvb-bDqqYnDdyEdJoQSRoIgsQmiwCliDt0g-SR3TlnILlNhDhNa1CZ1PEwZDg-q0y37udrHbWfVoyddOtv_36vkGQvqPxBd5dYDQujah82nC4II9ckWJL1kHVfGjYOSAft3Nfy-2yyUSCQNi5S9FsX6LDvs_7AAmZw!!/dl4/d5/L2dBISEvZ0FBIS9nQSEh/#/accordionGrp2-4

Other developments in Texas bode well for the growing viability of battery storage. Building on the results of a study by the Brattle Group, which found broad benefits to Electric Reliability Council of Texas customers from grid-integrated distributed electricity storage,[20] Texas utility Oncor is seeking regulatory approval to invest in 5 GW of energy storage, including $2 billion in battery storage predicated on declining battery costs.[21] Another commercial project underway in Illinois uses two 19.8-MW batteries to provide real-time frequency regulation service to the PJM Interconnection ancillary services market.[22]

As greater segments of the transportation sector are electrified, electric vehicle (EV) batteries are another grid-integrated storage application that holds promise for low-cost grid support services.[23] With high ramping capabilities and the ability to shift loads over many hours, aggregated EV batteries can offer demand response and ancillary services to help accommodate variable energy resources and replace fossil fuel consumption in the transportation sector. Various pilot projects around the country, including those spearheaded by the Department of Defense (e.g., at Los Angeles Air Force Base, California; Joint Base Andrews, Maryland; Fort Hood Army Base, Texas; Joint Base McGuire-Dix-Lakehurst, New Jersey; and Fort Carson, Colorado) are exploring the benefits and costs of EV grid support across different utility and market environments.[24]

As the costs of many of these technologies steadily decline and storage becomes an increasingly important component of resource portfolios, market and regulatory frameworks also need to follow suit to allow the benefits of energy storage, both distributed and centralized, to be adequately evaluated and compensated. This may mean allowing utilities to include energy storage investments in their rate base, giving the right to own storage assets to transmission and distribution utilities, modifications to ancillary service markets, or other things in different utility market structures. These issues are explored in recent studies by the National Renewable Energy Laboratory (NREL), which provides more detail on valuing energy storage and overcoming related market and policy barriers.[25]

## 2.2. Smart Grid

The term "smart grid" refers to a vision of a future power grid in which new types of information technology and other technological improvements are integrated into the existing power delivery system to enable more visibility, control, coordination, and management of both the existing grid and new assets, such as increased levels of renewables, customer-sited resources, electricity storage, and others. This information technology is envisioned to be provided by high-speed, two-way communications networks between utilities and customers, improved sensing systems, advanced metering infrastructure, energy management and

20 Chang, J., Pfeifenberger, J., Spees, K., Davis, M., Karkatsouli, I., Regan, L., & Mashal, J. (2014, November). *The Value of Distributed Electricity Storage in Texas: Proposed Policy for Enabling Grid-Integrated Storage Investments.* The Brattle Group, Prepared for Oncor. Available at: http://www.brattle.com/system/news/pdfs/000/000/749/original/The_Value_of_Distributed_Electricity_Storage_in_Texas.pdf?1415631708

21 Klump, E. (2014, November 12). Texas Utility Sees Benefit in Potential $2B Battery Storage Rollout. *EnergyWire.* See: http://www.eenews.net/stories/1060008712

22 PV Magazine. (2014, November 11). *RES Americas to Build 40 MW of Energy Storage System in Illinois.* Available at: http://www.pv-magazine.com/news/details/beitrag/res-americas-to-build-40-mw-energy-storage-system-in-illinois-_100017126/#ixzz3SaInSmbS

23 Energy and Environmental Economics, Inc. (2014, October 23). *California Transportation Electrification Assessment, Phase 2: Grid Impacts.* Available at: http://www.caletc.com/wp-content/uploads/2014/10/CalETC_TEA_Phase_2_Final_10-23-14.pdf

24 Morse, S., & Glitman, K. (2014, April). *Electric Vehicles as Grid Resource in ISO-NE and Vermont.* Vermont Energy Investment Corporation. Available at: https://www.veic.org/documents/default-source/resources/reports/evt-rd-electric-vehicles-grid-resource-final-report.pdf; California Independent System Operator. (2014, February). *California Vehicle Grid Integration Roadmap: Enabling Vehicle-Based Grid Services.* Available at: http://www.caiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf

25 Denholm, P., Jorgenson, J., Hummon, M., Jenkin, T., & Palchak, D., Kirby, B., Ma, O., & O'Malley, M. (2013, May). *The Value of Energy Storage for Grid Applications.* NREL. Available at: http://www.nrel.gov/docs/fy13osti/58465.pdf; Cappers, P., MacDonald, J., & Goldman, C. (2013, March). *Market and Policy Barriers for Demand Response Providing Ancillary Services in the US Market.* Lawrence Berkeley National Laboratory. Available at: http://emp.lbl.gov/sites/all/files/lbnl-6155e.pdf; Ela, E., Milligan, M., Bloom, A., Botterud, A., Towsend, A., & Levin, T. (2014, September). *Evolution of Wholesale Electricity Market Design With Increasing Levels of Renewable Generation.* NREL. Available at: http://www.nrel.gov/docs/fy14osti/61765.pdf

control systems in buildings, and other technologies that will better coordinate all the pieces of the power delivery system. When fully operational, the technologies will increase the use of and enable the better integration and control of:

- Demand response on end-use devices and systems to reduce the demand for electricity at certain times (discussed in Chapter 23);
- Behavior responses of customers who change their electricity use in response to feedback they receive through smart technologies (discussed in Chapter 13);
- Distributed generation, such as small engine or turbine generator sets, wind turbines, and solar electric systems connected at the distribution level;
- Distributed storage, such as batteries, flywheels, superconducting magnetic storage, and other electric and thermal storage technologies (discussed earlier in this chapter);
- Distribution/feeder automation, such as expanded communications in substations and other parts of the distribution network with remotely actuated switches, dynamic capacitor bank controllers, better transformer-management systems, and so forth;
- Transmission control systems that rapidly sense and respond to disturbances;
- Microgrids, which can disconnect from the traditional grid when it is stressed and thus improve system resiliency; and
- Electric and plug-in electric hybrid vehicles that charge and discharge energy stored in the batteries of the vehicles at appropriate times (discussed elsewhere in this chapter).

Operators of the smart grid (and customers and devices themselves), through the technologically improved electricity delivery system, will be able to actively control and respond in real time to grid conditions by adjusting usage and improving efficiencies in order to meet one or more of several goals. Those goals are varied, but some of the most important are: energy savings and emissions reductions; integrating renewables and other distributed sources into the grid; managing peak load capacity; operating ancillary services; and improving costs, reliability, resiliency, and security.

The potential applications of the smart grid are varied and diverse. For example, a smart grid application could allow a utility to have better awareness and communication of outages, allowing for faster recovery. During capacity-constrained periods, a smart grid application could help deploy distributed energy resources to a greater extent or interrupt commercial and industrial customer loads. Large buildings could use whole-building control systems that would integrate all the energy-using devices within the building and allow building energy managers and utilities to control the devices in real time for optimal energy efficiency or other goals. Large customers that can't afford long outages, such as hospitals and some manufacturers, could use microgrids, increasing the resiliency and security of the grid. The smart grid also could make evaluation, measurement, and verification of energy efficiency and demand response programs easier, because smart meters and other technologies can more accurately record, track, and measure the energy savings impact of the programs.

In order to make the smart grid fully operational, several things need to occur: the improvement and modernization of the grid infrastructure; the addition of the digital communications layer onto the grid; and the business approaches and policy transformations necessary to capitalize on the investments and bring about the other goals of the smart grid. These many parts of the smart grid have been rolling out in pieces in different jurisdictions since the late 1990s and early 2000s. The rate of smart grid adoption varies across the United States, and depends on state policies, regulatory incentives, and technology experience within utilities.

Advanced metering infrastructure has been one of the most frequently deployed elements of the smart grid. Advanced metering infrastructure refers to three components: the smart meters at the point of energy end-use, the communications networks that transmit metered data, and the information management systems used to receive and process these data at utility offices. By 2015, an estimated 65 million smart meters will be installed across the country, representing more than one-third of the US meters of all types in use today.[26] Thirty of the largest utilities in the United States have fully deployed smart meters to their customers.[27] The smart meters so far are being used to produce operational savings for the

26 US Department of Energy. (2014, August). *2014 Smart Grid System Report: Report to Congress.* Available at: http://energy.gov/sites/prod/files/2014/08/f18/SmartGrid-SystemReport2014.pdf

27 Institute for Electric Innovation. (2014, September). *Utility-Scale Smart Meter Deployments: Building Block of the Evolving Power Grid.* Available at: http://www.edisonfoundation.net/iei/Documents/IEI_SmartMeterUpdate_0914.pdf

utilities; to roll out new services such as bill management tools, dynamic pricing, and energy use notifications; to improve outage management systems and restoration services; and to integrate new distributed resources. When combined with customer-based technologies such as programmable thermostats, in-home displays, and building energy management systems, smart meters have the potential to produce higher levels of energy savings. For example, at Oklahoma Gas and Electric, advanced metering infrastructure, time-based rates, and in-home displays are reducing peak demand by an amount that will potentially allow the utility to defer building a 170-MW peaking power plant.[28]

Grid modernization within the distribution system includes the use of smart sensor, communications, and control technologies that create highly responsive and efficient grid operations. These technologies allow operators to locate and isolate faults using automated feeder switches and reclosers, optimize voltage and reactive power levels, and monitor the health of the system. Investments in distribution automation technology are now exceeding investments in smart metering, according to industry analysts.[29]

An important piece of the smart grid is a modernized transmission grid. Investor-owned utilities have substantially increased their transmission investments in the past 15 years. In 2000, annual investment in the transmission infrastructure was less than $4 billion; in 2013, annual investment had jumped to a record $16.9 billion.[30] Although much of this investment was targeted at new transmission infrastructure and replacement of old infrastructure, some of it was targeted at advanced technologies and other grid modernization projects. For example, synchrophasors[31] are an important element in a future resilient smart grid and have received increased attention as a technology that can improve grid reliability and resilience. There were roughly 1700 synchrophasors connected to the US grid in 2014, up from only 200 in 2009.[32] There are a number of other emerging transmission-related technologies that will help monitor and control operations within high-voltage substations and wide-area operations across the transmission grid, including dynamic line ratings, grid-scale energy storage, volt-VAR optimization, high-voltage direct current transmission, high-temperature low-sag transmission lines, and smart solar inverters. Some of these technologies are described in more detail in Chapters 5, 10, and 18.

More smart grid applications are also being deployed and required as a result of the growth in distributed energy resources that has occurred during the past several years, including rooftop solar, combined heat and power, EVs, energy storage, and demand response practices. Two-way power flows are required to optimally use such assets. Interest in microgrids also has increased with growing resilience and sustainability concerns. North American microgrid capacity may reach almost 6 GW by 2020, up from 992 MW in 2013, according to industry analysts.[33]

Many smart grid projects have been deployed since 2010 as a result of the US Department of Energy's American Recovery and Reinvestment Act (ARRA) Smart Grid Program, which facilitated more than $9 billion in public and private investments for smart grid applications. In total, the electric industry spent an estimated $18 billion for smart grid technology deployed between 2010 and 2013 (ARRA and non-ARRA applications).[34] However, there is still a long way to go before the smart grid is fully built out. Estimates of the cost of full build-out vary, and range from $338 to $476 billion over a 20-year period (Electric Power Research Institute estimate) to nearly $900 billion (nominal) for the transmission and distribution investment

28 Supra footnote 26.

29 Ibid.

30 US Energy Information Administration. (2014, September 3). Electricity transmission investments vary by region. Available at: http://www.eia.gov/todayinenergy/detail.cfm?id=17811; Edison Electric Institute. (2015, January 8). *Actual and Planned Transmission Investment by Shareholder-Owned Utilities (2008-2017)*. Available at: http://www.eei.org/issuesandpolicy/transmission/Documents/bar_Transmission_Investment.pdf

31 A synchrophasor is a device that measures the electrical waves on an electricity grid, using a common time source for synchronization, allowing for real-time measurements of multiple remote measurement points on the grid. This provides grid operators with a better image of the grid in real time, helping to alert them to grid stress early on, potentially avoiding power outages and maintaining power quality.

32 Chaudhry, U. M. (2014, July). *Survey of Emerging Transmission Technologies*. Americans for a Clean Energy Grid. Available at: http://cleanenergytransmission.org/transmission-technology-series/

33 Supra footnote 26.

34 Ibid.

by 2030 (The Brattle Group estimate).[35]

Smart grid applications, when combined with smart policy and business decisions, have the potential to enable more energy and emissions savings than would otherwise be possible. A 2008 estimate that examined seven smart grid mechanisms found that the applications, if deployed across the United States, could potentially reduce annual energy use by 56 to 203 billion kWh and GHG emissions equivalent to 60 to 211 million metric tons of carbon dioxide ($CO_2$) by 2030.[36] A 2010 analysis that considered nine smart grid applications found that electricity use and $CO_2$ emissions in 2030 could be reduced by 12 percent directly through the implementation of smart grid applications, and by a further 6 percent indirectly if cost savings from energy and avoided capacity were further invested in energy efficiency.[37] The many smart grid applications that are now underway will be providing real-life assessments of their impacts during the upcoming years.

## 2.3. Electric Vehicles

Powering vehicles with electricity offers the chance to reduce or eliminate emissions coming from a vehicle's tailpipe. As a result, steps have been taken by governments and manufacturers to encourage growth in the market for plug-in hybrid EVs (PHEVs) and battery EVs. But the uptake of EVs has been slow, because high initial costs of the vehicles make them less attractive than conventional vehicles with internal combustion engines (ICEs). Moreover, current battery technology does not store enough energy to give EVs the same range as ICE vehicles without the help of an additional source of energy, such as an onboard gasoline-powered engine. In 2013, there were about 70,000 battery EVs and 104,000 PHEVs registered in the United States, a small number compared to the total of 226 million registered vehicles. Nevertheless, the market for EVs has expanded in recent years as manufacturers introduced new EVs and electric versions of existing models.[38] US sales of PHEVs represented about 0.7 percent of new vehicle sales in 2014, up from 0.6 percent in 2013 and 0.4 percent in 2012.[39]

Transportation accounts for 32 percent of total $CO_2$ emissions from all uses, and passenger vehicles represent the largest share of transportation $CO_2$ emissions.[40,41] Compared to ICE vehicles, which depend on the combustion efficiency and sophistication of onboard emissions control systems and fuel quality, the emissions attributable to an EV depend on the fuel source, efficiency, and emissions controls on the electric power sources used to charge them. An EV might be charged by solar panels on an adjacent rooftop, or electricity from a coal or nuclear plant hundreds of miles away.

As a result, emissions from EV electricity use vary widely based on the local grid mix, which varies by the time of day and, in certain cases, the time of year. Electricity from high-emitting generators reduces the comparative emissions benefits of EVs over ICE vehicles. EVs move emissions from the tailpipe to the power source (typically an EGU), reducing localized mobile-source emissions where vehicles are driven, but increasing the need to generate electricity elsewhere. Therefore, a robust understanding of the emissions implications of charging strategies is necessary to

35 Supra footnote 26.

36 Electric Power Research Institute. (2008, June). *The Green Grid: Energy Savings and Carbon Emissions Reductions Enabled by a Smart Grid.* Available at: http://www.smartgridnews.com/artman/uploads/1/SGNR_2009_EPRI_Green_Grid_June_2008.pdf

37 Pratt, R. G., Balducci, P. J., Gerkensmeyer, C., Katipamula, S., Kintner-Meyer, M. C. W., Sanquist, T. F., Schneider, K. P., & Secrest, T. J. (2010, January). *The Smart Grid: An Estimation of the Energy and $CO_2$ Benefits.* Pacific Northwest Laboratory for the US Department of Energy. Available at: https://www.smartgrid.gov/document/smart_grid_estimation_energy_and_co2_benefits

38 M. J. Bradley & Associates for The Regulatory Assistance Project and the International Council on Clean Transportation. (2013, June). *Electric Vehicle Grid Integration in the U.S., Europe, and China: Challenges and Choices for Electricity and Transportation Policy.* Available at: http://www.raponline.org/document/download/id/6645 June 2013.

39 EIA. (2014). *California Leads in the Adoption of Electric Vehicles.* Available at: http://www.eia.gov/todayinenergy/detail.cfm?id=19131

40 US Environmental Protection Agency. (2014). *Overview of Greenhouse Gases, 2014.* Available at: http://www.epa.gov/climatechange/ghgemissions/gases/co2.html

41 E3/ICF. (2014, September). *California Transportation Electrification Assessment, Phase 1: Final Report.* Available at: http://www.caletc.com/wp-content/uploads/2014/09/CalETC_TEA_Phase_1-FINAL_Updated_092014.pdf

ensure net emissions reductions from EVs.[42,43]

A Texas EV study found that if vehicle charging is optimized, an EV fleet of up to 15 percent of light duty vehicles could actually decrease EGU nitrogen oxides ($NO_X$) emissions, even while increasing load. This is because selectively increasing system load allows EGUs to run more efficiently, and allows system operators to deploy more efficient units. The same study found that using the batteries in the EVs to provide "vehicle-to-grid" (V2G) services could also reduce the sulfur dioxide ($SO_2$) and $CO_2$ emissions impacts of increased load from charging EVs. V2G services include using EV batteries for spinning reserves, frequency regulation, and energy storage to address peak load.[44] The study did not compare EVs to conventional vehicles, however.[45,46]

EV charging strategies would typically seek to use off-peak electricity from the grid (i.e., nights and weekends). This would enhance the efficiency of the grid by shifting electricity use to off-peak nighttime hours, reducing the difference between off-peak and peak demand levels and allowing EGUs to operate more steadily and efficiently. As noted in Chapter 5, EVs can also be managed to help meet ancillary service needs on the grid as power supply market conditions change (e.g., by turning them off and on, drawing upon them as power "sources," or charging them as power "sinks"). Applying this V2G approach, a large number of EVs – plugged in and aggregated together as a single resource – could serve as a large battery for the grid, balancing variations in load and correcting for short-term changes in electricity use that might otherwise affect the stability of the power system.[47]

The wise application of EV charging strategies can provide benefits beyond peak shifting and the provision of ancillary services to the grid. Through their storage capabilities, EVs can also improve the ability of the grid to absorb higher levels of renewable generation.[48,49] EVs interfaced with the grid in a smart way can help meet balancing requirements associated with growing renewable energy deployment and maximize the amount of renewable energy that can be exploited without compromising grid robustness. Ultimately EVs and V2G could serve as twin pillars to boost renewables and simultaneously improve the overall performance of the grid.[50,51]

As also noted in Chapter 5, several questions associated with the Environmental Protection Agency's (EPA) proposed Clean Power Plan (CPP) must be addressed before EVs will contribute fully to grid optimization. States choosing a mass-based pathway for complying with the CPP, for example, could be discouraged from pursuing large-scale EV penetration because emissions from EGUs (which

42 Supra footnote 38.

43 US EPA. (2014). *Greenhouse Gas Emissions for Electric and Plug-In Hybrid Vehicles.* Available at: http://www.fueleconomy.gov/feg/Find.do?zipCode=82001&year=2014&vehicleId=34699&action=bt3

44 "Spinning reserves" are generation resources that are kept on standby and are able to provide capacity to the grid when called by the system operator. "Frequency regulation" is a service, typically provided by a power plant, which system operators use to maintain a target frequency on a power grid. Signaled, a frequency-regulating unit will either increase or decrease its output or load to rebalance system frequency.

45 Supra footnote 38.

46 Sioshansi, R., & Denholm, P. (2009, January). Emissions Impacts and Benefits of Plug-In Hybrid Electric Vehicles and Vehicle-to-Grid Services. *Environ Sci Technol* 43(4):1199–1204. Available at: http://pubs.acs.org/doi/abs/10.1021/es802324j

47 PJM Interconnection Fact Sheet. (2015, March 31). *Electric Vehicles and the Grid.* Available at: http://www.pjm.com/~/media/about-pjm/newsroom/fact-sheets/electric-vehicles-and-the-grid-fact-sheet.ashx

48 Keay-Bright, S. (2014). *EU Power Sector Market Rules and Policies to Accelerate Electric Vehicle Take-Up While Ensuring Power System Reliability.* Montpelier, VT: The Regulatory Assistance Project. Available at: http://www.raponline.org/document/download/id/7441

49 E3/ICF. (2014, October 23). *California Transportation Electrification Assessment, Phase 2: Grid Impacts.* Available at: http://www.caletc.com/wp-content/uploads/2014/10/CalETC_TEA_Phase_2_Final_10-23-14.pdf

50 Peças Lopes, J. A., Rocha Almeida, P. M., & Soares, F. J. (2009, June). *IEEE 2009 International Conference on Clean Electrical Power. Using Vehicle-to-Grid to Maximize the Integration of Intermittent Renewable Energy Resources in Islanded Electric Grids.* Available at: http://www.researchgate.net/profile/Joao_Abel_Lopes/publication/224581302_Using_vehicle-to-grid_to_maximize_the_integration_of_intermittent_renewable_energy_resources_in_islanded_electric_grids/links/53fc5c7c0cf22f21c2f3cc0a.pdf

51 Tuffner, F., & Kintner-Meyer, M. (2011, July). *Using Electric Vehicles to Meet Balancing Requirements Associated With Wind Power.* Pacific Northwest National Laboratory for the US Department of Energy. Available at: http://energyenvironment.pnnl.gov/pdf/PNNL-20501_Renewables_Integration_Report_Final_7_8_2011.pdf

are covered by the CPP) could rise owing to additional charging load, even though GHGs from motor vehicles (which the CPP does not cover) would decline.[52]

## 2.4. The Internet of Things

The *"Internet of Things"* (IoT) is a term used to describe an increasingly interconnected, responsive, and dynamic world in which many millions of new devices capable of two-way communication are being connected to the Internet every year. This interconnectedness offers convenience and comfort, but can also be designed to reduce costs and improve efficiency economy-wide.

In the industrial sector, smart manufacturing systems are connecting productivity on the factory floor with the business domain, permitting greater market responsiveness, reductions in lead times, and minimized material waste. In logistics, smart tagging of pallets and parcels is being deployed and piloted to enable a standardized, open transportation platform in global supply chains. These new models in transportation offer enormous potential improvements in freight utilization and associated reductions in GHG emissions.[53]

In the building sector, heating, ventilation, and air conditioning systems are being integrated with energy storage and distributed generation, such as ice storage, rooftop solar, and combined heat and power.[54,55] Networked locally, these systems can be optimized to incorporate renewable generation output and load forecasting. They can be controlled internally by building managers to respond to time-of-use (TOU) pricing and otherwise reduce energy costs. And they can be controlled remotely by grid operators to provide aggregated peak shaving and load-shifting benefits as well as ancillary services. Commercial and institutional buildings designed with this kind of interoperability are envisioned as key building blocks of a more resilient and distributed electric grid.[56]

In the residential sector, smart thermostats – notably the learning thermostat developed by Nest Labs and brought to media attention in 2014 after its acquisition by Google – are already gaining market share, reducing energy for heating and cooling by 10- to 15-percent, according to field studies.[57] Following smart thermostats, a new wave of lighting, water heating, and other smart appliances and automation platforms are making their way

52 Toor, W., & Nutting, M. (2014, November 30). *Southwest Energy Efficiency Project (SWEEP) and the Electric Vehicle Industry Coalition (EVIC), Comments on the Treatment of Electricity Used by Electric Vehicles in the EPA's Proposed Clean Power Plan Rule Docket ID No. EPA-HQ-OAR-2013-0602.* Available at: http://www.seealliance.org/wp-content/uploads/SWEEP-EVs.pdf

53 A National Science Foundation-supported analysis by the Center for Excellence in Logistics and Distribution estimated that smart-tagging enabled innovations in logistics (a vision for modern freight transport coined the physical Internet) applied to only a 25-percent subset of freight flows in the United States could reduce the total freight transportation emissions by 200 teragram (Tg), or 39 percent of a total of 517 Tg $CO_2$ per year. Meller, R. D., Ellis, K. P., & Loftis, B. (2012, September 24). *From Horizontal Collaboration to the Physical Internet: Quantifying the Effects on Sustainability and Profits When Shifting to Interconnected Logistics Systems.* Final Research Report of the CELDi Physical Internet Project, Phase 1. Available at: http://faculty.ineg.uark.edu/rmeller/web/CELDi-PI/Final%20Report%20for%20Phase%20I.pdf

54 US Department of Energy & Pacific Northwest National Laboratory. (2015). *Transactional Network and Rooftop Units Project Overview.* Available at: http://transactionalnetwork.pnnl.gov/overview.stm

55 Such integration can build on and be coupled with direct improvements to building energy use through benchmarking and annual disclosure of energy use, also called transparency. Benchmarking measures a building's energy use and compares it to the average for similar buildings, allowing owners and occupants to understand their building's relative energy performance and helping to identify opportunities to cut energy waste. More information is available at: http://www.imt.org/policy/building-energy-performance-policy

56 US Department of Energy, Building Technologies Office. *Sustainable and Holistic Integration of Energy Storage and Solar PV (SHINES).* Available at: http://energy.gov/eere/buildings/building-technologies-office-load-control-strategies

57 Three studies of the Nest Learning Thermostat have been conducted, one by Nest Labs and the other two by independent groups. Results generally agree, suggesting heating savings of about 10 percent to 12 percent and electric savings of about 15 percent of cooling use in homes with central air conditioning. Apex Analytics. (2014, October 10). *Energy Trust of Oregon Nest Learning Thermostat Heat Pump Control Pilot Evaluation.* Available at: http://energytrust.org/library/reports/Nest_Pilot_Study_Evaluation_wSR.pdf; Aarish, C., Perussi, M., Rietz, A., & Korn, D. (2015). *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program.* Prepared by Cadmus for Vectren Corporation; Nest Labs. (2015, February). *Energy Savings from the Nest Learning Thermostat: Energy Bill Analysis Results* (white paper). Available at: https://nest.com/downloads/press/documents/energy-savings-white-paper.pdf

to consumers and promising further interoperability.[58] The future of demand response–enabled homes will rely on the proliferation of interconnected hardware and compatible software tools, but also – and probably more importantly for energy saving – it will rely on dynamic or TOU pricing plans being offered to residential utility customers.

In the power sector, IoT applications will increasingly combine greater situational awareness on the grid, and at the point of final energy use, with the interoperability of distributed energy resources. The influence of communicating and computing technologies going forward will represent a quantum change. It will enable complex interactions that integrate millions of customers with grid operations to manage end-use load and maximize the performance of variable resources like wind and solar and storage resources. This interconnectivity can bring about emissions reductions through overall reductions in demand, as well as improved system efficiency in matching demand with cleaner, more cost-effective supply through load shifting, peak shaving, and the provision of regulation services – all of which are required for the integration of large shares of intermittent renewable energy.

Although product developers are at the cusp of envisioning, testing, and piloting these IoT developments today, how market forces, enabling regulation, and consumer demand will interact to realize the potential for greater efficiency and cost savings – and precisely how large that potential is – remains to be determined.

## 2.5. The Water-Energy Nexus

Large amounts of power are used in managing water resources, including pumping, treatment, distribution, and increasingly desalination; and likewise, large amounts of water are used in energy production, especially for boiler feedwater and cooling purposes at thermal power stations, as well as in extractive activities such as hydraulic fracturing of oil and natural gas wells. These linkages mean that water efficiency saves energy, and energy efficiency saves water.

With parts of the country facing growing water stress, as in California and other western states, the linkages between water and energy have attracted attention in recent years. However, these interconnections deserve consideration across the country, where nationwide, water pumping, treatment, and distribution account for a substantial portion of total electricity consumption – between 4 and 13 percent, according to various estimates.[59,60] For GHG mitigation planning, water efficiency – whether in the form of water conservation or improved energy efficiency in water systems – represents an important opportunity that can be factored into state compliance plans for the EPA's CPP rule.

Opportunities are especially ripe at the municipal level, where drinking water and wastewater treatment facilities are often the largest energy consumers. They account for 30 to 40 percent of energy consumed by municipal governments, according to the EPA.[61] Because energy comprises the lion's share of water system costs – for drinking water and wastewater utilities, energy is typically

58 For examples, see GE: http://www.geappliances.com/connected-home-smart-appliances/; Belkin Home Automation: http://www.belkin.com/us/Products/home-automation/c/wemo-home-automation/; Philips: http://www2.meethue.com/en-us/; Whirlpool 6th sense appliances and my smart appliances app: http://www.whirlpool.com/smart-appliances/; https://www.mysmartappliances.com/

59 Estimates vary widely. An EPRI study from 2002 estimated that drinking water and wastewater systems accounted for four percent of national electricity demand. A 2009 study by the River Network, which includes commercial and residential water heating, places it closer to 13 percent. Another investigation by researchers at the University of Texas Austin in 2011 found energy use associated with public water supply to be 6.1 percent of national electricity consumption. Regional differences can be significant. For example, in California, as much as 19 percent of the electricity is consumed in pumping, treating, collecting, and discharging water and wastewater. See: Electric Power Research Institute. (2002, March). *Water & Sustainability (Volume 4): US Electricity Consumption for Water Supply & Treatment.* Available at: http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001006787; Griffiths-Sattenspiel, B., & Wilson, W. (2009, May). *The Carbon Footprint of Water. River Network.* Available at: http://www.rivernetwork.org/resource-library/carbon-footprint-water; Twomey, K., & Webber, M. (2011, August). *Evaluating the Energy Intensity of the US Public Water System.* Proceedings of the ASME 2011 5th International Conference on Energy Sustainability. Available at: http://proceedings.asmedigitalcollection.asme.org/proceeding.aspx?articleid=1636857

60 A survey of current estimates is included in: Copeland, C. (2014, January 3). *Energy-Water Nexus: The Water Sector's Energy Use.* Congressional Research Service. Available at: http://fas.org/sgp/crs/misc/R43200.pdf

61 US EPA. *Energy Efficiency for Water and Wastewater Utilities.* Available at: http://water.epa.gov/infrastructure/sustain/energyefficiency.cfm

the second-largest expense after labor[62] – improvements in water efficiency can yield substantial economic returns for local government.

Utilities and jurisdictions around the country have existing water conservation policies and programs. Program evaluation in many cases already involves quantification of associated energy savings,[63] allowing the programs to be readily incorporated as a mitigation strategy in GHG reductions plans.[64] Take, for example, an energy-management pilot project targeting drinking water and wastewater facilities in Massachusetts that was framed around a 20-percent GHG mitigation goal.[65] The state of Massachusetts also provides guidance on emissions calculations for water and wastewater treatment facilities on the basis of an average energy cost per volume of treated water (e.g., within the territory of Massachusetts Water Resources Authority: 1.3 kWh/1000 gallons treated for wastewater treatment; 0.2 kWh/1000 gallons treated for water treatment).[66]

As in the case of the Massachusetts project, efficiency investments in the water sector are often designed to improve performance of motors and pumps in the treatment and distribution systems, or to produce onsite electric generation from methane biogas or other renewable energy sources.[67] Another inquiry by researchers at The Analysis Group and American Water Works Association examined the carbon emissions associated with lost water recovery and found significant energy and emissions benefits associated with infrastructure upgrades to reduce leaks.[68] Their findings suggest that general infrastructure spending in the water sector could also be tied to GHG reduction strategies. The authors recommend further consideration of using generalized versions of ratepayer-funded energy efficiency cost-effectiveness tests to compare water infrastructure investments with other carbon reduction options.

## 3. Other Policy Considerations

Advancing technology has led and is leading to profound changes in the entire electric power system. At the same time, new technologies often create new policy issues and opportunities as well. Technology often makes possible, for instance, the measurement, management, and control of system processes where it was previously infeasible to do so. Resources can be identified and enlisted in ways that were previously inconceivable. Several of the most basic and traditional policy considerations for public utility regulators may need to be re-examined in light of these new developments. These include the core issues of reliability, rate design and pricing, and utility business models.

### 3.1. Reliability

No attribute of the electric power system garners more attention from public utility regulators than reliability. Many regulators consider "keeping the lights on" to be their most important job, if not a near-sacred duty. When the lights go out, utility employees and utility regulators endure harsh criticism and enormous political pressure, and may even fear for their jobs. Enormous economic

62 Supra footnote 60.

63 American Council for an Energy Efficient Economy. *Local Technical Assistance Toolkit: Energy Efficiency Opportunities in Municipal in Water and Wastewater Treatment Facilities.* Available at: http://aceee.org/sector/local-policy/toolkit/water

64 Tierney, S. (2014, July 21). Analysis Group's Tierney Says States Ready to Comply With Carbon Rule. *OnPoint: E&ETV Interview.* Available at: http://www.eenews.net/tv/videos/1856/transcript

65 US EPA. (2009, December). *Massachusetts Energy Management Pilot Program for Drinking Water and Wastewater Case Study.* Available at: http://water.epa.gov/aboutow/eparecovery/upload/2010_01_26_eparecovery_ARRA_Mass_EnergyCasyStudy_low-res_10-28-09.pdf

66 Massachusetts Energy and Environmental Affairs. *Greenhouse Gas Emissions Policy and Protocol. Guidance for GHG Emissions Calculations for Water and Wastewater Treatment.* Available at: http://www.mass.gov/eea/agencies/mepa/greenhouse-gas-emissions-policy-and-protocol-generic.html

67 US EPA. (2010). *Evaluation of Energy Conservation Measures for Wastewater Treatment Facilities.* Available at: http://water.epa.gov/scitech/wastetech/upload/Evaluation-of-Energy-Conservation-Measures-for-Wastewater-Treatment-Facilities.pdf; California Energy Commission. Process Energy – Water/Wastewater Efficiency. Available at: http://www.energy.ca.gov/process/water/index.html

68 Aubuchon, C., & Roberson, J. (2013). *Embodied Energy of Lost Water: Evaluating the Energy Efficiency of Infrastructure Investments.* The Analysis Group and American Water Works Association. Available at: http://www.analysisgroup.com/uploadedFiles/Publishing/Articles/2013_Aubuchon_EconomicsOfWater.pdf

losses to businesses and individuals may occur from lost or spoiled production, as well as losses in service and Internet connectivity. Very real public health and environmental problems can also occur – for example, if water treatment or wastewater operations are interrupted, power to hospitals is lost, and so on. Simply stated, when reliability is raised as a concern against a particular regulation or compliance strategy, it must be taken seriously.

Reliability is a function of generation, transmission, distribution, and load interactions, and it may be measured on the local or regional level. Changes in one state or utility may impact the reliability or deliverability of power in another state or utility. As a result, generation and transmission projects must be assessed through regional processes to determine whether other upgrades are necessary and whether the benefits outweigh the costs overall. Resource adequacy and reserve margins are key elements of reliability, but they must also be supplemented with power flow studies. Reliability is maintained by a complex web of responsibilities at the utility, the balancing area, and authorities at the state, regional, and national levels. There are established procedures to assess reliability, to choose preferred solutions, and then to get solutions engineered, permitted, built, and operational. These processes can take several years, and they often involve significant tradeoffs for decision-makers.

Ensuring reliability is a fundamental constraint in reducing carbon emissions in the power sector, and it is a central concern of the EPA in developing the Carbon Pollution Emission Guidelines for Existing Stationary Power Sources (i.e., the proposed CPP). Accompanying the proposed rule, the EPA's Regulatory Impact Analysis used the Integrated Planning Model framework to assess impacts on the power sector, including reliability impacts.[69,70] The Integrated Planning Model is constrained by the need to maintain resource adequacy and meet reserve margin requirements in each of the 64 modeling regions.[71] It does this through existing sources or new construction, and limits interregional energy and capacity transfers such that the reliability of the bulk transmission system is ensured and the specific regional reserve requirements are met first.

Considering a policy scenario with state-specific goals (as opposed to goals associated with potential regional, multistate efforts), the EPA's modeling indicates that 49 GW of coal and 16 GW of oil-gas steam capacity would be uneconomic by 2020 as a result of its proposed CPP regulations. Where needed for reserves, the EPA's modeling assumes these retirements are replaced by 35 GW of new capacity, consisting of 23 GW of natural gas combined-cycle, 2 GW of combustion turbine capacity, and 10 GW of wind, and the equivalent of four percent of current reserve capacity. Retirements are also offset by energy efficiency, which reduces total operational capacity requirements by 35 GW, further reducing the capacity required to meet reserve margins and the burden on transmission infrastructure.[72] Given these results, the EPA concludes that the rule will not pose regional reliability risks that cannot be mitigated through standard planning processes within the timeline allowed.

The North American Electric Reliability Corporation (NERC) is an international regulatory authority responsible for assuring the reliability of the bulk power system in North America. In the United States, NERC acts under the oversight of the Federal Energy Regulatory Commission (FERC). In its *Initial Reliability Review*[73] of the proposed

69 US EPA. (2014, June). *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants.* Available at: http://www2.epa.gov/sites/production/files/2014-06/documents/20140602ria-clean-power-plan.pdf/

70 US EPA. (2014, June). *EPA Analysis of the Proposed Clean Power Plan: Supplemental Documentation and IPM (v5.13) Run Files.* Available at: http://www.epa.gov/airmarkets/programs/ipm/cleanpowerplan.html

71 Reserve margins are based on reliability assessments of NERC or state requirements, where they may be more stringent. For more on IPM, see: US EPA. (2013, November 27). *EPA's Power Sector Modeling Platform v.5.13: Documentation.* Available at: http://www.epa.gov/airmarkets/programs/ipm/psmodel.html

72 Greater detail on the resource adequacy analysis, including a regional breakdown of results, is provided in the Regulatory Impact Analysis and supplemental documents on resource adequacy. See: US EPA. (2014, June). *Technical Support Document: Resource Adequacy and Reliability Analysis.* Available at: http://www2.epa.gov/sites/production/files/2014-06/documents/20140602tsd-resource-adequacy-reliability.pdf

73 NERC. (2014, November). *Potential Reliability Impacts of EPA's Proposed Clean Power Plan: Initial Reliability Review.* Available at: http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/Potential_Reliability_Impacts_of_EPA_Proposed_CPP_Final.pdf

CPP, NERC questioned some of the EPA's assumptions and emphasized the importance of additional research and analysis to better understand how the CPP may affect reliability. Several independent system operators (ISOs) and regional transmission organizations (RTOs) published analyses of the impacts of the proposed rule on their systems as well.[74,75] Concerns raised by these groups generally focus on the following potential risks to reliability:

1. Insufficient reserve margins owing to retirements of fossil-fueled generators;
2. Inadequate *Essential Reliability Services,* for example, ramping flexibility, load following, reactive power, voltage control, frequency response, and so on, to accommodate increased supply of both utility-scale and distributed non-hydro renewable energy;
3. Insufficient planning time for expansions and enhancement to transmission infrastructure; and
4. Strained natural gas infrastructure owing to increased gas-fired generation.

NERC's preliminary assessment also questions specific assumptions in the EPA's CPP Regulatory Impact Analysis, namely that the EPA may have overstated the reductions achievable through heat rate improvements at fossil-fueled generators, increased natural gas generation, and reductions in demand through energy efficiency (i.e., what the EPA refers to as Building Blocks 1, 2, and 4 of its assessment of the Best System of Emission Reduction for existing fossil fuel-fired EGUs).

A study released in February 2015 by the Brattle Group reached very different conclusions. It found that, although the EPA may have moderately overestimated potential reductions in some areas, it underestimated, or altogether excluded, potential reductions in other areas.[76] For example, Brattle noted that the EPA did not explicitly consider the emissions reductions that could be achieved by states through non-utility energy efficiency programs, appliance standards, or building codes (as explained in Chapters 12, 14, and 15, respectively). The potential for demand response programs to reduce emissions and maintain reliability was also not considered by the EPA or NERC (demand response is considered in detail in Chapter 23). The Brattle Group also evaluated several ideas that could potentially alleviate reliability problems. For example, higher-emitting facilities are expected to scale down hours of operation, but they may not need to retire, or not immediately. Some of these EGUs could perhaps be maintained on an emergency-capacity–only basis for two to three years to meet reserve margin requirements until other capacity resources such as combustion turbines, demand response, and energy efficiency can be built. The Brattle study also found that regional solutions to fuel switching, versus state-by-state solutions, could help offset short-term constraints in natural gas infrastructure. On balance the study found the CPP would not create major risks to reliability.[77]

74 Midcontinent Independent System Operator. (2014, November 23). *MISO Comments on Docket ID No. EPA-HQ-OAR-2013-0602.* Available at: https://www.misoenergy.org/Library/Repository/Communication%20Material/EPA%20Regulations/MISO%20Comments%20to%20EPA%20on%20Proposed%20CPP%2011-25-14.pdf; New York ISO. (2014, December 19). *Comments of the NYISO on the Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units.* Available at: http://www.nyiso.com/public/webdocs/markets_operations/documents/Legal_and_Regulatory/Other_Filings/Other_Filings/20141201_IRC_Cmmnts_CLEAN_POWER_PLAN.pdf; SPP. (2014, October 8). *SPP's Reliability Impact Assessment of the EPA's Proposed Clean Power Plan.* Available at: http://www.spp.org/publications/CPP%20Reliability%20Analysis%20Results%20Final%20Version.pdf; ERCOT. (2014, November 17). *ERCOT Analysis of the Impacts of the Clean Power Plan.* Available at: http://www.ercot.com/content/news/presentations/2014/ERCOTAnalysis-ImpactsCleanPowerPlan.pdf

75 Comments submitted to the EPA from many ISOs and RTOs have requested that the final rule include a reliability safety valve to provide a process for undertaking reliability assessments and through which to be granted leniency to implement any requisite reliability solutions. ISO/RTO Council. (2014). *EPA $CO_2$ Rule – ISO/RTO Council Reliability Safety Value and Regional Compliance Measurements and Proposals.* Available at: http://www.isorto.org/Documents/Report/20140128_IRCProposal-ReliabilitySafetyValve-RegionalComplianceMeasurement_EPA-C02Rule.pdf

76 The Brattle Group. (2015, February). *EPA's Clean Power Plant and Reliability: Assessing NERC's Initial Reliability Review.* Available at: http://info.aee.net/hs-fs/hub/211732/file-2486162659-pdf/PDF/EPAs-Clean-Power-Plan--Reliability-Brattle.pdf

77 EGUs are also subject to new Maximum Achievable Control Technology (MACT) standards for mercury, Clean Water Act Section 316(b) cooling water regulations, and possible additional regulations associated with the Cross-State Air Pollution Rule (CSAPR). Some analysts have suggested that these requirements and other issues may create a greater impact on bulk or local electric grid reliability – at least in terms of coal shutdowns – than the CPP. See, for instance: Dumoulin-Smith, J. (2015, March 16). *U.S. IPP Power Shock: The Next Capex Cycle?* UBS.

A May 2014 report from the Analysis Group also considered the reliability impacts of GHG reduction strategies, and enumerated a number of approaches that can be applied in different market structures to balance reliability requirements with environmental compliance.[78] Restricting the operating permits of specific high-emitting facilities or using multiyear compliance periods are two mechanisms that would allow a fossil fuel-fired EGU to continue to serve reliability purposes. The Analysis Group study presents a range of emissions trading schemes that could be instituted, from bubbling of emissions across units at a single station, to interstate trading across various power plant owners. Inter-facility averaging, for instance, would allow a utility holding multiple plants to determine the best set of actions through which to maintain reliability while bringing its fleet into overall compliance (e.g., by limiting operations of certain high-polluting units, increasing capacity factors at underutilized natural gas combined-cycle units, investing in renewables, and reducing demand through energy efficiency programs).[79] Further modeling of the power system would be needed to properly understand reliability impacts, but these examples show how states could tailor their implementation plans to help manage those impacts.

A common finding of the Brattle Group and Analysis Group studies is that the flexibility afforded through Section 111(d) of the Clean Air Act allows states to use a broad range of options, both inside and outside the fenceline, to develop compliance strategies that can account for the unique factors affecting system reliability in a particular state or region. Both organizations conclude that existing institutions, operational tools, procedures, and planning processes are likely sufficient for regulators, market participants, and system operators to work together to resolve any reliability challenges that compliance strategies may present, and in some cases these efforts are already underway. In addition, the industry has a demonstrated track record of effectively responding to environmental regulations – where most regulations have been less flexible than the current ones – without sacrificing reliability.

If the EPA has overestimated potential carbon reductions from heat rate improvements, coal-to-gas fuel switching, and energy efficiency, as NERC asserts, greater reliance would fall on renewable energy (in the CPP, Building Block 3) to achieve compliance. This raises the question of what risks there are to regional reliability from integrating variable energy resources at levels comparable to those established by the Best System of Emission Reduction. NERC expressed concern that variable energy resources significantly impact reliability, require build-out of transmission, and require additional ancillary services. However, the EPA's targets for 2020 are based on levels of renewable energy deployment that many states are already expecting and planning to accommodate. Of the 34 states that have already adopted renewable portfolio standards, only three have set levels that would be exceeded by the assumptions the EPA used in setting state targets for 2020.

In fact, the EPA's analysis suggests only a minor incremental increase in average renewable generation by states over its base-case scenario – from seven percent of generation from renewables in 2020 without policy intervention, to eight percent with policy intervention. The Brattle Group study concluded that this minor incremental increase is unlikely to disrupt reliability, even if renewables need to provide a greater share of total emissions reductions than the EPA assumes (as would be the case for states planning Renewable Portfolio Standard goals that exceed the EPA's targets).

The EPA sets renewable penetration levels below 20 percent by 2020 for all but two states, with a maximum penetration of 25 percent in Maine (a rate that state already exceeds, according to the EPA).[80] With Germany at 27 percent, Denmark at 39 percent (wind only), and California

78 The Analysis Group. (2014, May). *Greenhouse Gas Emission Reductions from Existing Power Plants: Options to Ensure Electric System Reliability*. Available at: http://www.analysisgroup.com/uploadedFiles/Publishing/Articles/Tierney_Report_Electric_Reliability_and_GHG_Emissions.pdf

79 Inter-facility averaging, if conducted across facilities in multiple states operated by a multistate utility holding company, may require the relevant states to enter into a specific understanding that would enable each state's CPP compliance plan to appropriately account for the fleet-wide controls established for the multistate holding company.

80 US EPA. (2014, June). *Technical Support Document (TSD) for Carbon Pollution Guidelines for Existing Power Plants: Emission Guidelines for Greenhouse Gas Emissions from Existing Stationary Sources: Electric Utility Generating Units*. Docket ID No. EPA-HQ-OAR-2013-0602. Available at: http://www2.epa.gov/sites/production/files/2014-06/documents/20140602tsd-ghg-abatement-measures.pdf

on track to meet 33 percent of electricity from renewables by 2020,[81] experiences from around the world demonstrate that comparable rates of renewables do not inherently compromise reliability.

A number of operational practices have been proven to facilitate cost-effective integration of intermittent resources.[82] These include conventional techniques such as re-dispatch, curtailment, and adding additional flexible reserve capacity, as well as incorporating newer resources such as storage and demand response. Impacts of intermittency can also be mitigated by improving forecasting and scheduling, expanding balancing areas, and – where available and cost-effective – capturing a diversified portfolio of renewables, including resources with varying intermittency profiles and dispatchable resources such as geothermal, biomass, and biogas. These topics are addressed in more detail in Chapters 18 and 20 of this document.

Taking integration techniques like these into account, a number of recent analyses suggest that intermittent resources at higher levels than those set by the EPA in the CPP could be reliably accommodated. A study commissioned by Minnesota in collaboration with the Midcontinent Independent System Operator concluded that the state's electric power system could accommodate 40 percent variable renewable-energy resources without risking reliability.[83] Another study found that 30 percent of generation from wind and solar across the PJM Interconnection's territory would not have significant effects on reliability.[84] An additional study for California found levels of penetration of up to 50 percent were possible.[85] NREL has also conducted significant renewables integration work, including multiple phases of its Eastern Wind Integration and Transmission Study, Western Wind and Solar Integration Study, and Eastern Renewable Generation Integration Study.[86]

NERC's preliminary assessment and the other comments and studies discussed earlier agree that as states and regions develop implementation plans to comply with the EPA's CPP, additional modeling and analysis will be needed to ensure reliability. Some parties have suggested that some form of "reliability safety valve" should be built into the CPP or the state plan approval process, whereby detailed modeling could be conducted to ensure that state compliance strategies do not jeopardize reliability. In the CPP technical conferences that FERC held in early 2015, parties raised several possible iterations of such a safety valve, including broad-brush studies conducted using the EPA Building Blocks as a whole, followed by more detailed modeling after state plans are submitted. Actual power flow studies cannot be completed until regional groups have a clearer understanding of what individual states might propose in their compliance plans. These studies may indicate a need for more detailed regional assessment and possible adjustments to the timelines or to preferred methods in order to maximize benefits. Other parties recommend that the EPA build a step into the compliance process only if and when reliability issues arise and plan adjustments become necessary. Because reliability impacts cross state lines, no individual state is in a position to address this issue on a standalone basis. Safety valve studies, if conducted, must be transparent and include stakeholder participation, review periods, and opportunity for debate.

81 California Public Utilities Commission. (2014). *Renewables Portfolio Standard Quarterly Report: 3rd Quarter 2014*. Available at: http://www.cpuc.ca.gov/NR/rdonlyres/CA15A2A8-234D-4FB4-BE41-05409E8F6316/0/2014Q3RPSReportFinal.pdf

82 For discussion of costs of ancillary services, see: (1) NREL. (2013, September). *The Western Wind and Solar Integration Study Phase 2: Executive Summary, Technical Report, NREL/TP-5500-58798*. Available at: http://www.nrel.gov/docs/fy13osti/58798.pdf; (2) ERCOT. (2013, November 1). *Future Ancillary Services in ERCOT, Concept Paper, Draft Version 1.1*. Available at: http://www.ercot.com/committees/other/fast; (3) Porter, K , Mudd, C., Fink, S., Rogers, J., Bird, L., Schwartz, L., Hogan, M., Lamont, D., & Kirby, B. (2012, June 10). *Meeting Renewable Energy Targets in the West at Least Cost: The Integration Challenge*. Western Governors' Association. Available at: http://www.uwig.org/variable2012.pdf

83 GE Energy Consulting and MISO for Minnesota Department of Commerce. (2014, October 31). *Minnesota Renewable Energy Integration and Transmission Study: Final Report*. Available at: http://www.minnelectrans.com/documents/MRITS-report.pdf

84 GE Energy Consulting for PJM Interconnection, LLC. (2014, March 31). *PJM Renewable Integration Study: Executive Summary Report*. Available at: http://www.pjm.com/committees-and-groups/subcommittees/irs/pris.aspx

85 Energy and Environmental Economics. (2014, January). *Investigating a Higher Renewables Portfolio Standard in California*. Available at: https://ethree.com/documents/E3_Final_RPS_Report_2014_01_06_with_appendices.pdf

86 Additional information on these projects is available at: www.nrel.gov

The flexibility of Section 111(d) of the Clean Air Act gives states the opportunity to draw on a wide range of options – including operational practices, technological applications, pricing strategies, and market-based policies, among other approaches – which they can use to help mitigate potential reliability impacts while achieving compliance.

## 3.2. Rate Design and Pricing

The rate structure that electric utilities apply to residential, commercial, and industrial customers has a direct impact on the *amount* of electricity that customers consume and *when* they consume it. The impact occurs in at least five different ways:

- **Conservation.** Customers who face a higher price per kWh will be more likely to participate in energy efficiency programs or acquire more efficient appliances and equipment to save money;
- **Time-Shifting.** Customers who face time-varying rates may choose to schedule energy use, such as laundry and dishwashing (for residential customers), business activities or production processes (for commercial or industrial customers), or EV charging (for both) into lower-cost time periods;
- **Fuel-Switching.** Customers who face a higher price per kWh may be more likely to choose fuels other than electricity to meet needs, including natural gas for space heat and water heat, and natural gas or a clothesline for clothes drying;
- **Economic Curtailment.** Customers who face a higher price per kWh may choose to change their thermostat settings, be more attentive to turning off lights and appliances when not in use, or wash clothes in cold water; and
- **Onsite Generation.** Customers who face a higher price per kWh may be more likely to choose to install a solar PV system or other onsite generating facility.[87]

Although it is difficult to measure exactly which of these impacts causes the reduction in usage in response to a higher price (or an increase in response to a lower price), it is generally accepted that there is a price elasticity for electricity. Elasticity measures the change in the quantity demanded with respect to a change in price. That elasticity is generally recognized to be small in the short-run (one to three years) and higher in the long-run (over a period when appliances, lighting, and other energy-consuming equipment are replaced).

Although the techniques used to set prices are complex, the result is not. Customers deal with price-driven decisions every day. For example, an ice cream parlor entices customers to eat more ice cream with simple pricing tools, making additional scoops cheaper than the initial scoop. In electricity, this is known as a "declining block" rate design.

Residential rates are the best-understood rate designs, and they can have a dramatic impact on residential electricity consumption. Across the country, higher-cost utilities have lower usage per customer than lower-cost utilities. And there is plentiful evidence that the design of rates, within the constraint of the utility revenue requirement, also affects usage.

Residential prices generally include:

- **Customer Charge.** A fixed monthly charge, usually to cover billing and collection costs, but sometimes including distribution system costs as well.
- **Energy Charge.** A price per kWh for all usage; this may be in multiple blocks, differentiated by season, or differentiated by time of day.
- **Tariff Riders.** These are adjustments applied to rates that operate between general rate cases. The most common are for fuel and purchased-power recovery, but some regulators have allowed multiple riders that amount to one-third of the total bill or more.

### Impact of Price Level on Usage

In general, the higher the per-kWh charge, the more incentive there is for customers to find alternatives to consumption. Economists use a concept known as "price elasticity" to estimate the change in usage in response to a change in price. An elasticity factor of –0.1 means that a one-percent increase in price is expected to produce a 0.1-percent decrease in the quantity demanded. Most estimates of the elasticity of demand for electricity are in the range of -0.2 to -0.7, with the expected price response greater over the long-term. For illustrative purposes below,

87 Rate designs may increasingly impact customers who face *low* kWh prices as well, as when an excess of low-cost renewable power exists. Such situations present an opportunity to specifically target electricity use for some industrial production, water pumping or heating, car charging, and so on. For instance, a standby desalinization facility could be operated when an excess of solar or wind generation might otherwise cause their use to be curtailed.

*Table 26-1*

**Illustrative Residential Rate Design**

| | Flat Rate | Inclining Block Rate | High Customer Charge |
|---|---|---|---|
| **Customer Charge** | $ - | $ - | $25.00 |
| **First 250 kWh** | $0.15 | $0.1160 | $0.1025 |
| **Over 250 kWh** | $0.15 | $0.1740 | $0.1025 |
| **Usage Change With Elasticity of -0.2** | | -2.6% | +6.3% |

we use an elasticity of -0.2.[88]

Table 26-1 shows three alternative residential rate designs, all designed to produce the same total revenue from a given mix of customer usage. The first is a simple rate, with only a per-kWh charge that applies to all usage. The second divides these into two blocks, usage before 250 kWh, and a higher price for usage above that level. The third collects $25 per month in a customer charge, independent of usage, and the balance in a uniform price per kWh. Because the overwhelming majority of usage is by customers whose monthly usage exceeds 250 kWh per month, this "end block" price is the primary determinant upon which elasticity is measured; only a few customers using a very small percentage of power face the initial block rate for their marginal consumption. Therefore, a reduction in the price for the first 250 kWh has a very small effect increasing consumption, whereas a higher price for usage above 250 kWh affects a much larger percentage of total usage.

By applying the economic concept of elasticity, we estimate that, compared to the flat rate, the inclining block rate would result in about 2.6 percent *less* consumption, whereas the high customer charge (and lower per-kWh price) would result in 6.3 percent *more* consumption. This shows that the type of residential rate design *to produce the same revenue* can cause a swing of nine percent in total customer usage. This does not inform us as to whether the reduced usage is the result of conservation, curtailment, fuel switching, or other options the customer may choose.

### Commercial and Industrial Prices

Prices for commercial and industrial customers are generally more complex. They often include a "demand charge" that is based on the customer's peak demand, usually measured as the highest hour (or even the highest 15 minutes) of the billing period. Although demand charges can be designed to fairly price the cost of providing adequate capacity for peak periods, they generally result in lower per-kWh prices, and can thus result in higher consumption. An illustrative commercial rate is shown in Table 26-2.

*Table 26-2*

**Illustrative Commercial Rate Design With Demand Charge**

| Rate Element | Price |
|---|---|
| **Monthly Customer Charge** | $20.00 |
| **Demand Charge** *($/kW/month)* | $10.00 |
| **Energy Charge** | $0.08/kWh |

Because the typical commercial customer has usage of about 300 kWh per peak kW of demand, this rate design collects about $0.03 per kWh of the total revenue requirement through the demand charge.[89] Without the demand charge, the energy charge would have to be about $0.11 per kWh. The principal adverse impact of a demand charge is that once the customer had "hit their peak" for the month, they no longer see the demand charge as an incremental cost, and make consumption decisions based solely on the $0.08 per kWh energy price.

An alternative to imposing a commercial demand charge is to convert this into a TOU rate design. For example, if the $10.00 per kW demand charge were applied only to the 100 highest-use hours of the month (3:00 PM to 8:00 PM, Monday to Friday, for example), it would add about $0.06 per kWh to the energy price in those hours (the

88 For a detailed discussion of price elasticity, see: Lazar, J. (2013, April). *Rate Design Where Advanced Metering Infrastructure Has Not Been Fully Deployed,* Appendix A. Montpelier, VT: The Regulatory Assistance Project. Available at: http://www.raponline.org/document/download/id/6516

89 A typical commercial customer using 300 kWh per peak kW means that its normal operations may reflect electricity use of about 40 percent of its peak, not surprising for a retail or office environment or a one-shift, light-manufacturing operation. The $10.00 per-kW demand charge, if amortized over these 300 kWh, would equate to about $0.03 per kWh. Meeting the utility's revenue requirements without the demand charge would require the energy charge to be the $0.08 per kWh plus this $0.03 per kWh, or about $0.11 per kWh.

*Table 26-3*

| Illustrative Commercial Rate Design Without Demand Charge | |
|---|---|
| **Rate Element** | **Price** |
| **Monthly Customer Charge** | $20.00 |
| **On-Peak Energy** *(3:00 PM to 8:00 PM Monday to Friday)* | $0.18/kWh |
| **Off-Peak Energy** *(other hours)* | $0.09/kWh |

actual calculation requires dividing the demand charge revenue by the expected kWh consumed during that period). The resultant rate design is shown in Table 26-3.

This TOU rate would provide a strong incentive to conserve during the on-peak hours, whereas a higher energy rate for off-peak usage would encourage somewhat more conservation during the off-peak hours as well. But it could result in a higher customer peak demand during some normally off-peak hours of the month.

Another alternative would be to confine the demand charge to the few hours of the month when peak demands are expected to occur, in order to constrain usage during those particular hours. An example of this is shown in Table 26-4. This is known as a "coincident peak" demand charge, because it applies only when the *system* peak is likely to occur, rather than applying to the *customer's* individual demand, whenever it occurs. This would serve to constrain demands on the utility system during peak periods. Because it would apply to a lower total number of kW (because some customers have their individual peaks outside of these hours), the energy charge would need to be a little higher, leading to more incentive to conserve energy at all hours. Note that with a demand charge of this type, there would be no on-peak versus off-peak energy charge differential.

*Table 26-4*

| Illustrative Coincident Peak Demand Charge Rate Design | |
|---|---|
| **Rate Element** | **Price** |
| **Customer Charge $/month** | $20.00 |
| **Demand Charge** *(4:00 PM to 8:00 PM, Monday to Friday)* | $10.00/kW |
| **Energy Charge** | $0.09/kWh |

There are a few electric utilities that impose residential demand charges. Most of these are based on the customer's non-coincident peak (highest usage, whenever it occurs during the month). These tend to increase usage (because of the correspondingly lower energy charge) without having a meaningful impact on peak demand. If narrowly focused on the highest hours of the day (for example, 4:00 PM to 7:00 PM), they may result in load-shifting out of those hours, similar to the effect of a TOU rate design, but with a lower level of customer understanding, and thus less impact.

Rate design concepts that result in lower usage include:

- **Inclining Block Rates.** Prices that apply higher per-kWh charges to usage over a baseline that generally reflects what is deemed to be essential-needs level of usage.
- **Low or Zero Customer Charges.** If the fixed charge per month is lower, then the per-kWh price must be higher to produce the utility's allowed revenue. A low customer charge thus results in lower expected usage.

Rate design concepts that generally result in higher usage include:

- **High Fixed Charges.** If a utility recovers a greater portion of its revenue requirement in a fixed charge or customer charge, the price per-kWh will be lower, and usage will increase.
- **Demand Charges.** If a separate charge is imposed based on the customer's highest usage for a short period during the month (15 minutes or 1 hour, typically), the price per kWh will be lower, and usage during hours other than those when the customer's highest demand occurs will increase.

Rate design concepts that may increase or decrease usage include:

- **Time-Varying Rates.** Prices that are higher during peak periods will reduce usage during those periods, but will be offset by lower prices at off-peak times, increasing usage during these periods. If time-varying rates are used to reduce or eliminate demand charges, they will likely result in reduced usage.[90]

90 For more discussion of time-varying pricing, see: Faruqui, A., Hledik, R., & Palmer, J. (2012, July). *Time Varying and Dynamic Rate Design.* The Regulatory Assistance Project and the Brattle Group. Available at: http://www.raponline.org/document/download/id/5131

- **Critical Peak Pricing.** Many utilities have implemented what is known as critical peak pricing, where in the highest 50 to 100 hours of the year, a much higher price is implemented, with customers notified by text, email, or telephone. These result in higher collection during the highest hours, and slightly lower rates in all other hours, and the overall impact on usage varies from circumstance to circumstance.
- **Peak-Time Rebates.** Many utilities have implemented a different form of peak load pricing that provides a rebate when usage is curtailed during the highest-cost hours. Although not shown separately, these require a slightly higher base rate in order to fund the rebates.

### Clarity and Transparency

Many electric bills are either impossibly complex or hopelessly opaque. They have become more of a litigator's scorecard or an accountant's worksheet than a price that consumers can respond to. Improving clarity enables customers to take appropriate actions to save energy and money, based on an informed perspective on the benefits.

In addition, the more clarity there is in the electric bill, the more likely consumers are to understand the price and to respond to it. Table 26-5 provides an example of how one electric bill is calculated – and Table 26-6 shows what that rate design really means.

***Table 26-5***

**Illustrative Elements of an Electric Bill With Multiple Tariff Riders**

*Your Usage: 1,266 kWh*

| Base Rate | Rate | Usage | Amount |
|---|---|---|---|
| **First 500 kWh** | $0.04000 | 500 | $20.00 |
| **Next 500 kWh** | $0.06000 | 500 | $30.00 |
| **Over 1,000 kWh** | $0.08000 | 266 | $21.28 |
| **Fuel Adjustment Charge** | $0.03456 | 1,266 | $43.75 |
| **Infrastructure Tracker** | $0.00789 | 1,266 | $9.99 |
| **Decoupling Adjustment** | $(0.00057) | 1,266 | $(0.72) |
| **Conservation Program Charge** | $.00123 | 1,266 | $1.56 |
| **Nuclear Decommissioning** | $.00037 | 1,266 | $0.47 |
| **Subtotal** | | | $126.33 |
| **State Tax** | 5% | | $6.32 |
| **City Tax** | 6% | | $7.96 |
| **Total Due** | | | $140.60 |

***Table 26-6***

**Distillation of an Electric Bill With Multiple Tariff Riders**

*Effective Rate Including All Adjustments*

| Base Rate | Rate | Usage | Amount |
|---|---|---|---|
| **First 500 kWh** | $0.09291 | 500 | $46.46 |
| **Next 500 kWh** | $0.11517 | 500 | $57.59 |
| **Over 1,000 kWh** | $0.13743 | 266 | $36.56 |
| **Total Due:** | | | $140.60 |

Table 26-6 distills these multiple elements into a more understandable inclining-block structure.

Consumers do not generally value the additional information provided in the example shown in Table 26-5. This can be seen in gasoline pricing, for example. Gasoline prices also include numerous components, from crude oil and refining to tankers and retailers. But consumers respond to a single per-gallon price in choosing where to buy gasoline. They aren't asked or expected to consider the fixed and variable costs of each component.

Encouraging utility regulators to simplify, condense, and improve the presentation of the effective prices that customers will incur or save with changed usage is important. There is no problem providing detailed information in a tariff published on the utility website, or even printed on the reverse side of the bill. But what consumers really need to know to make rational decisions is how much their bill will increase or decrease in response to a change in usage.

### Load Shifting

Most time-varying pricing is designed to shift load from on-peak periods to lower-use periods, in order to improve the use of transmission and distribution system capacity, and to avoid the high costs of securing resources to meet short durations of high demand. The impact of this pricing structure on total usage, and on emissions, is a complex calculation.

Sometimes it will increase usage; for example, if a commercial building is pre-cooled in the early afternoon to a lower temperature, in order to be able to comfortably "ride through" a higher rate in the late afternoon, there may be a net increase in kWh usage. Conversely, if a residential customer chooses to raise the thermostat to reduce cooling costs during an on-peak period, the customer is unlikely to make this up by lowering the thermostat below a comfortable level at night.

There is an environmental issue with load shifting as well. If the effect of load shifting is to shift load from hours when natural gas is the marginal resource to hours when coal is the marginal resource, then criteria and $CO_2$ emissions may increase. If the effect of load shifting is to increase usage of natural gas power plants with better heat rates, and decrease usage of less-efficient natural gas power plants, then emissions will decrease. This topic is covered in detail in Chapter 23.

However, load shifting also affects transmission and distribution line losses. As noted in Chapter 10, line losses are highest during peak hours. Shifting loads to lower-use periods will reduce line losses, and thus reduce the total number of kWh that are needed.[91]

### 3.3. Utility Business Models

The traditional electric utility business model is based on "cost of service" regulation. The essence of this model is that the rates utilities charge to customers are designed to recover the utility's costs of serving those customers. In the case of investor-owned utilities, rates also allow utilities the opportunity to replenish their capital stock and to earn a reasonable rate of return on capital invested by shareholders. Implicit in this model is the fact that investor-owned utilities earn profits by making capital investments in generation, transmission, and distribution system assets. Where a third party or a customer invests in similar assets, the utility's shareholders lose the opportunity to enjoy that return. Finally, as noted in the preceding section, rates have typically been designed in such a way that utilities collect most of their revenue based on volumetric sales (i.e., per-kWh and per-kW). Absent any mitigating policies, this gives utilities an inherent interest in maximizing their sales volume.

It is widely agreed that the US electric industry is at the cusp of a fundamental transformation, which is both challenging the traditional utility business model and offering significant opportunities to reduce the carbon intensity of the power sector. The transformation at hand is from a twentieth century model of central power generation and unidirectional delivery, toward a decentralized model in which the provision and management of electric services are distributed across end-users, for which the grid serves as a transactive platform.

This shift is being driven by a number of factors, notably the improved performance and availability of distributed energy resources. Distributed energy resources incorporate both demand- and supply-side resources deployed across the grid, including, for example, small-scale generation, combined heat and power, energy storage, microgrids, sensors, smart inverters, and load control technologies. Siting generation at the point of consumption, be it residential solar PV or commercial combined heat and power, cuts into retail sales of electricity, and therefore bypasses traditional cost recovery mechanisms for the regulated utility. Reducing demand, whether through demand response or energy efficiency programs, similarly cuts into utility sales. Therefore, even though distributed energy resources have been demonstrated to provide a broad variety of system benefits, such as resilience, electric reliability, congestion relief, and other ancillary services, many of which directly enhance the grid, utility incentives still typically discourage customer-owned assets.

The more recent technological advances in distributed energy resources are occurring against a backdrop of steadily declining growth in electricity demand, another factor driving industry transformation. Growth in electricity consumption has dropped from 9.8 percent per year in the 1950s to 0.7 percent per year since 2000,[92] and demand has begun to level off over the last decade, with sales having declined in six out of the last seven years (2007 to 2014).[93] Reduced demand further undermines

91 See: Lazar, J., & Baldwin, X. (2011, August). *Valuing the Contribution of Energy Efficiency to Avoided Marginal Line Losses and Reserve Requirements.* Available at: http://www.raponline.org/document/download/id/4537

92 US Energy Information Administration. (2014, May 7). *Annual Energy Outlook 2014. Market Trends: Electricity Demand.* Available at: http://www.eia.gov/forecasts/aeo/MT_electric.cfm

93 US Energy Information Administration. (2015, February). *Electric Power Monthly With Data for December 2014.* Available at: http://www.eia.gov/electricity/monthly/pdf/epm.pdf; US Energy Information Administration. (2015, February). *Monthly Energy Review. Table 7.6 Electricity End Use.* Available at: http://www.eia.gov/totalenergy/data/monthly/pdf/sec7.pdf; US Energy Information Administration. (2014, April 30). *Implications for Low Electricity Demand Growth.* Available at: http://www.eia.gov/forecasts/aeo/elec_demand.cfm

utility revenue and is contributing to the upward pressure on rates seen across the country.[94] The traditional utility model may have been well suited for planning investment in large facilities and infrastructure projects at economies of scale, where continuous growth in demand was all but guaranteed. Today, not only are the economies of scale in power generation known to be limited,[95] but owing to structural economic changes and improvements in end-use efficiency, large capacity additions are no longer needed in the same way to meet planning requirements.

This evolution, from a natural monopoly to a participatory network that relies more on customer interaction, energy services, and information management, will require a redefinition of the utility profit regime. What exactly this will look like is the subject of debate. Numerous research efforts have investigated the issue, representing a broad array of perspectives, including those of regulators, consumer advocates, environmental advocates, as well as the utility industry[96] and investors.[97]

The Electricity Markets and Policy Group at Lawrence Berkeley National Laboratory has been working in this space since the 1990s, analyzing business models, quantifying financial impacts of distributed energy resources on shareholders and ratepayers, and providing technical assistance to utilities across the country. A library of related resources is available online.[98] With funding from the US Department of Energy, Lawrence Berkeley National Laboratory began convening a high-level advisory group of regulators, utilities, experts, and other stakeholders in late 2014, with the objective of exploring a vision for utility models that can enable distributed energy resources. The initial round of issue papers is scheduled for release in 2015.[99]

One of the forerunners on the subject was Peter Fox-Penner's *Smart Power,* a 2010 book widely praised for presenting a rigorous yet accessible account of the challenges to electric utilities posed by smart grid technologies, energy efficiency, and related policy goals of reducing carbon emissions.[100] Fox-Penner envisions the utility of the future as a "smart integrator" of upstream supply, local supply, and storage, whose chief role is one of network operator, rather than commodity retailer.

The first wave of changes to the traditional business model has been less visionary, consisting instead of incremental variations to cost-of-service regulation. The most common example of this kind of regulatory fix is *revenue decoupling,* an approach that originated in the 1980s and has been instituted for electric utilities in 16 states as of 2013 (22 states have decoupling for gas utilities).[101] Decoupling separates revenue from volumetric sales and allows utilities to recover fixed costs even when pursuing public policy objectives that may reduce sales.

Work by the Rocky Mountain Institute (RMI) through its eLab collaboration[102] outlines additional incremental steps that utilities and regulators can take to create the price signals needed to optimize the deployment and operation of distributed energy resources. RMI frames pricing reforms in terms of three objectives:

94 Satchwell, A. (2014, April 2). *Utility Business Models in a Low Load Growth/High DG Future.* Presentation to the California Municipal Utilities Association. Lawrence Berkeley National Laboratory. Available at: http://cmua.org/wpcmua/wp-content/uploads/2014/04/Utility-Bus-Mods-of-FutureCMUA_20140327_Andy.pptx

95 Burger, C., & Weinmann, J. (2013). *Small Is Beautiful: Decentralized Energy Revolution: Business Strategies for a New Paradigm.* Palgrave Macmillan.

96 Kind, P. (2013, January). *Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business.* Energy Infrastructure Advocates for Edison Electric Institute. Available at: http://www.eei.org/ourissues/finance/documents/disruptivechallenges.pdf

97 Small, F., & Frantzis, L. (2010, July). *The 21st Century Electric Utility: Positioning for a Low-Carbon Future.* Navigant Consulting for Ceres. Available at: http://www.ceres.org/resources/reports/the-21st-century-electric-utility-positioning-for-a-low-carbon-future-1

98 Lawrence Berkeley National Laboratory, Electricity Markets and Policy Group. *Utility Business Models, Research Area.* Available at: http://emp.lbl.gov/ubm

99 Lawrence Berkeley National Laboratory, Electricity Markets and Policy Group. (2015, forthcoming). *Future Electric Utility Regulation Series Reports.* Available at: http://emp.lbl.gov/future-electric-utility-regulation-series

100 Fox-Penner, P. (2010). *Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities.* Island Press. Available at: http://www.smartpowerbook.com/

101 Natural Resources Defense Council. (2013, August). *Map of Gas and Electric Decoupling in the US.* Available at: http://www.nrdc.org/energy/decoupling/files/Gas-and-Electric-Decoupling-Maps.pdf

102 Rocky Mountain Institute eLab. Available at: http://www.rmi.org/elab

1. ***Attribute unbundling*** — shifting from fully bundled pricing to rate structures that break apart energy, capacity, ancillary services, environmental attributes, and other components;
2. ***Temporal granularity*** — shifting from flat or block rates to pricing structures that differentiate the time-based value of electricity generation and consumption (e.g., peak versus off-peak, hourly pricing); and
3. ***Locational granularity*** — shifting from pricing that treats all customers equally regardless of their location on the distribution system to pricing that provides geographically differentiated incentives for distributed energy resources.[103]

By unbundling attributes and increasing temporal and locational resolution, rate design monetizes the system benefits provided by specific applications of distributed energy resources. As a result, prices can more effectively steer investment toward the areas, hours, and technologies that offer the greatest public benefit.[104] To achieve these objectives, RMI lays out six specific options for rate design, as shown in Table 26-7.

Ultimately prices would be highly differentiated to fully incorporate a two-way exchange of value and services. But interim rate structures offer actionable options over the near-term, which can help optimize the investment flows that are already being made in distributed energy resources and set pricing on a trajectory toward greater sophistication in reflecting marginal costs and benefits over the load curve.

In addition to adequately valuing and incenting distributed energy resources, another looming challenge is how to organize multiple third-party service providers at the distribution level. In one model, an independently reviewed Integrated Resource Planning (IRP) process would be undertaken for the distribution network. The IRP would be used to identify least-cost procurement needs, for which proposals would be solicited from third-party service providers, aggregators, and consumer advocates. Utilities could provide financing or invest directly in owning and operating assets on the customer side. In another model, the distribution utility would offer customer outreach and on-bill financing for qualifying distributed energy resources, which would be installed and managed by approved third-party service providers. Rates could be designed to reflect the attributes and performance of specific assets.[106]

***Table 26-7***

**Rate Design Reforms as Proposed by RMI**[105]

| Near-Term Option | Longer-Term Option |
|---|---|
| **Energy + Capacity Pricing**<br>Unbundling energy and capacity (demand) values helps differentiate prices, but leaves many elements still bundled. Time- and location-based differentiation is still minimal. | **Attribute-Based Pricing**<br>Attribute-based pricing more fully unbundles electricity prices, and doing so could also add time- and location-based sophistication. |
| **Time-Of-Use Pricing**<br>Relatively basic TOU pricing (e.g., off-peak, peak, critical peak) begins to add time-based differentiation, but could still allow attributes to remain fully bundled with no location-based differentiation. | **Real-Time Pricing**<br>Real-time pricing, with prices dynamically varying by one-hour or sub-hour increments, adds much time-based sophistication, but could still allow attributes to remain fully bundled with no location-based differentiation. |
| **Distribution System Hot Spot Pricing**<br>Identifying distribution system "hot spots" begins to add location-based differentiation, but could still allow fully bundled attributes and little or no time-based differentiation. | **Distribution Locational Marginal Pricing**<br>Distribution locational marginal pricing adds location-based sophistication, and in turn a high degree of temporal sophistication. |

103 Rocky Mountain Institute. (2014, August). *Rate Design for the Distribution Edge: Electricity Pricing for the Distributed Resource Future.* Available at: http://www.rmi.org/elab_rate_design

104 Linvill, C., Lazar, J., & Shenot, J. (2013, November). *Designing Distributed Generation Tariffs Well: Ensuring Fair Compensation in a Time of Transition.* Montpelier, VT: The Regulatory Assistance Project. Available at: http://www.raponline.org/press-release/designing-distributed-generation-tariffs-well-ensuring-fair-compensation-in-a-time-of

105 Supra footnote 103.

106 Rocky Mountain Institute. (2013, April). *New Business Models for the Distribution Edge: The Transition From Value China to Value Constellation.* Available at: http://www.rmi.org/New_Business_Models

These models are attractive on the one hand, because they could be implemented within the existing utility structure. However, utilities would still be subject to conflicts of interest, and ensuring oversight and transparency in acquisition and valuation would remain a challenge. To enable a fully transactive platform, the logical extension of these models would require the more disruptive intervention of separating the ownership and operational roles of the distribution utility.

Former Chairman of the FERC Jon Wellinghoff is among those who have come out in support of imposing reforms on the distribution utility that would transfer its operational authority to an independent distribution system operator, not unlike RTOs and ISOs in the bulk transmission system.[107,108] A 2014 article by James Tong and Jon Wellinghoff in *Public Utilities Fortnightly* makes the case that the separation of assets from operations would be the best way for distribution utilities to embrace new innovation in consumer-based energy resources and eliminate the conflict of interest with grid management. The new independent distribution system operator would be responsible for: "maintaining the safety and reliability of the distribution system; (2) providing fair and open access to the distribution grid and information from the system; (3) promoting appropriate market mechanisms; and (4) overseeing the optimal deployment and dispatching of distributed energy resources."[109] This opening at the distribution level to competitive forces would be designed to create greater customer choice, facilitate a broad deployment and integration of distributed resources, and ultimately "spur the development of the 'Transactive Energy Framework' in which independent energy agents in the distribution system can trade and combine their services to meet increasingly disparate customer needs."

Without the burden of operations, the distribution utilities would retain ownership of assets and continue to be compensated through rates for the value of service provided. Distribution utilities would also continue to be responsible for maintaining and upgrading the system, which could potentially include investment in distributed energy resources on the utility side of the meter to capture associated grid services and public benefits, where appropriate as subject to state laws.

This model of reform is similar to the course that is being set in New York's Reforming the Energy Vision proceedings.[110] In April 2014, the New York Public Service Commission launched an ambitious initiative to modernize the institutions and incentives that govern the electric utility industry to better promote energy efficiency, renewable energy, and distributed energy resources. Central to this effort is the task of redefining the distribution utility as a platform that serves as an interface between energy products, services, and market participants, including producer-consumers ("prosumers").[111] The commission envisions this as a Distributed System Platform (DSP) provider, defined as follows:

> *The DSP is an intelligent network platform that will provide safe, reliable and efficient electric services by integrating diverse resources to meet customers' and society's evolving needs. The DSP fosters broad market activity that monetizes system and social values, by enabling active customer and third party engagement that is aligned with the wholesale market and bulk power system.*[112]

On February 26, 2015, the New York Public Service

107 Wellinghoff, J., Hamilton, K., & Cramer, J. (2014, September 22). *Comments Submitted Before the State of New York Department of Public Service, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision Case No. 14-M-0101.*

108 Others have proposed this model of reform as well. See, for example: Rehimi, F., & Mokhtari, S. (2014, June). From ISO to DSO: Imagining a New Construct – An Independent System Operator for the Distribution Network. *Public Utilities Fortnightly.* Also see: Kristov, L., & De Martini, P. (2014, May). *21st Century Electric Distribution System Operations* [discussion paper]. Available at: http://resnick.caltech.edu/docs/21st.pdf

109 Tong, J., & Wellinghoff, J. (2014, August). Rooftop Parity: Solar for Everyone, Including Utilities. *Public Utilities Fortnightly 152,* 8:18. Available at: http://www.fortnightly.com/fortnightly/2014/08/rooftop-parity

110 New York Department of Public Service. *Case 14-M-0101. REV: Reforming the Energy Vision Proceedings.* Available at: http://www3.dps.ny.gov/W/PSCWeb.nsf/All/26BE8A93967E604785257CC40066B91A?OpenDocument

111 New York Department of Public Service. (2014, April 24). *Case 14-M-0101. Reforming the Energy Vision: NYS Department of Public Service Staff Report and Proposal.* Available at: http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/26be8a93967e604785257cc40066b91a/$FILE/ATTK0J3L.pdf/Reforming%20The%20Energy%20Vision%20(REV)%20REPORT%204.25.%2014.pdf

112 New York Department of Public Service. (2014, August 22). *Case 14-M-0101. Developing the REV Market in New York: DPS Staff Straw Proposal on Track One Issues,* p. 12. Available at: http://energystorage.org/system/files/resources/nyrev_dpsstaffproposal_8_22_14.pdf

Commission issued its Reforming the Energy Vision order,[113] determining that the DSP function be filled by incumbent utilities, as opposed to an independent entity. The main reason for this is to avoid creating redundancy in system planning and operations.[114] The order put forward transitional steps, requiring each utility to undertake an IRP-like, least-cost planning exercise, called a Distributed System Implementation Plan (DSIP), which:

> *[S]hould present the utility's proposed investment plan for the next five years, and should reflect an integrated view of (transmission and distribution) investment needs and DER [distributed energy resources] resource alternatives. Beyond resource investments, the DSIP should include the utility's plan for implementing DSP platform and market components in the plan period. The actions proposed in the DSIP should be evaluated via a business plan that includes a benefit-cost assessment, a qualitative assessment of non-quantifiable benefits, and a risk assessment.*

Extending the transactive energy market into the retail domain, the DSP would need to be in an unbiased position in order to optimize across all available distributed energy resources. To eliminate the conflict of interest in using the existing utilities to host the DSP platforms, New York is proposing to move away from cost-of-service regulation toward an outcome-oriented, performance-based regulation.

In performance-based regulation, utility profits are tied to achieving specific goals determined by the regulator. These can be a composite framework of environmental targets, service quality metrics, price caps, reliability goals, or other goals based on related indices. If carefully designed, performance-based metrics can harness the utility profit motive to inspire innovation in targeted areas of public interest. The challenge lies in framing the goals, however, which may include a system of penalties and rewards for under- and over-achievement, respectively, and require extensive financial modeling.[115,116] New York will be looking to the United Kingdom, where performance-based regulation is the basis of the new "Revenues = Incentives plus Innovation plus Outputs" (RIIO) framework. RIIO is a major reform effort to align utility business models with the policy-driven investment required to transition the nation to a low-carbon economy.[117] One potential impact of RIIO of relevance to readers is that it intends over time to diminish and eliminate any bias favoring utility capital investments over operating expenses. This step is important if emissions-reducing demand-side investments by customers are motivated by utility expenses to support assets they will not own. A focus on total expenses assures attention to overall rate levels. New York is exploring this approach with Consolidated Edison's Brooklyn-Queens reliability project.[118]

Whether utility transformation is being advanced by consumer demand (as in Hawaii and Arizona, for instance), by utilities (as in the case of Duke Energy in North Carolina), or by regulators (as in New York and Minnesota),[119] different models will work in different regulatory environments. And although near-term

113 New York Department of Public Service. (2015, February 26). *Case 14-M-0101. Order Adopting Regulatory Policy Framework and Implementation Plan.* Available at: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b0B599D87-445B-4197-9815-24C27623A6A0%7d

114 Supra footnote 112.

115 Goldman, C. A., Satchwell, A., Cappers, P., & Hoffman, I. M. (2013, April 10). *Utility Business Models in a Low Load Growth/High DG Future: Gazing Into the Crystal Ball?* Presentation Before the Committee on Regional Electric Power Cooperation (CREPC)/State-Provincial Steering Committee (SPSC) Meeting. Lawrence Berkeley National Laboratory. Available at: http://emp.lbl.gov/publications/utility-business-models-low-load-growthhigh-dg-future-gazing-crystal-ball

116 Goldman, C. (2014, September 24). *Utility Regulatory Models: LBNL Technical Assistance Analysis and Tools. Presentation Before DOE OE Electricity Advisory Committee Meeting.* Available at: http://energy.gov/sites/prod/files/2014/10/f18/02d-CGoldman.pdf

117 Fox-Penner, P., Harris, D., & Hesmondhalgh, S. (2013, October). A Trip to RIIO in Your Future? *Public Utilities Fortnightly.* Available at: http://www.brattle.com/system/publications/pdfs/000/004/958/original/A_Trip_to_RIIO_in_Your_Future.pdf?1386706496

118 Whited, M., Woolf, T., & Napoleon, A. (2015, March 9). *Utility Performance Incentive Mechanisms: A Handbook for Regulators.* Synapse Energy Economics, Inc. Available at: http://synapse-energy.com/sites/default/files/Utility%20Performance%20Incentive%20Mechanisms%2014-098_0.pdf

119 GTM Research. (2015). *Evolution of the Grid Edge: Pathways to Transformation: A GTM Research Whitepaper.* Available at: http://www.greentechmedia.com/research/report/evolution-of-the-grid-edge-pathways-to-transformation

modifications to traditional cost-of-service regulation will be appropriate as interim solutions in many markets, thought leaders are converging on a vision of the future utility as a transactive energy platform that will eventually require dramatic changes to the role of the distribution utility.

### 3.4. Carbon Offsets

A carbon offset is a certificate or credit that is created to represent the reduction of a fixed amount of GHG emissions (generally, one metric ton of $CO_2$ or $CO_2$-equivalent) through an activity that is not directly regulated or is supplemental to regulatory requirements. These can be activities that reduce emissions, avoid emissions, or sequester carbon. Offsets are registered, tracked, traded, and retired in a manner similar to the renewable energy credits described in Chapter 16. Offsets can be used to assist in compliance with California's AB-32 requirements, in the European Union's Emissions Trading Scheme, in Clean Development Mechanism (CDM) and Joint Implementation (JI) projects under the United Nations Framework Convention on Climate Change, and in voluntary markets, among other purposes.

The carbon offset concept first arose more than a decade ago to serve the needs of individuals, businesses, and institutions that wanted to voluntarily reduce their contribution to climate change but found that the options to directly reduce their own emissions were limited in amount or unacceptably expensive. Recognizing that other parties often had more potential to reduce emissions and to do so at lower costs, but couldn't afford to or were not so inclined, some early entrepreneurs created carbon offsets as a means to put these two groups together. The buyers of offsets, in effect, finance the sellers' emissions reduction projects. For example, anaerobic digesters installed on dairy farms can capture methane from cow manure, burn it to generate electricity, and reduce GHG emissions. However, anaerobic digesters require a large upfront capital investment, and they can be complicated and expensive to maintain. As a result, few dairy farms in the United States have installed a digester. However, in recent years some farmers have financed digester projects by selling carbon offsets to willing buyers.

Today the market for carbon offsets is no longer limited only to voluntary buyers. Many of the established GHG cap-and-trade programs include provisions allowing for the use of carbon offsets as an alternative to emissions allowances. For example, under the current cap-and-trade rules adopted by the nine Northeast states participating in the Regional Greenhouse Gas Initiative (RGGI), regulated power plants are allowed to meet up to 3.3 percent of their compliance obligation for each control period using $CO_2$ offset allowances. The RGGI states have thus far limited eligibility for offset allowances to just five project categories, each of which represents a project-based GHG emissions reduction outside of the capped electric power generation sector:

- Landfill methane capture and destruction;
- Reduction in emissions of sulfur hexafluoride in the electric power sector;
- Carbon sequestration in US forests (through reforestation, improved forest management, avoided conversion, or afforestation);
- Reduction or avoidance of $CO_2$ emissions from natural gas, oil, or propane end-use combustion owing to end-use energy efficiency in the building sector; and
- Avoided methane emissions from agricultural manure management operations.

Additionality requirements apply to all RGGI offset allowances, which means in this specific case that projects are not eligible for offsets if they are funded with utility ratepayer dollars or required under any statute, regulation, or order. A rigorous procedure has been developed for registering and verifying offset allowances. It is notable that no offset allowances had been awarded to any projects as of the end of 2013, in part because the low price of emissions allowances has not encouraged alternative investments.[120]

The state of California has also opted to allow the use of registered and verified offsets for compliance with its GHG cap-and-trade program, but in its case more than 17 million offset credits have already been issued.[121] Regulated entities in California can use offsets to meet up to eight percent of their compliance obligation. Projects in five categories are currently eligible for offset credits if they meet all program requirements:

- US Forest Projects;
- Urban Forest Projects;
- Livestock Projects;

120 Potomac Economics for RGGI. (2014, May). *Annual Report on the Market for RGGI $CO_2$ Allowances:* 2013. Available at: http://www.rggi.org/docs/Market/MM_2013_Annual_Report.pdf

121 See: http://www.arb.ca.gov/cc/capandtrade/offsets/issuance/arb_offset_credit_issuance_table.pdf

- Ozone Depleting Substances Projects; and
- Mine Methane Capture Projects.

At the international level, the Kyoto Protocol to the United Nations Framework Convention on Climate Change includes two offset programs, the CDM and JI. Countries that committed to limiting GHG emissions under the Kyoto Protocol are allowed to meet some of their commitment by funding and implementing emissions reduction projects in other countries. These projects can earn offset credits representing one metric ton of GHG emissions reductions, which can be counted toward meeting Kyoto Protocol targets. The list of eligible projects is much broader than the five categories approved for use in RGGI.

A CDM or JI project has to meet additionality requirements (i.e., provide emissions reductions that are additional to what would otherwise occur, and not result in the diversion of normal international development assistance). Verification and approval requirements also apply. Since the beginning of 2006, thousands of projects have registered and produced almost 2.5 billion credits.[122] In Europe, where the European Union's Emissions Trading Scheme is used by most countries to comply with Kyoto Protocol commitments, CDM and JI credits can be used for Emissions Trading Scheme compliance purposes by regulated entities.

The voluntary offset market is now much smaller than the markets using offsets for compliance purposes. A recent report on the state of the voluntary market found that it encompassed 102.8 million metric tons of GHG emissions in 2012, and 76 million metric tons in 2013. Most of this decline is attributed to changes in California, where offset projects that had previously been registering credits for voluntary purposes instead began registering for the new, mandatory cap-and-trade program. Even so, the voluntary market in 2013 brought in $379 million for offset projects that reduce GHG emissions.[123] A common criticism of voluntary offsets is that they are not regulated and thus not subject to the same project eligibility, additionality, and verification standards as compliance market offsets. However, several voluntary standards administered by independent third-party verifiers have been introduced in recent years to bring more credibility to this market.

The EPA, in its 111(d) rulemaking, proposed that offsets from outside the US power sector could not be applied to demonstrate compliance by regulated sources. The rationale behind this decision appears to be based on the idea that out-of-sector offsets do not, by definition, reduce power sector emissions and may not be a legal option under the specific language of Section 111 of the Clean Air Act. However, the EPA tried to make clear that programs like the RGGI and California cap-and-trade programs, which allow for the use of offsets, will not run afoul of the regulations so long as the affected EGUs would not exceed their federal 111(d)-based emissions limits. Officials in some states feel that this does not go far enough, and have asked the EPA to afford states more flexibility to use offsets. For example, comments on the proposed rule that were submitted by officials in Kentucky and Georgia recommend that the EPA allow offsets from outside the power sector to be used for compliance.[124]

## 4. Multi-Pollutant Planning

Most US states require utilities to plan for meeting forecasted annual peak and energy demand, plus an established reserve margin, considering all available supply- and demand-side resource options over a specified future period. Called "integrated resource planning" (IRP) and discussed at length in Chapter 22, such planning is often time- and resource-intensive, but its benefits are great – particularly to consumers. State public utilities commissions typically review and approve IRP plans submitted by utilities.[125]

There is no similarly comprehensive consideration in air

122 Refer to: http://cdm.unfccc.int/index.html and http://ji.unfccc.int/statistics/2015/ERU_Issuance_2015_01_31_1200.pdf

123 Peters-Stanley, M., & Gonzalez, G. (2014). *Sharing the Stage: State of the Voluntary Carbon Markets 2014.* Forest Trends' Ecosystem Marketplace. Available at: http://www.forest-trends.org/documents/files/doc_4841.pdf

124 Refer to pp. 13–14 of the Kentucky cabinet's comments at http://eec.ky.gov/Documents/Ky%20EEC%20111(d)%20Comments%20Nov.%2026,%202014.pdf, and p. 7 of the comments submitted by the Georgia Public Service Commission at http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2013-0602-23535

125 Wilson, R., & Biewald, B. (2013, January). *Best Practices in Electric Utility Integrated Resource Planning: Examples of State Regulations and Recent Utility Plans.* Synapse Energy Economics, Inc. for The Regulatory Assistance Project. Available at: www.raponline.org/document/download/id/6608

quality planning that takes into account the multiple public health and welfare threats of various air pollutant emissions and how collectively they might be addressed most cost-effectively and expeditiously. Instead, the Clean Air Act clearly delineates and separates different air pollutants and different ways in which they are to be regulated. This is unfortunate because sources often emit multiple pollutants, and control measures can often be selected that reduce emissions of multiple pollutants simultaneously.

The idea of addressing air quality from a holistic, multi-pollutant perspective is not new. Several papers and books have been written on this topic and several recommendations made for the EPA, state, and local air quality agencies to consider adopting multi-pollutant approaches. Economic models also conclude that reducing multiple air pollutants through root-of-pipe measures (e.g., at the beginning of industrial processes) is far more cost-effective than multiple pollutant-specific approaches focused only at the end of the pipe.[126]

Two influential bodies in fact have recommended that the EPA explicitly enable and encourage states to develop multi-pollutant plans. In 2004, the National Research Council of the National Academies of Science published "Air Quality Management in the United States." This comprehensive assessment identified five major recommendations for the EPA to consider and adopt. Among them were to "transform the [state implementation plan] SIP process into a more dynamic and collaborative performance-oriented, multi-pollutant air quality management planning (AQMP) process" and to "develop an integrated program for criteria pollutants and hazardous air pollutants."[127] In 2010, the Clean Air Act Advisory Committee (CAAAC) developed a framework for a multi-pollutant strategy. The CAAAC's objectives were to align four major Clean Air Act programs: National Emission Standards for Hazardous Air Pollutant Standards (NESHAPS), New Source Performance Standards (NSPS), National Ambient Air Quality Standard (NAAQS), and New Source Review (NSR), and to coordinate – for the affected sources of pollution – the timing and obligations associated with these programs. CAAAC noted, "The Clean Air Act – read according to its express terms and without much of the intervening interpretative gloss of the past four decades – provides sufficient flexibility to achieve these objectives."[128] These recommendations appear even more appropriate with the recent addition of proposed GHG emissions reduction requirements.

The National Academies of Science and CAAAC recommendations anticipate that, done correctly along the lines of an "air quality IRP," states could develop comprehensive plans that meet existing NAAQS, as well as anticipate future NAAQS, hazardous air pollutant standards, and GHG reduction requirements. This concept has been explored further by The Regulatory Assistance Project under the rubric of Integrated Multi-Pollutant Planning for Energy and Air Quality (IMPEAQ).[129] IMPEAQ would identify all measures needed to meet a state's long-term air quality goals. Each time a NAAQS, NSPS, or NESHAP is revised by the EPA, the state would identify, assign, and/or add appropriate elements from its IMPEAQ planning process and incorporate them into the required state implementation plan (SIP) or other compliance plan revision as needed for EPA approval. Unlike IRP as generally practiced in the power sector, IMPEAQ would seek to include "externalities" in air quality decisions (e.g., the societal benefits and costs associated with the adoption and implementation of air quality control measures).

Although the Clean Air Act generally applies a pollutant-by-pollutant approach, it does not restrict states to developing air quality plans that only address one pollutant or that only include measures to reduce a single pollutant. Economic models conclude that the costs to achieve a particular environmental end-point are lower when the selected control measures reduce several pollutants at the

126 James, C., & Colburn, K. (2013, March). *Integrated, Multi-Pollutant Planning for Energy and Air Quality (IMPEAQ)*. Montpelier, VT: The Regulatory Assistance Project. Available at: www.raponline.org/document/download/id/6440

127 National Research Council, Committee on Air Quality Management in the United States. (2004). *Air Quality Management in the United States*. Available at: http://www.nap.edu/catalog/10728/air-quality-management-in-the-united-states

128 Clean Air Act Advisory Committee, Economic Incentives and Regulatory Innovation Subcommittee. (2010, September). *A Conceptual Framework for a Source-Wide Multi-Pollutant Strategy*. Available at: http://www.eli.org/sites/default/files/docs/seminars/10.20.10dc/EPA-Attachment-4.pdf?q=pdf/seminars/10.20.10dc/EPA-Attachment-4.pdf. CAAAC formally advises the EPA on air quality programs and regulatory standards.

129 Supra footnote 126.

same time and when both demand-side measures and end-of-pipe measures are applied. For example, modeling completed by the Bay Area Air Quality Management District for its 2010 Clean Air Plan indicated that public health benefits and reduced damages from climate change in the range of $270 million to $1.5 billion per year could be achieved from a suite of 55 control measures that would jointly reduce criteria, toxic, and GHG pollutants.[130]

Similarly, work using the GAINS model demonstrates that the cost to reduce public health risk by 50 percent over 20 years can be reduced by one-third when the control measures include energy efficiency, combined heat and power, and end-of-pipe controls, as compared to only end-of-pipe controls.[131] The EPA's regulatory impact analysis for the Mercury and Air Toxics Standards also showed that the costs of meeting the mercury standard were $3 to $12 billion lower when energy efficiency was an integral part of the control strategy, and that emissions of $SO_2$, $NO_X$, and $CO_2$ were also lower.[132] Another EPA analysis performed for the cement industry indicated that compliance costs to meet NSPS and NESHAPs would be lower and provide greater environmental benefits if the various regulations were synchronized.[133]

Among US states, Maryland is a leader in advancing multi-pollutant approaches. Working with the Northeast States for Coordinated Air Use Management, the University of Maryland, and Towson University, the Maryland Department of the Environment has leveraged Maryland's 2015 ozone SIP requirements and state-legislated 2012 GHG reduction requirements to build a multi-pollutant analytical framework. The Maryland Department of the Environment's framework allows it to:

- Quantify the emissions reductions of multiple pollutants for a broad suite of energy efficiency and renewable energy efforts;
- Model the reductions in ozone, fine particulate, and other pollutants;
- Estimate the public health benefits associated with those reductions; and
- Quantify the economic benefits and costs.[134]

The Regulatory Assistance Project envisions IMPEAQ as an air quality planning process that builds upon the best components of utility IRP processes and also incorporates environmental, energy, and economic externalities that are not typically included in an IRP. Including externalities and their influence on the cost-effectiveness of control measures – and considering whether and how control measures may have unintended consequences – can help meet both air regulators' goals to attain and maintain compliance with NAAQS and other requirements of the Clean Air Act, and energy regulators' goals to assure reliable and affordable electric and gas service.

## 5. Conclusion

As noted in the introduction to this document, the EPA's proposed Clean Power Plan establishes state-specific $CO_2$ emissions standards using four building blocks. These building blocks are intended to reflect the degree of emissions limitation achievable through the application of the best system of emission reduction that the EPA believes has been adequately demonstrated, taking into account the cost of achieving such reductions and any non-air-quality health and environmental impacts and energy requirements.

The proposed CPP does not, however, compel states to use the same four building blocks to meet the state-specific emissions targets. Instead, states are free to identify other options to reduce $CO_2$ emissions and to submit compliance plans that incorporate any combination of measures in the

130 Bay Area Quality Managment District. (2010, September 15). *2010 Clean Air Plan.* Available at: http://www.baaqmd.gov/Divisions/Planning-and-Research/Plans/Clean-Air-Plans.aspx

131 Bollen, J. C., van der Zwaan, B., Corjan, B., & Eerens, H. (2009). Local Air Pollution and Global Climate Change: A Combined Cost-Benefit Analysis. *Resource and Energy Economics 31;* 161–181. Available at: https://ideas.repec.org/a/eee/resene/v31y2009i3p161-181.html

132 US EPA. (2011, March). *Regulatory Impact of the Proposed Toxics Rule, Final Report (Chapter 8).*

133 Witosky, M. (2010, May 26). *Sector-Based Multi-Pollutant Approaches for Stationary Sources.* Presentation to the Clean Air Act Advisory Committee. US EPA Office of Air Quality Planning and Standards. Available at: http://www.eli.org/sites/default/files/docs/seminars/10.20.10dc/EPA-Attachment-1.pdf?q=pdf/seminars/10.20.10dc/EPA-Attachment-1.pdf

134 Adburn, T. (2013, March 25). *Building Energy Efficiency and Renewable Energy Programs Into the Clean Air Planning Process: Taking Credit for Nontraditional Programs.* Presentation at ACEEE Market Transformation Symposium. Maryland Department of the Environment. Available at: aceee.org/files/pdf/conferences/mt/2013/Tad%20Aburn_D2.pdf

EPA's building blocks, as well as other options that in total reduce $CO_2$ emissions sufficiently to achieve compliance with the CPP's emissions targets. The broad variety of technology and policy options available for states to consider and incorporate in their CPP compliance plans is evident in the previous 25 chapters of this *Menu of Options* – a breadth that far exceeds the EPA's four building blocks.

This twenty-sixth chapter introduces a variety of rapidly emerging technologies and additional policy opportunities that regulators may wish to consider as they formulate plans to reduce future power sector GHG emissions. With the dramatic evolution underway in the power sector, additional options – some not even conceived today – are likely to become available. Illustration of this rapid evolution is evident in the fact that many of the technologies and policies covered in this *Menu of Options* have advanced significantly during the year of its development and publication.

# Multi-Pollutant Planning Exercise for Maryland

## A Weight-of-Evidence Approach for the Maryland State Implementation Plan for Ozone and the Greenhouse Gas Reduction Act Plan Update

**Prepared by**
**NESCAUM**

**May 20, 2015**

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# MULTI-POLLUTANT PLANNING EXERCISE FOR MARYLAND

## A WEIGHT-OF-EVIDENCE APPROACH FOR THE STATE IMPLEMENTATION PLAN FOR OZONE AND THE GREENHOUSE GAS REDUCTION ACT PLAN UPDATE

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NESCAUM is an association of the eight northeastern states' air pollution control programs. NESCAUM provides technical guidance and policy advice to its member states.

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# Abbreviations and Acronyms

BenMAP: Environmental Benefits Mapping and Analysis Program

bVMT: Billion vehicle miles traveled

bn-lum-yr: Billion lumens per year

CAFE: Corporate Average Fuel Economy

CMAQ: Community Multi-scale Air Quality model

CNG: Compressed natural gas

$CO_2$: Carbon dioxide

E85: A fuel blend of 85 percent ethanol and 15 percent gasoline

EPA: U.S. Environmental Protection Agency

GGRA: Greenhouse Gas Emissions Reduction Act

GHG: Greenhouse gas

Hg: Mercury

kT: Kiloton

LPG: Liquefied petroleum gas

MDE: Maryland Department of the Environment

MDOT: Maryland Department of Transportation

MEA: Maryland Energy Administration

MMBtu: Million British Thermal Units

MPAF: Multi-pollutant Policy Analysis Framework

mpg: Miles per gallon

MSW: Municipal solid waste

NAAQS: National Ambient Air Quality Standard

NE-MARKAL: Northeast version of the Market Allocation model

NESCAUM: Northeast States for Coordinated Air Use Management

$NO_2$: Nitrogen dioxide

$NO_X$: Oxides of nitrogen

$PM_{2.5}$: Fine particulate matter (particles less than 2.5 microns in diameter)

REMI: Regional Economic Models, Inc.

RGGI: Regional Greenhouse Gas Initiative

RPS: Renewable Portfolio Standard

$SO_2$: Sulfur dioxide

SIP: State Implementation Plan

tBTU: Trillion British Thermal Units

tcfm-hr: Trillion cubic feet per meter per hour

VMT: Vehicle miles traveled

VOCs: Volatile organic compounds

# Executive Summary

## ES1. Maryland Context for Multi-pollutant Planning

This report presents the findings of a multi-pollutant planning exercise the Maryland Department of the Environment (MDE) initiated in April 2013. The goals are to continue to build capacity in Maryland to conduct multi-pollutant planning and analyses as well as inform Maryland's 2012 Greenhouse Gas Emissions Reduction Act (GGRA) Plan Progress Report. The GGRA Plan of 2012's Progress Report is due in 2015.

The 2012 GGRA Plan seeks to achieve a 25 percent statewide reduction in greenhouse gas (GHG) emissions by 2020, while also spurring job creation and helping improve the economy. In the multi-pollutant planning context, it is part of a "multi-pollutant" planning approach for selecting and analyzing control programs to address multiple public health and environmental goals. The 2012 GGRA Plan will not only help reduce emissions of GHGs, but will also help Maryland meet its mandates to: (1) further clean up the Chesapeake Bay; (2) meet and maintain National Ambient Air Quality Standards for ground-level ozone, fine particles, sulfur dioxide, and nitrogen dioxide; and (3) meet federal and state requirements to further reduce regional haze as well as air emissions of mercury and other air toxics.

Maryland also intends to use a multi-pollutant framework to look at all pollutants whenever a single pollutant State Implementation Plan (SIP) is being developed. Therefore, this exercise is also a part of Maryland's preliminary effort to establish credit for energy efficiency and renewable energy (EE/RE) programs as part of its ozone SIP. To that end, it feeds into a larger effort in Maryland to better address some of the uncertainties associated with the SIP process through an expanded weight-of-evidence (WOE) approach.

## ES2. Multi-Pollutant Policy Analysis Framework

The planning exercise presented in this report employed the Multi-pollutant Policy Analysis Framework (MPAF), which consists of the following model components to provide a broad view of climate and air quality program impacts:

1. NE-MARKAL, a Northeast version of the MARKet ALlocation (MARKAL) model, an energy model that is widely used in Europe. EPA has a nine-region national version of this model, called US9r;
2. Regional Economic Models, Inc. (REMI), a 12-state model that evaluates the effects of policies and programs on the economies of local regions;
3. EPA's Community Multi-scale Air Quality (CMAQ) model, which assesses future air quality impacts arising from changes in air emissions due to a set of policies and programs;

4. EPA's Environmental Benefits Mapping and Analysis Program (BenMAP), which estimates health impacts and associated monetized values resulting from changes in ambient air pollution.

Two meta-scenarios, an initial and an enhanced, were developed in collaboration with MDE and other Maryland state agencies, which were then analyzed through the MPAF. Each meta-scenario combined a suite of selected policies into a single NE-MARKAL run that captured their interactive effects. The initial meta-scenario was comprised of selected policies as they were defined in the GGRA Plan of 2012. The enhanced meta-scenario was comprised of a combination of individual policies, some of which had enhanced goals defined either in the GGRA Plan or by MDE. Note that enhanced policies not based on the GGRA Plan are for analytical exercise purposes only, and may not reflect current Maryland policy.

## ES3. Multi-Pollutant Impact of GGRA Policies

The multi-pollutant planning exercise demonstrated that the selected GGRA policies collectively made positive contributions to near-term air quality outcomes, including the 2020 GGRA climate target. The analysis also indicated that further reductions in $CO_2$ emissions are needed to meet a hypothetical 80 percent reduction goal by 2050. In order to meet longer-term emission reduction goals, more measures involving the transportation sector would need to be considered. Climate sensitivity analyses undertaken as an extension of the meta-scenarios analyses found that in 2050, the combination of the most aggressive modeled GGRA policies alone lowered Maryland's reference case 2050 GHG emissions from almost 90 million tons of $CO_2$ to about 46 million tons (other GHGs were not considered in these analyses). This is still about 30 million tons short of a 2050 80 percent GHG reduction target of 17 million tons (relative to 2006 emissions). Of the 46 million tons, about 35 million tons comes from the transportation sector. This is not surprising, as the sensitivity analyses focused on more aggressive options for renewable energy and energy efficiency, while more aggressive transportation policies were not considered.

The GGRA measures in the two meta-scenarios also led to projected emission reductions in nitrogen oxides ($NO_X$) and sulfur dioxide ($SO_2$), key precursor pollutants for the criteria pollutants ozone ($NO_X$) and $PM_{2.5}$ ($NO_X$ and $SO_2$) over the modeling timeframe through 2023. Cumulatively over this time period, the initial meta-scenario projected reductions of 63,000 tons of $NO_X$ and 399,000 tons of $SO_2$ in Maryland. Larger reductions were seen for the enhanced meta-scenario, with 70,000 tons of $NO_X$ and 492,000 tons of $SO_2$ reduced.

## ES4. GGRA Contributions to Maryland's Ozone State Implementation Plan Reductions

A selected set of GGRA measures that were included in an ozone sensitivity analysis demonstrated promise for achieving additional $NO_X$ reductions relevant to Maryland's ozone SIP timelines (2017 to 2023). These $NO_X$ reductions go beyond current ozone SIP baseline projections and enforceable control strategies, thus they provide the technical basis for an expanded weight-of-evidence demonstration of reasonably foreseeable $NO_X$ reductions in excess of those attributable to traditional ozone SIP measures.

The estimated additional $NO_X$ reductions from the GGRA measures are in the range of 1,200 to 1,600 tons in the year 2017, which is Maryland's ozone attainment deadline for the 0.075 ppb ozone NAAQS (current NAAQS at the time of this analysis). Additional $NO_X$ reductions in the range of 2,200 to 2,600 annual tons are projected for the year 2023, which is relevant to maintaining the current ozone NAAQS, as well as achieving a possible future revised ozone NAAQS. By way of comparison, the annual $NO_X$ reductions projected under the ozone SIP sensitivity scenarios are somewhat less than, but comparable to, projected annual $NO_X$ reductions from gasoline passenger vehicles in Maryland expected from implementation of EPA's Tier 3 motor vehicle program. The Tier 3 program represents one of the largest, if not the largest, measure in Maryland for reducing $NO_X$ emissions in 2017 and beyond, and the results of the ozone sensitivity runs indicate the potential for additional $NO_X$ reductions of a similar magnitude from the modeled GGRA policies.

## ES5. Maryland's GGRA Measures Have Positive Air Quality, Health, and Economic Benefits

The projected GGRA emission changes estimated by NE-MARKAL were input into the Community Multi-scale Air Quality (CMAQ) model to evaluate their impacts on ambient air quality. The projected changes in emissions estimated by NE-MARKAL give rise to CMAQ-modeled air quality improvements for ozone and fine particulate matter ($PM_{2.5}$) in Maryland and in regions outside of the State, which in turn result in positive net health benefits in terms of avoided adverse health outcomes, including premature mortality. These avoided health incidences were quantified, along with their monetized benefits, using EPA's BenMAP tool coupled with the modeled air quality changes in ozone and $PM_{2.5}$ from CMAQ for each of the meta-scenarios.

As a result of the air quality changes attributable to the GGRA meta-scenarios, the BenMAP analysis found many reduced incidences of respiratory ailment, asthma attack, heart attack, hospital room visits, and lost work and school days. The monetary benefits of these public health improvements were driven largely by the reduced mortality, which includes (within Maryland) 43 to 100 avoided deaths per year due to reduced ozone and $PM_{2.5}$ under the initial meta-scenario, and 84 to 192 avoided deaths per year under the enhanced meta-scenario.

The monetized value of avoided mortality within Maryland ranges between $420 million to $850 million per year under the initial meta-scenario, and between $810 million to $1.6 billion per year under the enhanced meta-scenario, assuming a 3 percent discount rate for future health effects. With a 7 percent discount rate, the value is $320 million to $740 million per year under the initial meta-scenario, and $620 million to $1.4 billion under the enhanced meta-scenario.

The regional economic assessment using REMI found that overall, the GGRA measures as analyzed under the initial meta-scenario will benefit Maryland's economy with respect to jobs, wages, and real disposable income growth. However, the output and value added to Maryland's economy may decline given the large declines in demand for energy and maintenance associated with the electric power sector in the short term. Private, state, and households' continual structured investments in the economy toward GGRA goals under the enhanced meta-scenario mitigated some loss reported in the initial meta-scenario. Specifically, programs associated with increasing public transit helped to offset the later declines. The initial work creates construction jobs within the region, but the longer-term benefits associated with reduced motor fuel purchases and maintenance of private vehicles provide additional disposable income to households in the form of savings. Given this newly acquired disposable income, consumers are more likely to spend it locally, thereby creating additional induced impacts. Review of both scenarios indicates there will be a short-term negative impact incurred for implementation, but Maryland's economy benefits from nearly 20 additional years of increased jobs, wages, and output in the long-term.

# 1. INTRODUCTION

Historically, air pollution problems have been addressed on a pollutant-by-pollutant basis, whereby each pollutant or pollutant category of concern has required its own discrete planning effort. This approach has been fostered by media-specific federal and state statutes primarily designed to address the most serious pollution problems.

While states have made significant progress in reducing pollution over the years, there is a growing recognition that focusing on discrete pollutants or categories may not encompass the most effective strategies, or may lead to unintended results in other areas of the environment or economy. One critical aspect for more effective planning is the understanding of interactions between pollution sources. For example, motor vehicles, industrial facilities, and fossil-fuel power plants contribute not only to ground-level ozone, but also to fine particles, mercury and acid deposition, and climate change. As recognition increases that today's environmental, public health, energy, and economic challenges are increasingly intertwined, states are realizing the importance of moving to a more integrated, multi-pollutant, economy-wide approach.

## 1.1. Definition of Multi-pollutant Planning

Multi-pollutant planning is a process that identifies the air quality co-benefits of select policy options. By looking at multiple air quality goals concurrently and identifying potential control approaches and their environmental, public health, energy, and economic impacts together, a more complex set of policy questions emerges that can then be addressed. Multi-pollutant planning analysis should be able to help states assess unintended consequences of various policy options and identify the best policy mix and design, given the mandate to protect public health and the environment. If done appropriately, multi-pollutant planning should identify tradeoffs of implementing one policy over another, help states to set priorities and appropriate planning horizons, allow for more informed decisions about policy and program design, and ultimately provide regulatory certainty. As such, it has the potential to be a more economical way to address environmental and public health issues than traditional pollutant-by-pollutant approach.[1]

## 1.2. Context for Multi-pollutant Planning

Over the past 15 years, states have been exploring opportunities to integrate clean energy programs into their State Implementation Plans (SIPs) required by the federal Clean Air Act. These efforts have recently escalated due to increases in energy efficiency investments, the prioritization of energy security and climate change, and fiscal constraints. For air regulators, energy efficiency also offers new opportunities as the emission reductions needed to achieve clean air goals become more elusive.

The federal government has also been taking steps to encourage states to explore multi-pollutant planning approaches. In June 2007, the federal Clean Air Act Advisory Committee recommended that governments adopt a comprehensive statewide air quality planning process and move from a single- to a multi-pollutant approach in managing air

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[1] Weiss, L., M. Manion, G. Kleiman, C. James, Building Momentum for Integrated Multipollutant Planning; Northeast States' Perspective. *EM*, May 2007, 25-29.

quality.[2] The U.S. Environmental Protection Agency (EPA) subsequently initiated pilot projects with three jurisdictions to explore ways to approach multi-pollutant planning by developing Air Quality Management Plans (AQMPs).[3] In July 2012, the EPA released its *Roadmap for Incorporating Energy Efficiency/Renewable Energy Policies and Programs into State and Tribal Implementation Plans*. The document builds upon EPA's 2004 guidance on how states may account for energy efficiency (EE) and renewable energy (RE) programs in their SIPs.[4] The Roadmap identifies four pathways: (1) baseline emissions forecast; (2) control strategy quantification; (3) weight-of-evidence; and (4) innovative and emerging measures.[5]

Several states have been investigating and applying existing multi-pollutant planning analytical approaches to help advance the methodology. New York and Massachusetts undertook pilot projects to integrate energy and air quality planning by evaluating energy programs for criteria pollutant co-benefits and multi-sector interactions.[6,7] The city of Detroit, Michigan evaluated potential SIP strategies for ozone, fine particulates, and selected air toxics.[8]

Maryland has been involved in several multi-pollutant planning and analysis exercises in recent years. The Maryland Department of the Environment (MDE) has worked with NESCAUM on various preliminary multi-pollutant assessment exercises to become familiar with available tools. This work was conducted in collaboration with the Maryland Public Service Commission, the Maryland Energy Administration, and the Maryland Department of Natural Resources' Power Plant Research Project.[9] A subsequent exercise focused on greenhouse gas reductions and criteria pollutant co-benefits from a subset of policies contained in the Maryland Greenhouse Gas Reduction Act (GGRA) Plan of 2012.[10] The GGRA requires a state plan to reduce greenhouse gas emissions by 25 percent by 2020.

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[2] Recommendations to the Clean Air Act Advisory Committee: Air Quality Management Subcommittee. Phase II Recommendations, June 2007, available at: http://epa.gov/air/caaac/aqm/phase2finalrept2007.pdf.

[3] See: http://www.epa.gov/air/aqmp/.

[4] See: http://epa.gov/airquality/eere/pdfs/EEREmanual.pdf.

[5] The fourth pathway, innovative and emerging measures, was used as the basis for EPA's 2004 guidance on energy efficiency in SIPs. See: http://www.epa.gov/ttncaaa1/t1/memoranda/ereseerem_gd.pdf.

[6] NESCAUM, Applying the Multi-Pollutant Policy Analysis Framework to New York: An Integrated Approach to Future Air Quality Planning. Prepared for the New York State Energy Research and Development Authority, ST10600, May 2012. See: http://www.nescaum.org/documents/applying-the-multi-pollutant-policy-analysis-framework-to-new-york-an-integrated-approach-to-future-air-quality-planning/.

[7] NESCAUM, How Cost-Effective Energy Efficiency and Renewable Energy Projects Can Help Achieve Northeast Regional Air Quality Goals: An Integrated Assessment for the Commonwealth of Massachusetts, August 2010.

[8] Wesson, K., N. Fann, M. Morris, T. Fox, B. Hubbell, A multi-pollutant, risk-based approach to air quality management: Case study for Detroit, *Atmos Poll Res* 1 (2010), 296–304. See: http://www.atmospolres.com/articles/Volume1/issue4/APR-10-037.pdf.

[9] NESCAUM, Maryland Multi-Pollutant Project; Final NE-MARKAL Calibration for Maryland, March 2011.

[10] NESCAUM, A Multi-Pollutant Planning Approach for Maryland: A Weight-of-Evidence Analytical Exercise for the Maryland Greenhouse Gas Reduction Act Plan. Prepared for Maryland Department of the Environment, November 2012.

## 1.3. Project Goals

This report presents the findings of a multi-pollutant planning exercise MDE initiated in April 2013. The project's goals were to continue to build capacity in Maryland to conduct multi-pollutant planning and analyses as well as inform Maryland's ozone SIP and GGRA Plan Progress Report. Maryland's intention is to use a multi-pollutant framework to look at all pollutants whenever a single pollutant SIP is being developed. It is part of Maryland's preliminary effort to build credit for energy efficiency and renewable energy (EE/RE) programs into the ozone SIP. The requirement for Maryland to submit a SIP for attainment of the 2008 8-hour ozone NAAQS is currently suspended following EPA's determination that the Baltimore area has attained the 2008 8-hour ozone National Ambient Air Quality Standard (NAAQS). This proposed determination is based upon complete, quality-assured, and certified ambient air monitoring data that show the Baltimore area has monitored attainment for the 2012–2014 monitoring period. The multi-pollutant planning exercise is being conducted because this determination does not relieve Maryland from its obligation to submit a SIP if the Baltimore Area returns to non-attainment in the future.

This exercise is part of a larger effort in Maryland to better address some of the uncertainties associated with the SIP and attainment demonstration process, specifically the modeling and future year projections. The uncertainty analysis is currently captured in the SIP process through a weight-of-evidence (WOE) approach. In this context, EPA views WOE as "a supplemental analysis to an attainment demonstration in cases where a jurisdiction is not predicted to attain an air quality standard based on air quality modeling." EPA recommends this as an option to account for EE/RE policies and programs "where a state, tribal or local agency wants to claim emissions benefit that will potentially affect air quality in the attainment year, but where modeling the impacts of the policy or program is either too resource intensive or not feasible for other reasons and/or the jurisdiction is not interested in SIP/TIP credit."[11]

MDE's position is that EPA's approach is a limited construct, and that explicit analyses of uncertainty should be a mandatory element of all SIPs. It hopes that EPA considers this effort more broadly as an "expanded WOE" approach, as it goes beyond what is included in EPA guidance and more explicitly addresses all of the inherent uncertainties of a SIP.

[11] U.S. EPA, Roadmap for Incorporating Energy Efficiency/Renewable Energy Policies and Programs into State and Tribal Implementation Plans, July 2012, pp. 14–15.

# 2. MULTI-POLLUTANT PLANNING IN MARYLAND

## 2.1. Assessing Co-Benefits of EE/RE Programs in Maryland

Since the early 1990s, the MDE has been developing SIPs for ground level ozone, fine particles, and other air pollutants that have led to many regulatory programs to meet Clean Air Act requirements. High profile state regulatory initiatives have included the Maryland Healthy Air Act, which targets power plants, the Maryland Clean Car Program, aimed at mobile source emissions, and numerous point, area, and mobile source control programs developed regionally through the Ozone Transport Commission.

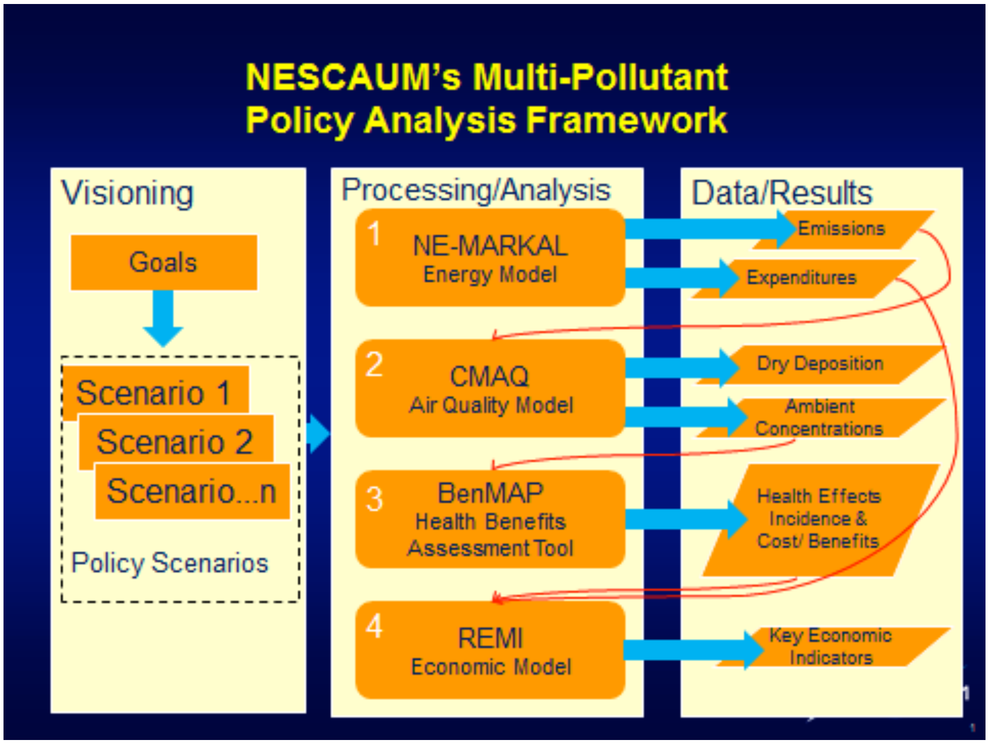
Despite Maryland's efforts, it remains a continuing challenge to attain and maintain the ozone and fine particle National Ambient Air Quality Standards (NAAQS). The State is pursuing efforts on two primary fronts: (1) targeting air pollution that is transported in-state from upwind sources; and (2) implementing effective non-traditional control programs to further reduce local emissions in lieu of traditional command-and-control regulatory drivers. This project examines how one of those non-traditional areas, energy efficiency and renewable energy (EE/RE) programs, can help clean the air and be included and credited within the SIP context. The EE/RE programs are drawn from the GGRA Reduction Act Plan.[12]

## 2.2. The Multi-Pollutant Framework

Maryland's approach to multi-pollutant planning is to reduce emissions through an integrated process that maximizes the co-benefits of reduction policies. This process allows for multi-sector analysis and estimates environmental, public health, economic and energy benefits of policies designed to reduce criteria pollutants, air toxics, and greenhouse gases. The approach, developed by the Northeast States for Coordinated Air Use Management (NESCAUM), is the Multi-pollutant Policy Analysis Framework (MPAF). The MPAF consists of three broad areas of activity: visioning, processing and analysis, and data/results assessment. The process is illustrated in Figure 2-1.

[12] Maryland's Greenhouse Gas Reduction Act Plan, October 2013. See: http://climatechange.maryland.gov/publications/greenhouse-gas-emissions-reduction-act-plan/.

**Figure 2-1. NESCAUM's Multi-Pollutant Policy Analysis Framework**




The framework brings together a series of assessment models, tools, and databases that connect through their data inputs or outputs. The models include:

1. NE-MARKAL, a Northeast version of the MARKet ALlocation (MARKAL) model, an energy model that is widely used in Europe. EPA has a nine-region national version of this model, called US9r;
2. Regional Economic Models, Inc. (REMI), a 12-state model that evaluates the effects of policies and programs on the economies of local regions;
3. EPA's Community Multi-scale Air Quality (CMAQ) model, which assesses future air quality impacts arising from changes in air emissions due to a set of policies and programs;
4. EPA's Environmental Benefits Mapping and Analysis Program (BenMAP), which estimates health impacts and associated monetized values resulting from changes in ambient air pollution.

The centerpiece of the framework is the NE-MARKAL model, an economy-wide energy model that that encompasses the entire energy infrastructure of the Northeast. It is capable of modeling all energy demand and supply in the transportation, commercial, industrial, residential, and power generation sectors to calculate least-cost combinations of energy technologies for achieving a prescribed pollution reduction goal. The model covers 11 states plus the District of Columbia,[13] and characterizes electricity generation, transportation, and the industrial, residential and commercial building sectors over a 30- to 50-year time horizon.

The MPAF allows the user to input the outputs of NE-MARKAL (which are changes in emissions across sectors) into other models that, in turn, can provide output data on potential air quality impacts (through CMAQ) and health benefits (using BenMAP). NE-MARKAL also provides inputs to the REMI economic model, which estimates economic metrics, such as gross state product, jobs, and household disposable income. Such complementary analyses have not been traditionally available to air quality planners.

The MPAF models can also help policymakers evaluate the relative importance of various policies and programs over others by assessing cross-sector impacts (e.g., how transportation programs may affect power plant emissions). It provides data on technology evolution for modeled programs (e.g., how many and what type of electric vehicles would be needed to achieve a certain emissions reduction goal). This type of specific information on program characteristics can be very helpful to state agencies in designing future regulatory programs.

For more information on the models within MPAF, see Appendices A through E.

## 2.3. Multi-Pollutant Planning Process

Starting in May 2013, MDE worked with NESCAUM, Towson University's Regional Economic Studies Institute, and the University of Maryland at College Park to conduct a multi-pollutant analysis with updated assumptions from the Greenhouse Gas Reduction Act Plan of 2012. This effort took approximately 18 months, which is consistent with other SIP planning and analytical exercises.

A subset of policies listed in the GGRA Plan was analyzed that were best suited to the NE-MARKAL model capabilities, specifically programs that affect the power generation and motor vehicle sectors as well as residential and commercial energy efficiency. The policies selected by MDE were:

- Regional Greenhouse Gas Initiative
- Maryland Renewable Portfolio Standard Program
- EmPOWER Maryland Energy Conservation Program
- Main Street Initiatives
- Energy Efficiency for Affordable Housing
- Maryland Clean Car Program
- Corporate Average Fuel Economy Standards for Model Years 2008 through 2011 for Light-duty Passenger Cars and Trucks
- Fuel Efficiency for Medium-and Heavy-duty Trucks
- Public Transportation and Intercity Transportation Initiatives

[13] The jurisdictions covered in the NE-MARKAL model include: Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

- Gasoline Tax
- Federal Tier 3 Motor Vehicle Emission and Fuel Standards
- Building and Trade Codes

NESCAUM characterized, quality assured, and simulated the policies in the NE-MARKAL energy model. The data derived from NE-MARKAL simulations were then used as inputs to other MPAF models: University of Maryland College Park processed and incorporated NE-MARKAL outputs into the CMAQ model to assess air quality impacts of the selected policies; NESCAUM input the CMAQ results into BenMAP to assess health impacts associated with the policies. The Regional Economic Studies Institute of Towson University used selected outputs from NE-MARKAL to examine economic effects using the REMI model.

Two key GGRA Plan policies—Leadership by Example and Maximum Achievable Control Technology Standards for Boilers (Boiler MACT)—were not analyzed in NE-MARKAL but were incorporated into the other MPAF analyses. Additional refined simulations, called sensitivity analyses, were also conducted using NE-MARKAL to further inform the analysis.

## 2.4. Context and Caveats

In the context of using multi-pollutant analyses to support the ozone SIP and GGRA Plan in a weight-of-evidence approach, there are inherent limitations, as is typical in most modeling systems. The following focuses on the NE-MARKAL model, as it is an energy model that is new to air quality planners, and serves as the centerpiece of the MPAF. Notwithstanding its limitations, NE-MARKAL and the full complement of the MPAF models provide a set of tools for decision-makers to assess the relative benefits of environmental policies and programs at a high level of detail at the state level.

The NE-MARKAL model is not an energy forecasting tool. It is designed to explore implications of implementing possible future energy policies and programs collectively (referred to as a meta-scenario). The NE-MARKAL modeling relies on a calibrated "reference case" against which those possible future energy policies are tested and compared. The reference case is not a prediction of future events absent major policy changes. Rather, it reflects one projection based on reasonable assumptions about energy and air emissions trends in Maryland. A simulation modeled by NE-MARKAL explores the projected changes arising from a given energy policy relative to the reference case. When modeled, these simulations are influenced by changes to the reference assumptions and other system constraints that reflect various policy choices.

Each modeled simulation projects technology shifts, costs, and emissions. The results are shaped by the data bases used and the assumptions or constraints placed on the model. The assumptions used in calibrating the reference case for the analyses are based on what the MDE and the Maryland Energy Administration agreed to as the most likely plausible future outcome at a specified point in time. NESCAUM compared the initial NE-MARKAL reference case energy consumption trends, by sector, to the U.S. Department of Energy's (DOE's) Annual Energy Outlook (AEO) 2012 forecast, and made appropriate updates and refinements. The simulations run for this exercise examined how various system constraints, representing policies and programs, would change that plausible future outcome in response to those changes.

Another important caveat in applying these tools is that the modeling results are constrained by the underlying data. In some cases, the limitations are inherent to the availability of data. In other cases, they may be due to the quality of the data. Understanding such limitations is important in terms of placing the results in context. Details on how the policies and meta-scenario were constrained and simulated in NE-MARKAL are presented in Appendix A.

The technology shifts projected by the model do not reflect individual or societal behavior associated with risk aversion or consumer preferences. To address these issues, the model can be constrained in a manner to more realistically represent future technology trends. Input by experts knowledgeable in such trends is important to ensure that the modeled assumptions and constraints are reasonable and appropriate for purposes of a given policy analysis.

In the NE-MARKAL framework, the decision-making objective is to minimize the total discounted cost of the energy system over the modeling horizon. Its strength is in exploring the relative cost effectiveness of meeting various policy goals, such as limits on carbon dioxide ($CO_2$) emissions from power generation or performance requirements on vehicles, based on total system cost. Total system cost is an internal accounting and decision-making criteria used within the NE-MARKAL modeling framework to choose between the alternative portfolios of energy sources and technologies represented in the NE-MARKAL database. The total system cost in the NE-MARKAL framework includes the following components:

- Annualized investments in technologies;
- Fixed and variable operations and maintenance of technologies;
- Cost of energy imports and domestic energy production;
- Revenue from energy exports;
- Energy costs;
- Taxes and subsidies associated with energy sources, technologies, and emissions.

NE-MARKAL does not directly estimate macroeconomic effects of introducing various programs, but within the MPAF, certain components of the projected optimized total system costs and savings can be used as inputs into the regional economic model.

# 3. THE MULTI-POLLUTANT WEIGHT-OF-EVIDENCE EXCERCISE

## 3.1. Energy Use and Emissions Changes: NE-MARKAL Results

### *3.1.1. Introduction*

This section presents the NE-MARKAL energy use and emissions modeling results for the multi-pollutant exercise. Working with MDE staff, NESCAUM populated the NE-MARKAL model with Maryland-specific data as appropriate and then calibrated the model through sensitivity analyses and quality assurance/quality control efforts. NESCAUM and MDE then identified and developed policies that were modeled within two meta-scenarios. Appendix A details the core input assumptions for the NE-MARKAL model, how the specific policies and meta-scenarios were developed, and the data sets on which the policies were based.

### *3.1.2. Approach*

NE-MARKAL is the Northeast-specific version of the economy-wide MARKet ALlocation (MARKAL) energy systems model, representing the energy infrastructure of the northeastern U.S. NE-MARKAL models energy demand and supply in the power generation, commercial, industrial, residential, and transportation sectors. NE-MARKAL currently includes the six New England states, New York, New Jersey, Pennsylvania, Delaware, Maryland, and Washington, D.C. Key inputs to the model include energy demand, emission factors for GHGs and criteria air pollutants, and the operational and economic characteristics of all technologies critical to characterizing energy supply and demand.

In the NE-MARKAL modeling framework, the energy infrastructure is configured to meet estimated energy demand using the most cost-effective technologies and fuel sources. The model can be configured to represent enforceable requirements as well as incentives, such as energy efficiency programs, carbon mitigation strategies, and vehicle performance standards. The NE-MARKAL model currently begins in 2005 and models state and regional energy decision-making out to 2053 in three year time increments. For the core GGRA analysis, the modeling timeframe ranged between the years 2008 and 2023. For the climate sensitivity analysis, however, the timeframe was extended to 2050. Modeled outcomes from NE-MARKAL include: GHG and criteria pollutant emissions, energy consumption, and a variety of cost metrics.

For this analysis, the reference case NE-MARKAL energy calibration was accomplished in two phases. The first phase focused on aligning energy consumption in NE-MARKAL with observed historical trends between 2005 and 2011. This phase was executed by fixing NE-MARKAL energy consumption trends by sector and fuel type to Maryland-specific data reported in the EIA State Energy Data System (SEDS). The second phase focused on developing future NE-MARKAL reference case energy consumption trends by sector and fuel type. The first step in the second phase was to develop a set of benchmark future energy consumption trends that NE-MARKAL could be calibrated to. The benchmark energy consumption trends were constructed by applying AEO 2012 energy consumption growth rates by sector and fuel for the 2011-2023 period to the SEDS data used in the first phase of the energy calibration. Having established the benchmark energy consumption trends, a series of soft constraints were created in NE-MARKAL to ensure that the model's reference case energy consumption trends matched the main features of the AEO 2012 reference case. A detailed presentation of the energy calibration is found in section A.4.

There are a number of important caveats to keep in mind when assessing modeled NE-MARKAL results. (1) NE-MARKAL is best suited for "what-if" exploratory analyses of climate and air quality policies that probe a variety of possible technological and resource outcomes; the modeled results do not represent simulation-based forecasts of future energy, technology, and emissions trends. (2) NE-MARKAL is focused on a region's energy infrastructure and as such is best suited to assess policies aimed at technology and resource choices in this domain. The model is not well suited, for example, to assess policies aimed at land-use, agriculture, or waste management practices. (3) The electricity sector in NE-MARKAL uses a simplified load duration curve representation that breaks a typical year into six aggregate time-slices. This precludes analysis of policies aimed at affecting peak-generation resources and other scenarios aimed at shifting short-term load.

### *3.1.3. Policy and Meta-scenario Descriptions*

As a first step, NESCAUM worked with MDE to select policies for analysis from the GGRA Plan of 2012 that were of key interest from a policy perspective and were most appropriate for characterizing in the NE-MARKAL model. The next step was to characterize the selected policies in NE-MARKAL and appropriately calibrate them. After the policies were finalized, two meta-scenarios were developed and analyzed.

The multi-pollutant analysis was based on an initial and an enhanced meta-scenario. Each meta-scenario combined all of the selected policies into a single NE-MARKAL run that captured their interactive effects. The initial meta-scenario was comprised of selected policies as they were defined in the GGRA Plan of 2012. The enhanced meta-scenario was comprised of a combination of individual policies, some of which had enhanced goals defined either in the GGRA Plan or by MDE. Initial and enhanced policy definitions were provided either in the GGRA Plan or by MDE.

Table 3-1 summarizes the initial and enhanced meta-scenarios, and Table 3-2 summarizes which policies are contained in the two meta-scenarios, with "I" denoting initial policies and "E" denoting enhanced policies. The scenarios highlighted in blue font, collectively referred to as the transportation bundle, remained at initial levels in both the initial and enhanced meta-scenarios.

## Table 3-1. Initial and Enhanced Policy Definitions

| Policy | Definition |
|---|---|
| **RGGI** | • **Initial GGRA**: model the RGGI cap before the updated model rule.<br>• **Enhanced GGRA**: model the 91 MT updated model rule cap (using scenario: 91cap alt bank MR). |
| **EmPOWER Maryland** | • **Initial GGRA**: reduce MD per capita total electricity consumption 15% by 2015 relative to 2007; represented as an energy efficiency program.<br>• **Enhanced GGRA**: expand energy efficiency to include natural gas |
| **MD RPS** | • **Initial GGRA**: require 20% qualified renewable generation regionally by 2022--only solar required in-state; the rest can come from the region.<br>• **Enhanced GGRA**: require 25% qualified renewable generation regionally by 2020.<br>• **For both scenarios**: (1) Tier 2 hydro to remain constant at 2.5% until 2018, and then sunset; (2) 2% solar by 2020. |
| **Main Street Initiatives** | • **Initial GGRA**: defined using the analysis of the low potential for energy efficiency provided by MDE.<br>• **Enhanced GGRA**: defined using the analysis of the high potential for energy efficiency provided by MDE |
| **Energy Efficiency for Affordable Housing** | • **Initial GGRA**: Use methodology on pp. 115-116 of the GGRA Plan at $6,500 per retrofit.<br>• **Enhanced GGRA**: Use methodology on pp. 115-116 of the GGRA Plan at $5,268 per retrofit. |
| **CAFE Model Year 2008-2011** | • **Initial GGRA**: NHTSA's pre-existing 2008-2011 fuel efficiency standards of 20.5 mpg.<br>• No enhanced scenario. |

## Table 3-1. Continued

| Policy | Definition |
|---|---|
| **MD Clean Cars Program** | • **Initial GGRA**: For model years 2012-2025: assume passenger fleet achieves most recent CAFE standards (~54.5 mpg by 2025).<br>• No enhanced scenario. |
| **National Fuel Efficiency and Emissions Standards for Medium- and Heavy-Duty Trucks** | • **Initial GGRA**: EPA/NHTSA standards for model years 2012-2016 for medium- and heavy-duty trucks.<br>• Standard does not sunset after 2016.<br>• No enhanced scenario. |
| **Public Transportation and Intercity Transportation Initiatives** | • **Initial GGRA**: Assume 2.3% of Maryland's passenger vehicle fleet will be composed of BEVs and PHEVs by 2020.<br>• No enhanced scenario |
| **Building and Trade Codes** | • **Initial GGRA**: Commercial and residential buildings to increase energy efficiency by 15%, starting in 2012.<br>• No enhanced scenario. |
| **Gas Tax** | • **Initial GGRA**: Based on the documentation sent by MDOT, apply a gas tax of $0.27 per gallon.<br>• **Enhanced GGRA**: Based on the documentation sent by MDOT, apply a gas tax of $1.20 per gallon. |
| **Tier 3** | • **Initial GGRA:** Adopt new SO2, NOx, and PM standards for motor gasoline beginning in 2017.<br>• No enhanced scenario. |

## Table 3-2. Meta-scenario Definitions

| | Scenario Definitions | |
|---|---|---|
| **Policy** | **Initial Meta-scenario** | **Enhanced Meta-scenario** |
| Regional Greenhouse Gas Initiative | I | E |
| Maryland Renewable Portfolio Standard | I | E |
| EmPOWER Maryland | I | E |
| Main Street | I | E |
| Energy Efficiency for Affordable Housing | I | E |
| **Maryland Clean Cars** | **I** | **I** |
| **CAFE 2008-2011** | **I** | **I** |
| **Fuel Efficiency for Medium and Heavy Duty Trucks** | **I** | **I** |
| **Public Transportation and Intercity Transportation Initiatives** | **I** | **I** |
| **Tier 3 Vehicle and Emission Standards** | **I** | **I** |
| Gas Tax | I | E |
| Building and Trade Codes | I | I |

### *3.1.4. Modeled Energy Use Changes*

NE-MARKAL modeling results were generated in three-year time intervals, from 2008 to 2023. All meta-scenario results should be considered relative to the reference case. In the figures, "tBTU" stands for trillion British Thermal Units, "LPG" refers to liquefied petroleum gas, and "E85" is a fuel blend comprised of 85 percent ethanol and 15 percent gasoline. For this analysis, "biomass" refers to dedicated biomass-electric generating plants; it does not include disaggregated wood burning for residential heating or in outdoor wood-fired boilers.

## Buildings Sector

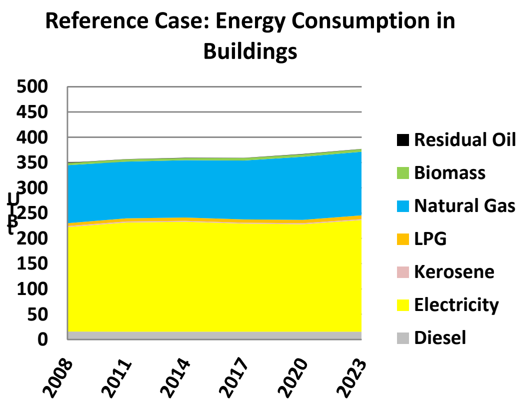
The results of the buildings sector are presented first, as they help establish the energy efficiency-related basis for some of the load reduction and fuel switching that is observed in the power sector (presented in the next section).

In this analysis, the buildings sector refers collectively to residential and commercial buildings. The individual GGRA Plan policies targeted at the buildings sector are: EmPOWER Maryland, Main Street, Energy Efficiency for Affordable Housing, and Building and Trade Codes. These policies are intended to increase adoption of energy efficient technologies and practices in residential and commercial buildings, and most of them are aimed at electrical end-uses.

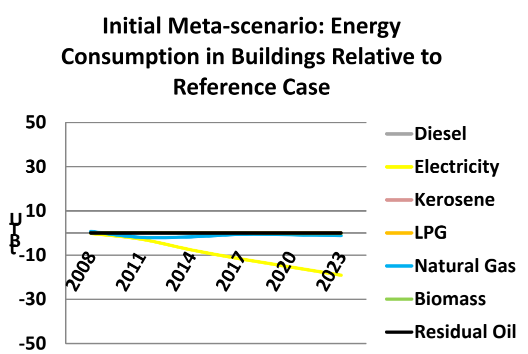
In the initial meta-scenario, only the Energy Efficiency for Affordable Housing policy is aimed at residential natural gas efficiency. Natural gas efficiency plays a larger role in the enhanced meta-scenario, as the EmPOWER Maryland policy was expanded in that context to include greater potential for natural gas efficiency in heating applications.

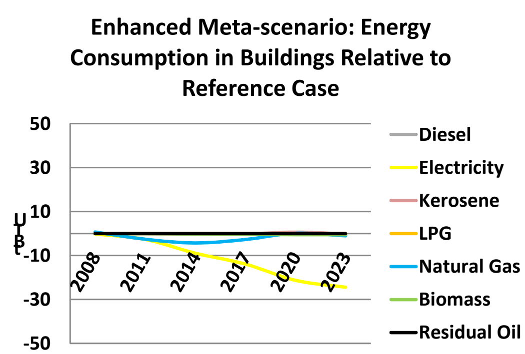
Figure 3-1 summarizes the buildings sector energy consumption trends in the reference case and in each of the meta-scenarios relative to the reference case. The chart in the upper left presents the reference case energy consumption trends by fuel type. The bottom two charts show changes in energy consumption relative to the reference case for each meta-scenario. The table in the upper right summarizes the cumulative change in energy consumption relative to the reference case for each meta-scenario.

**Figure 3-1. Buildings Sector Energy Results**




| Cummulative Change 2008-2023 (tBTU) | Initial | Enhanced |
|---|---|---|
| Diesel | -2 | -5 |
| Electricity | -170 | -214 |
| Kerosene | -1 | 0 |
| LPG | 0 | 0 |
| Natural Gas | -17 | -30 |
| Biomass | -2 | -5 |
| Residual Oil | 0 | 0 |
| Total | -192 | -254 |
| Total % Diff | -2.9% | -3.9% |




In both the initial and enhanced meta-scenarios, there is a decline in overall electricity consumption in buildings. Relative to the reference case, cumulative electricity consumption declines by 4.4 percent and 5.6 percent, respectively. The electrical energy efficiency targets in the EmPOWER Maryland scenario are the primary drivers of the decreases, although each of the other buildings-related policies included in the meta-scenarios also have small electrical efficiency components.

A secondary result, observed in both meta-scenarios, is a smaller decline in natural gas consumption relative to electricity. In the initial meta-scenario, cumulative natural gas consumption decreases by 0.8 percent, and in the enhanced meta-scenario, cumulative natural gas consumption in buildings decreases by 1.4 percent. There are also smaller decreases in energy consumption for other fossil fuels. The smaller decreases for other fuels are associated with components of the Main Street Initiative that focus on heating and end-use efficiency (rather than the electrical or other fuel-specific efficiency provisions of the policy).

On an overall net energy basis, modeled energy consumption decreases in buildings by 2.9 percent in the initial meta-scenario and by 3.9 percent in the enhanced meta-scenario.

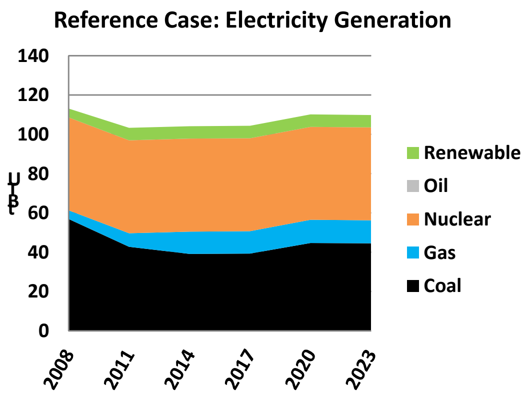
## Power Sector

The GGRA Plan policies targeted at the power sector that were included in this analysis are the Regional Greenhouse Gas Initiative (RGGI) and the Maryland Renewable Portfolio Standard (RPS). The buildings sector policies that act to reduce electricity consumption through efficiency targets also have a significant impact on power sector outcomes. Generally, the load reductions associated with energy efficiency account for the largest impacts on power sector electricity generation trends in both the initial and enhanced meta-scenarios. The in-state impacts of the RPS are modest, based on the estimated in-state potential for renewable development. However, the impacts of renewable development on electricity generation trends are noticeably different in the initial and enhanced meta-scenarios. The RGGI policy is binding only in the enhanced meta-scenario, as slower-than-expected macro-economic trends and low natural gas prices have the combined effect of keeping the reference case $CO_2$ levels below the RGGI cap level that was modeled in the initial meta-scenario.

Figure 3-2 summarizes the power sector electricity generation trends in the reference case and in each of the meta-scenarios relative to the reference case. The chart in the upper left presents the reference case electricity generation by fuel type. The bottom two charts show changes in electricity generation (relative to the reference case) for each of the meta-scenarios. The table in the upper right summarizes the cumulative change in electricity generation relative to the reference case for each meta-scenario by fuel type.

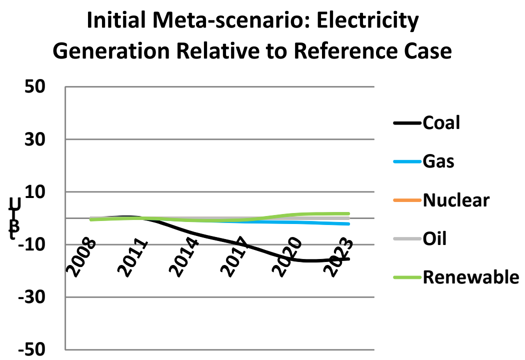
In the initial and enhanced meta-scenarios, there is a switch away from coal-fired generation. Relative to the reference case, cumulative electricity generation from coal declines by 17.8 and 23.4 percent, respectively. These declines are primarily associated with the load reduction impacts of the energy efficiency targets that were modeled in the buildings sector. Efficiency-related load reduction has a smaller impact on natural gas generation trends in the initial meta-scenario that is directionally consistent with coal. In the enhanced meta-scenario, natural gas generation declines more aggressively in the later modeling years, as the RPS policy becomes more stringent and requires a larger share of in state-renewable development, relative to other fossil fuels. On an overall net energy basis, modeled electricity generation decreases by 8.1 percent in the initial meta-scenario and by 10.6 percent in the enhanced meta-scenario.

**Figure 3-2. Power Sector Electricity Generation Energy Results**




Cummulative Change 2008-2023 (tBTU)

| | Initial | Enhanced |
|---|---|---|
| Coal | -143 | -188 |
| Gas | -18 | -45 |
| Nuclear | 0 | 0 |
| Oil | 0 | 0 |
| Renewable | 4 | 27 |
| Total | -157 | -205 |
| Total % Diff | -8.1% | -10.6% |



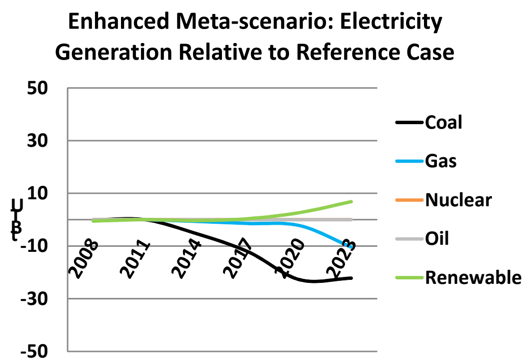
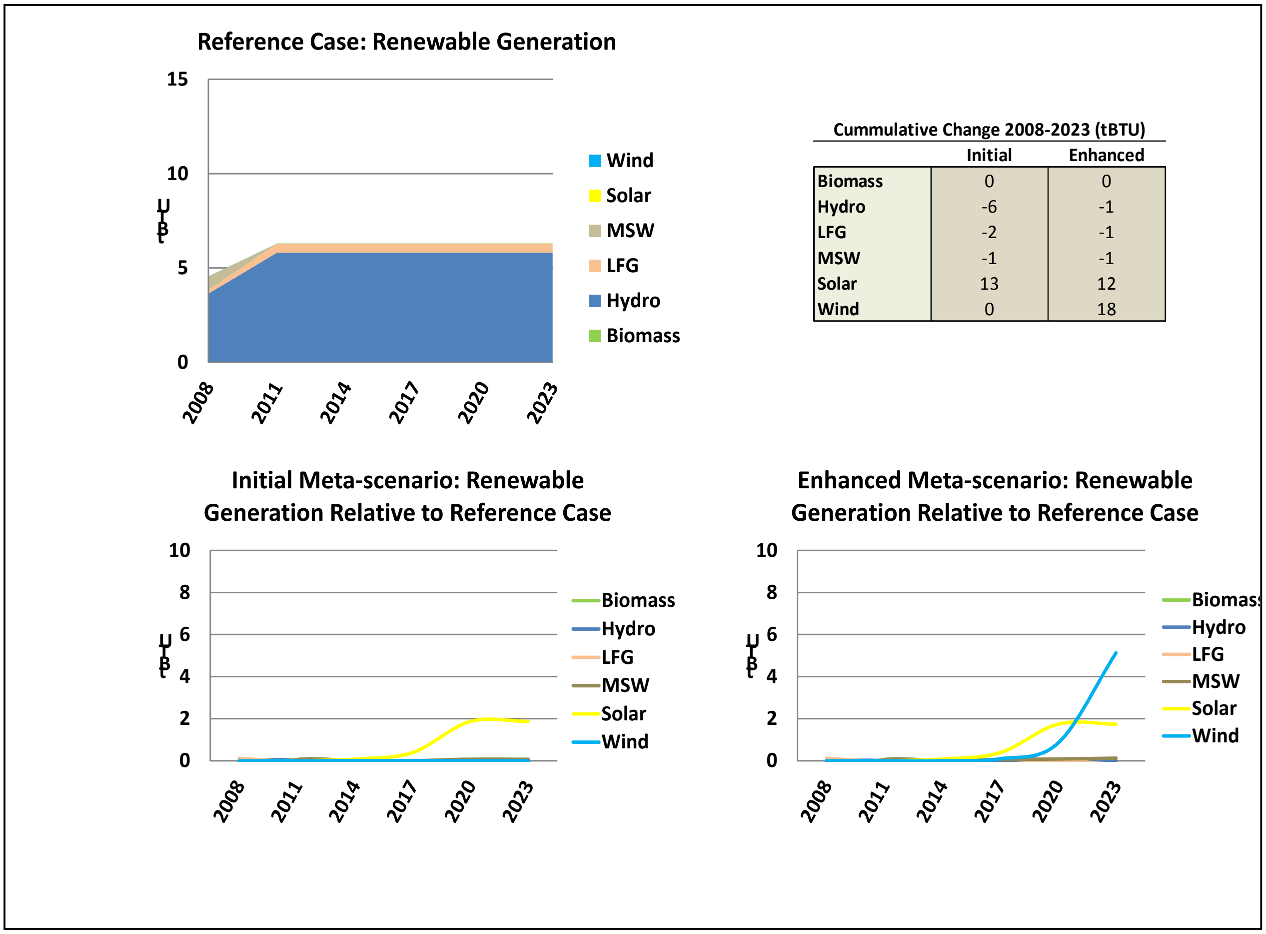




Figure 3-3 summarizes in-state renewable power generation by resource type. The chart in the upper left presents the reference case renewable electricity generation by resource type. The bottom two charts present changes in renewable electricity generation relative to the reference case for each of the meta-scenarios. The table in the upper right summarizes the cumulative change in renewable electricity generation relative to the reference case for each meta-scenario.

Figure 3-3 highlights the impact of the Maryland RPS on in-state renewable generation. Estimates for in-state renewable potential were derived from sources provided by the MDE and Maryland Energy Administration (MEA).[14] In the initial meta-scenario, the only aspect of the RPS that necessitates increased deployment of renewable technologies is the state solar carve-out. The solar carve-out requires that 2 percent of total generation comes from solar photovoltaic sources by 2020. This requirement remained the same for both the initial and enhanced meta-scenarios. In the enhanced meta-scenario, the cumulative in-state development of wind resources increased by 6 tBTU, which is roughly equivalent to 200 megawatts. This is a result of increasing both the RPS requirement to 25 percent renewable generation by 2020 and in-state potential for wind development from 2.3 percent to 3.5 percent by 2020.

[14] Personal communication from Christopher Beck, MDE, on April 1, 2014.

**Figure 3-3. Renewable Generation Energy Results**




Cummulative Change 2008-2023 (tBTU)

| | Initial | Enhanced |
|---|---|---|
| Biomass | 0 | 0 |
| Hydro | -6 | -1 |
| LFG | -2 | -1 |
| MSW | -1 | -1 |
| Solar | 13 | 12 |
| Wind | 0 | 18 |

## Transportation Sector

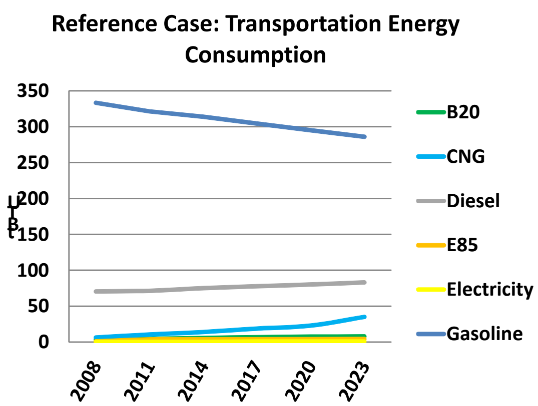
The GGRA Plan policies targeted at the transportation sector and included in this analysis are: Maryland Clean Cars, Corporate Average Fuel Economy standards for model years 2008 through 2011 for light-duty passenger cars and trucks (CAFE 2008–2011), Fuel Efficiency for Medium and Heavy-Duty Trucks, Public Transportation and Intercity Transportation Initiatives, Tier 3 Motor Vehicle Emission and Fuel Standards, and Maryland State Gas Tax. Of these policies, only the Gas Tax was modified for the enhanced the meta-scenarios; the other policies remained constant for both meta-scenarios.

Figure 3-4 summarizes the transportation sector energy consumption trends in the reference case and in each of the meta-scenarios relative to the reference case. The chart in the upper left presents the reference case energy consumption by fuel type. The bottom two charts present changes in energy consumption relative to the reference case for each of the meta-scenarios. The table in the upper right summarizes the cumulative change in energy consumption relative to the reference case for each meta-scenario.

Both the initial and enhanced meta-scenarios show a decline in overall motor gasoline consumption relative to the reference case by 1.6 and 2.1 percent, respectively. The advanced 54.5 miles per gallon (mpg) CAFE target in the Maryland Clean Cars policy is the primary driver of the decreases in gasoline consumption in both meta-scenarios.

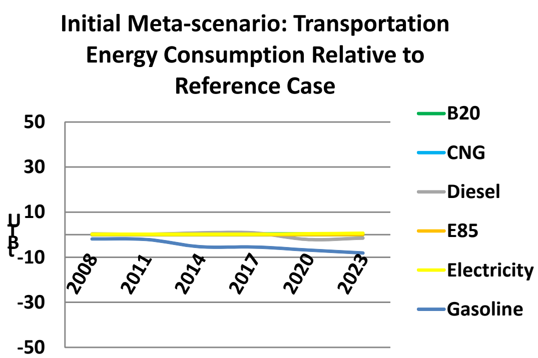
Another observed result is an increase in transportation electricity consumption in both meta-scenarios. The Public Transportation and Intercity Transportation Initiatives assume that 2.3 percent of Maryland's passenger vehicle fleet will be comprised of battery electric vehicles and plug-in hybrid electric vehicles by 2020. The Maryland State Gas Tax has an additional incremental effect in the enhanced meta-scenario, causing cumulative gasoline consumption to decrease by an additional 9 tBTU. On an overall net energy basis, modeled transportation energy consumption decreases by 1.1 percent in the initial meta-scenario and by 1.6 percent in the enhanced meta-scenario.

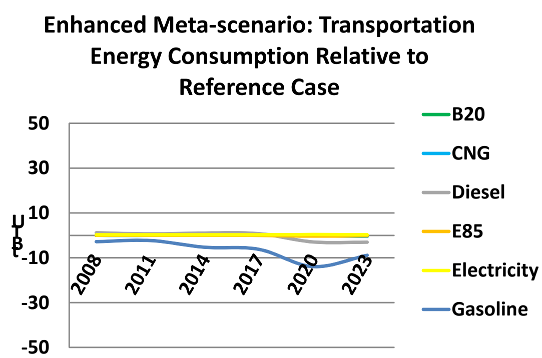
**Figure 3-4. Transportation Sector Energy Results**




Cummulative Change 2008-2023 (tBTU)

| | Initial | Enhanced |
|---|---|---|
| B20 | 0 | 0 |
| CNG | 4 | 1 |
| Diesel | -5 | -7 |
| E85 | 0 | -2 |
| Electricity | 6 | 5 |
| Gasoline | -90 | -118 |
| Total | -85 | -121 |
| Total % Diff | -1.1% | -1.6% |




## *3.1.5. Modeled Emissions Changes*

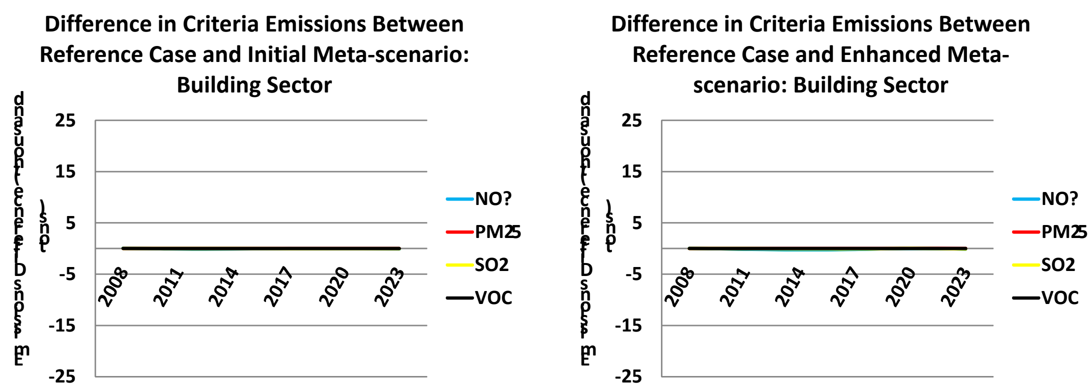
This section describes the modeled emissions changes across energy sectors from each of the meta-scenarios. Emissions indicators included nitrogen oxides ($NO_X$), fine particulate matter ($PM_{2.5}$), sulfur dioxide ($SO_2$), and volatile organic compounds (VOCs) for criteria pollutants, and $CO_2$ for greenhouse gases. The criteria pollutant carbon monoxide (CO) was included for the transportation sector only. NE-MARKAL modeling results were generated from 2008 to 2023. All meta-scenario results should be considered relative to the reference case. For this analysis, "biomass" refers to dedicated biomass-electric generating plants; it does not include disaggregated wood burning for residential heating or in outdoor wood-fired boilers.

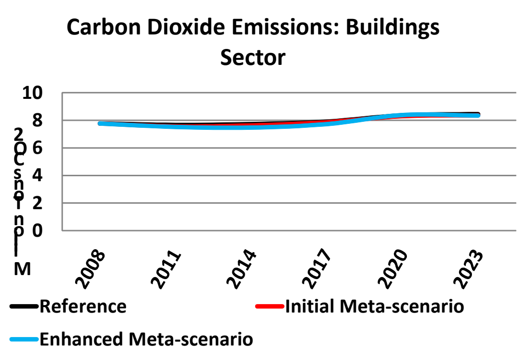
## Buildings Sector

Figure 3-5 summarizes the modeled buildings sector emissions trends for each meta-scenario relative to the reference case. The top two charts present changes in criteria emissions relative to the reference case for the two meta-scenarios. The bottom left chart presents $CO_2$ emissions trends for the reference case and the meta-scenario. The table in the lower right summarizes cumulative changes in all emissions indicators relative to the reference case for each meta-scenario.

There are few observed emissions changes in the buildings sector for either meta-scenario. The primary energy-related effect of the modeled buildings sector policies was to reduce electricity demand through energy efficiency and conservation, which does not have direct emissions implications in the buildings sector, per se. In the enhanced meta-scenario, where natural gas efficiency is expanded, small decreases are observed in $CO_2$ and $NO_X$.

**Figure 3-5. Building Sector Emissions Results**




Cummulative Change 2008-2023 (kt)

| | Initial | Enhanced |
|---|---|---|
| CO2* | -1 | -2 |
| NO? | -1 | -2 |
| PM25 | 0 | 0 |
| SO2 | 0 | -1 |
| VOC | 0 | 0 |

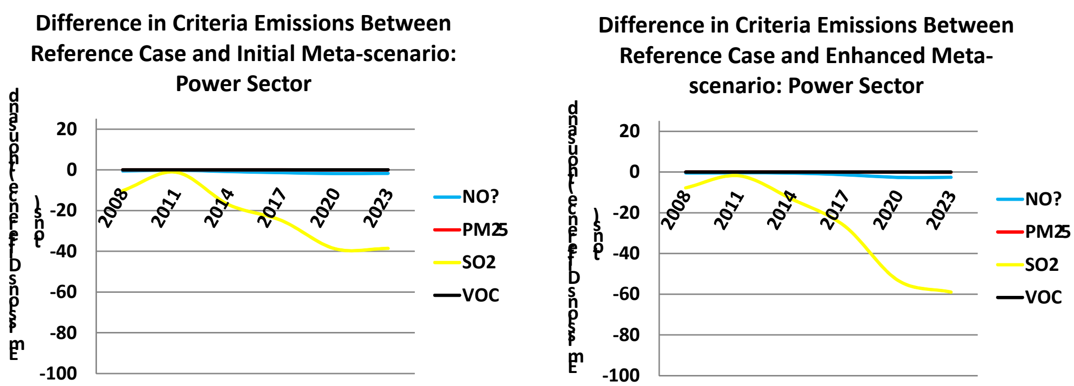
* CO2 in Million Tons

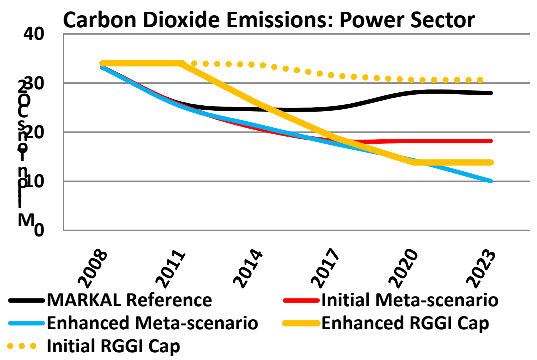
## Power Sector

Figure 3-6 summarizes the modeled power sector emissions trends for the meta-scenarios relative to the reference case. The top charts examine changes in criteria emissions. The bottom left chart presents modeled $CO_2$ emissions trends in the reference case and for the meta-scenarios; the initial and enhanced RGGI caps are displayed as dotted and unbroken yellow lines, respectively, to provide reference. The table in the lower right summarizes the cumulative change in all emissions indicators relative to the reference case for the two meta-scenarios.

There is a significant reduction in $SO_2$ emissions for both meta-scenarios. Relative to the reference case, cumulative $SO_2$ emissions decline by 131,000 tons by 2023 in the initial meta-scenario and by 162,000 tons by 2023 in the enhanced meta-scenario. These effects are likely due to efficiency-related load reductions induced by the suite of building efficiency measures in the EmPOWER Maryland policy playing a large role in driving coal-fired generation down. In the enhanced meta-scenario, RGGI plays a role, albeit modest, in driving coal generation down further; this is seen in the additional $SO_2$ and $CO_2$ reductions. The significant decline in coal-fired generation also has a marked impact on $CO_2$ emissions. Relative to the reference case, cumulative $CO_2$ emissions decline by 16 million tons in the initial meta-scenario and by 20 million tons in the enhanced meta-scenario. The RPS policy plays a role in driving natural gas generation down in each meta-scenario, as renewable targets shift the generation mixes towards wind and solar generation. However, relative to the efficiency-related changes in coal generation, changes in natural gas generation in each meta-scenario have marginal impacts on climate and criteria pollutant emissions.

**Figure 3-6. Power Sector Emissions Results**




Cummulative Change 2008-2023 (kt)

| | Initial | Enhanced |
|---|---|---|
| CO2* | -47 | -61 |
| NO? | -20 | -24 |
| PM25 | -1 | -1 |
| SO2 | -393 | -485 |
| VOC | 0 | 0 |

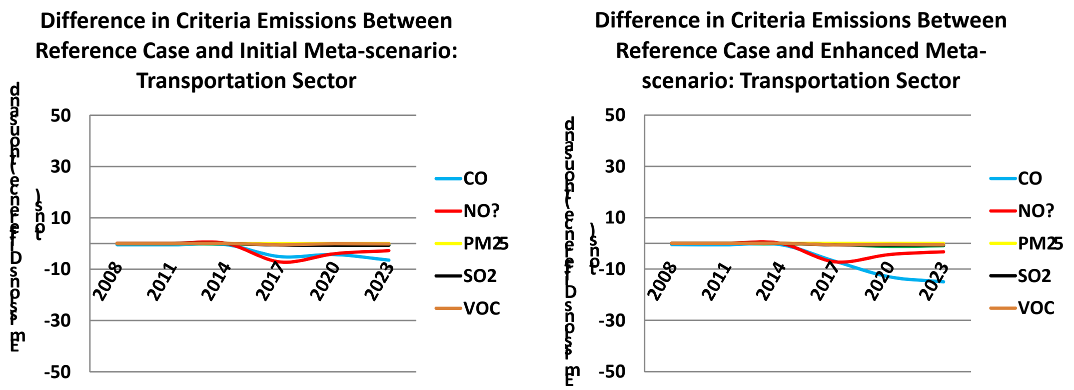
* CO2 in Million Tons

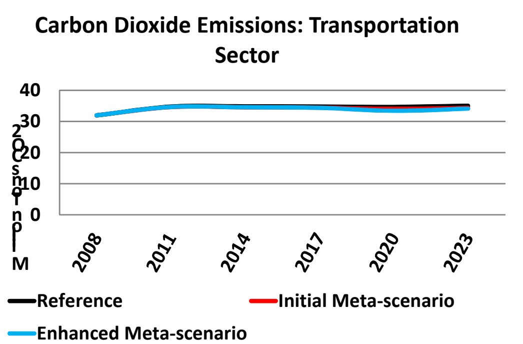
## Transportation Sector

Figure 3-7 summarizes the modeled transportation sector emissions trends for the meta-scenarios relative to the reference case. The top two charts show changes in criteria emissions, and the chart on the bottom left presents $CO_2$ emissions trends. The table on the lower right summarizes cumulative changes in all emissions indicators.

With the exception of CO, overall cumulative changes in criteria emissions are similar for both meta-scenarios. The largest cumulative change in criteria pollutant emissions is observed for $NO_X$, which decreases by 14 million tons in the initial meta-scenario and 15 million tons in the enhanced meta-scenario by 2023. Both $PM_{2.5}$ and $SO_2$ emissions decline by the same amount in each of the meta-scenarios. The primary drivers for these criteria emissions changes are the Tier III Vehicle and Emissions Standards and the advanced 54.5 mpg CAFE targets in the Maryland Clean Cars policy, (which are defined identically in the initial and enhanced meta-scenarios). The Maryland Gas Tax enhancements (introduced in the enhanced meta-scenario), drives the incremental differences between the initial and enhanced scenarios for both criteria emissions and $CO_2$.

**Figure 3-7. Transportation Sector Emissions Results**




Cummulative Change 2008-2023 (kt)

| | Initial | Enhanced |
|---|---|---|
| CO2* | -7 | -9 |
| CO | -52 | -110 |
| NO? | -42 | -44 |
| PM25 | 0 | 0 |
| SO2 | -6 | -6 |
| VOC | -2 | -5 |

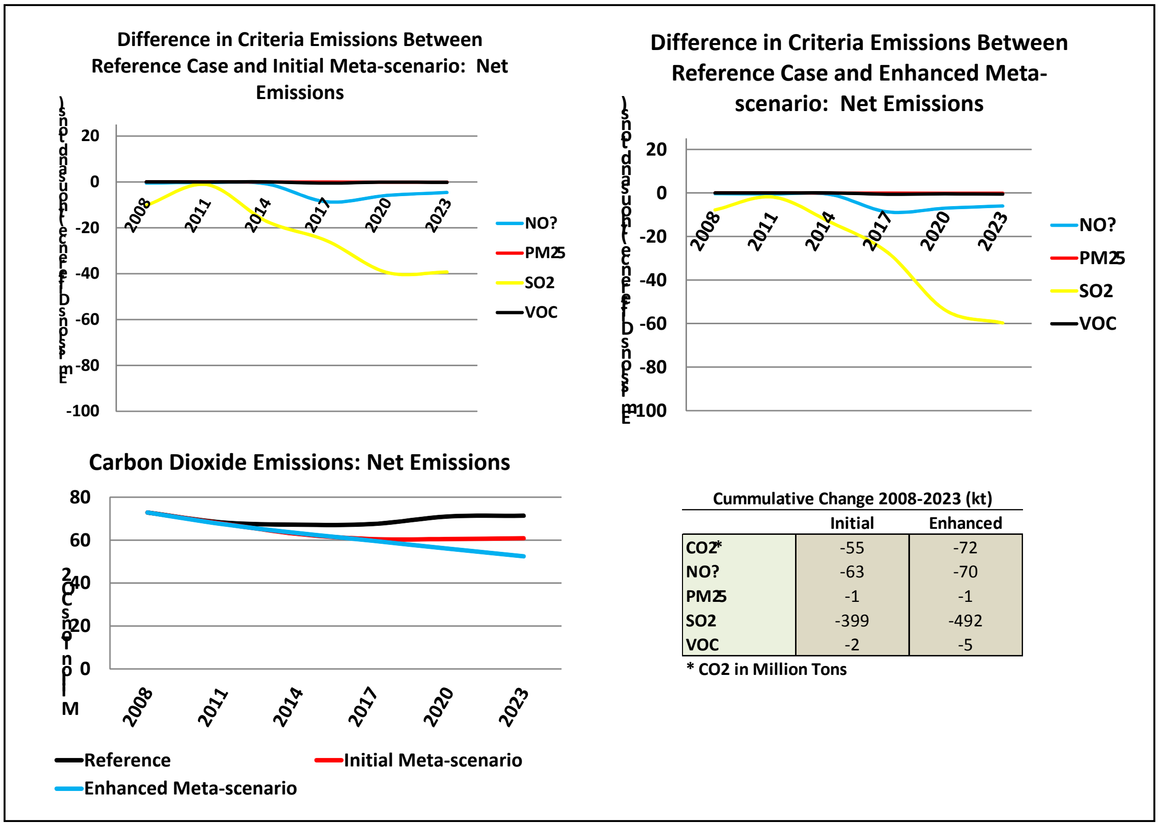
* CO2 in Million Tons

## Net Emissions

Figure 3-8 summarizes the modeled net emissions trends for each meta-scenario relative to the reference case. The top two charts examine changes in criteria emissions and the chart on the bottom left presents $CO_2$ emissions trends. Finally, the table in the lower right summarizes the cumulative change in net emissions for all emissions indicators relative to the reference case for each meta-scenario.

Changes in net emissions are the sum of emissions changes from the power, buildings and transportation sectors of the NE-MARKAL model. As a result, the trends in Figure 3-8 follow directly from the emissions trends presented in Figure 3-5 through Figure 3-7. On a cumulative basis, the largest observed changes in criteria emissions are in $SO_2$ and $NO_X$. Relative to the reference case, $SO_2$ emissions decline by 133,000 tons in the initial meta-scenario and by 164,000 tons in the enhanced meta-scenario by 2023. $NO_X$ emissions decline by 21,000 tons in the initial meta-scenario, and by 23,000 tons in the enhanced meta-scenario by 2023. The cumulative change in VOCs and $PM_{2.5}$ relative to the reference is less than 1.25 percent in each meta-scenario. Cumulative $CO_2$ emissions decline by 18 million tons in the initial meta-scenario, and by 24 million tons in the enhanced meta-scenario.

**Figure 3-8. Net Emissions Results**




| | Initial | Enhanced |
|---|---|---|
| CO2* | -55 | -72 |
| NO? | -63 | -70 |
| PM25 | -1 | -1 |
| SO2 | -399 | -492 |
| VOC | -2 | -5 |

## *3.1.6. Sensitivity Analyses*

NESCAUM conducted two sensitivity analyses after completing the core GGRA modeling exercise. The first sensitivity analysis was designed to examine the GGRA policies specifically in the context of Maryland's current SIP planning work. The second sensitivity analysis was designed to assess the GGRA scenarios in the context of long-term climate planning targets. The rest of this section describes each of the sensitivity analyses.

## Ozone Sensitivity

This section presents the ozone SIP sensitivity analysis conducted to inform the weight-of-evidence planning approach Maryland is exploring to account for $NO_X$ reductions tied to policies such as energy efficiency, renewable energy, and market-based carbon reduction schemes that are not fully accounted for in ozone SIP strategies. For example, state renewable portfolio standards are mostly incorporated into AEO projections used in SIPs, but the full range of state-based measures, especially energy efficiency programs, are typically not included. In addition, the AEO2012 projection (the most recent projection available at the time of this analysis) did not include the revised carbon dioxide cap for the power sector in states participating in the Regional Greenhouse Gas Initiative (RGGI), which includes Maryland. Following a 2012 program review, the RGGI member states implemented a revised cap of 91 million short tons in 2014, which then declines 2.5 percent annually from 2015 to 2020.[15]

A new round of NE-MARKAL modeling was designed to highlight the benefits of GGRA policies from the Maryland GGRA Plan that focus specifically on projected $NO_X$ emission reductions over a timeframe relevant to current ozone attainment planning. To this end, a new reference case was developed along with two additional “ozone SIP sensitivity” scenarios that incorporate GGRA policies beyond AEO projections used in setting the ozone SIP baseline. This provides a more robust estimate of $NO_X$ emission reductions reasonably expected from Maryland’s GGRA policies that are not included as control measures in the ozone SIP. The ozone SIP sensitivity analysis serves as an expanded weight-of-evidence method to estimate additional $NO_X$ reductions that will contribute to future ozone air quality improvements beyond what is expected to be achieved through enforceable SIP measures. The ozone SIP sensitivity scenarios are described in more detail in the next sub-section.

The GGRA modeling conducted using the NE-MARKAL MPAF was designed around a policy neutral reference case meant to demonstrate how Maryland would benefit from implementing selected GGRA policies. Benefits were demonstrated by comparing the policy neutral reference case results to an initial meta-scenario, which represented each policy as described in Maryland’s GGRA policy documentation, and an enhanced meta-scenario, which examined more ambitious goals for selected policies characterized in the initial meta-scenario.[16] This scenario modeling framework was not well suited to examine the weight-of-evidence benefits of the GGRA policies in the context of ozone SIP planning. NESCAUM worked closely with MDE staff to construct a new reference case and ozone sensitivity scenarios that were more closely aligned with the aim of demonstrating the weight-of-evidence impacts of the GGRA policies selected for the analysis. Table 3-3 presents how the ozone SIP reference case was constructed and also defines each of the weight-of-evidence ozone SIP sensitivity scenarios.

[15] Regional Greenhouse Gas Initiative, *The RGGI CO2 Cap,* http://www.rggi.org/design/overview/cap (accessed December 15, 2014).
[16] The policy neutral reference case and the initial and enhanced meta-scenarios were described in earlier sections.

**Table 3-3. Ozone SIP Scenario Definitions**

| Policy | Reference O3 SIP | 2 EE/RE alternative strategies (I & E) |
|---|---|---|
| Regional Greenhouse Gas Initiative | None | E |
| MD Renewable Portfolio Standard | I | E |
| EmPOWER Maryland | None | I & E |
| Main Street Initiatives | None | I & E |
| Energy Efficiency for Affordable Housing | None | I & E |
| ***MD Clean Cars Program*** | ***I*** | ***I*** |
| ***Corporate Average Fuel Economy 2008-2011*** | ***I*** | ***I*** |
| ***Fuel Efficiency and Emissions Standards for Medium- and Heavy-Duty Trucks*** | ***I*** | ***I*** |
| ***Public Transportation and Intercity Transportation Initiatives*** | ***I*** | ***I*** |
| ***Tier 3 Motor Vehicle Emission and Fuel Standards*** | ***I*** | ***I*** |
| Gas Tax | 2014 tax $0.27/gal | 2014 tax $0.27/gal |
| Building and Trade Codes | None | I |

Table 3-4 summarizes the NE-MARKAL modeling results for the ozone SIP sensitivity scenarios. Results are focused on changes in $NO_X$ emissions to highlight the ozone impacts of each weight-of-evidence sensitivity defined in Table 3-3.[17] Table 3-4 presents the 3-year annual average change in $NO_X$ emissions for each of the ozone SIP sensitivities. The annual average is centered on the middle year of the three-year intervals projected by NE-MARKAL (i.e., 2017, 2020, 2023).

[17] A full set on NE-MARKAL modeling results for the ozone SIP sensitivity analysis is in the file: *MD MultiP_NE-MARKAL Output Template - O3 Sensitivity (11-5-2014).xls*.

**Table 3-4. Annual Average Decrease in $NO_X$ Emissions Relative to Ozone SIP Reference Case Centered on 2017, 2020, and 2023 (thousand tons)**

| Sector | Initial | | | Enhanced | | |
|---|---|---|---|---|---|---|
| | 2017 | 2020 | 2023 | 2017 | 2020 | 2023 |
| Electricity | -1.3 | -2.5 | -2.2 | -1.3 | -2.5 | -2.3 |
| Buildings | 0.2 | 0.2 | 0.1 | -0.2 | -0.2 | -0.2 |
| Transportation | -0.1 | -0.1 | -0.1 | -0.1 | -0.1 | -0.1 |
| Total | -1.2 | -2.4 | -2.2 | -1.6 | -2.8 | -2.6 |

The total modeled annual decreases in the initial sensitivity scenario are associated with the enhanced Regional Greenhouse Gas Initiative (RGGI) cap,[18] the enhanced Renewable Portfolio Standard (RPS),[19] and the initial energy efficiency programs. By far, the largest reductions of $NO_X$ emissions occur in the electricity sector and are associated with the state RPS and the enhanced RGGI cap. There is a marginal increase in building sector $NO_X$ emissions driven primarily by a small increase in natural gas consumption, and this increase is offset by a marginal decrease transportation sector $NO_X$. The initial sensitivity scenario energy efficiency assumptions do not include a natural gas efficiency component; as a result in the later years there is a small electricity price-driven fuel switch away from electricity towards natural gas.

The additional $NO_X$ reductions (about 400 tons annually) in the enhanced sensitivity scenario relative to the initial scenario are associated with modeling the energy efficiency programs with enhanced efficiency potential assumptions. The largest reductions continue to occur in the electricity sector and are associated, as previously noted, with the state RPS and the enhanced RGGI cap.

## Climate Sensitivity

This section presents the climate sensitivity analysis. Unlike the ozone SIP sensitivity analysis, which focused on near-term air quality planning concerns, the primary focus of the climate sensitivity analysis is to examine the long-term climate implications of the multi-pollutant planning approach Maryland is using.

The climate sensitivity analysis focused on longer term emissions trends beyond the original GGRA planning exercise, which estimated emissions trends over the 2008-2023 timeframe. In this analysis, emissions trends were estimated out to the year 2050 (based on the 3-year steps of the NE-MARKAL outputs). The goals of the climate sensitivity analysis were to examine both the long-term emissions implications of the original GGRA scenarios and also to assess the climate response to a set of more aggressive renewable energy and energy efficiency scenarios based on the original core GGRA scenarios. In addition to the renewable energy and efficiency sensitivities, the analysis also examined how electricity sector trends in the context of

[18] The AEO 2012 projection used for this analysis does not include the revised RGGI cap for 2020, therefore we include it in the sensitivity scenarios. The U.S. DOE Energy Information Administration is including the revised RGGI cap in AEO 2014.
[19] The initial Maryland RPS is part of the AEO 2012 projection, hence it is included in the reference case rather than the ozone sensitivity scenarios.

these sensitivities would be affected by imposing a carbon price and adjusting downward the investment cost for solar technologies.

The climate sensitivity analysis is based on the NE-MARKAL database and modeling framework developed for both the core GGRA analysis and the ozone SIP sensitivity. For the climate sensitivity, all of the individual GGRA scenarios were extended out to 2050, and then new extended initial and enhanced meta-scenarios were run over the extended timeframe. The climate sensitivities were only layered on top of the extended enhanced meta-scenario – the initial meta-scenario was not the most logical choice as a basis for examining more aggressive renewable and energy efficiency scenarios. The reference case for the climate sensitivities was the same policy neutral scenario used for the original GGRA analysis. Table 3-5 lists and describes each of the scenarios assessed as part of the climate sensitivity analysis. The analysis considered three sensitivities around the RPS, two sensitivities around the EmPOWER Maryland goals and an additional three sensitivities that looked at the combined effects of the RPS and EmPOWER Maryland sensitivities while also examining the role of carbon pricing and alternate solar investment costs.

**Table 3-5. Climate Sensitivity Scenario Definitions**

| Scenario | Description |
|---|---|
| GGRA Sensitivity Reference Case | Original policy neutral reference case |
| Enhanced - Meta Scenario | Original definition of enhanced meta-scenario with all policy components extended to 2050 |
| RPS 1 | Enhanced + 16.4% RPS by 2050 |
| RPS 2 | Enhanced + 50% RPS by 2050 |
| RPS 3 | Enhanced + 50% RPS by 2050 + (Alternate Solar Investment Cost) |
| EmpMD 1 | Enhanced + 30% reduction in per-capita electricity consumption by 2050. |
| EmpMD 2 | Enhanced + 30% reduction in per-capita electricity consumption by 2050 + Triple natural gas efficiency potential by 2030 and hold constant out to 2050. |
| Combined Scen | Enhanced + RPS3 (Alternate Solar Investment Cost) + EmpMD 2 |
| Combined Scen 2 | Enhanced + RPS3 (Original Solar Investment Cost) + EmpMD 2 + Carbon Tax |
| Combined Scen 3 | Enhanced + RPS3 (Alternate Solar Investment Cost) + EmpMD 2 + Carbon Tax |

The climate sensitivities were primarily focused on adjusting policies and assumptions germane to the electricity sector, as such the results presented below focus on how the sensitivities affected electricity sector outcomes. NESCAUM has provided MDE a full set of climate sensitivity results covering all sectors and pollutants in an Excel workbook.

Figure 3-9 presents the cumulative change in electricity generation for each sensitivity scenario relative to the reference case. The key differences between the scenarios are the total decline in coal generation and the total addition of new renewable generating resources. The stringency of the RPS is the key driver of these differences. The Enhanced, RPS 1, EmPOWER Maryland 1 and EmPOWER Maryland 2 scenarios have similar 2050 RPS targets and thus lead to qualitatively similar levels of renewables and coal retirements. The two EmPOWER Maryland scenarios are focused on energy efficiency and have the effect of decreasing electricity load requirements, which accounts for the overall lower levels of new renewables in these two scenarios. RPS scenarios 2 and 3 and all of the combined scenarios have a renewable target of 50 percent by 2050, and thus lead to similar electricity sector outcomes. The combined scenarios also each include the EmPOWER Maryland efficiency targets and as such are also faced with lower levels of electricity load – again this explains the slightly smaller level of renewable deployment relative to RPS scenarios 2 and 3. Combined scenarios 2 and 3 also each apply a carbon tax in the power sector starting at $20/ton in 2015 and increasing to $200/ton in 2035. In each of these scenarios, coal-fired power plants are entirely phased out by 2029.

**Figure 3-9. Cumulative (2008-2050) Change in Electricity Generation Relative to the Reference Case**

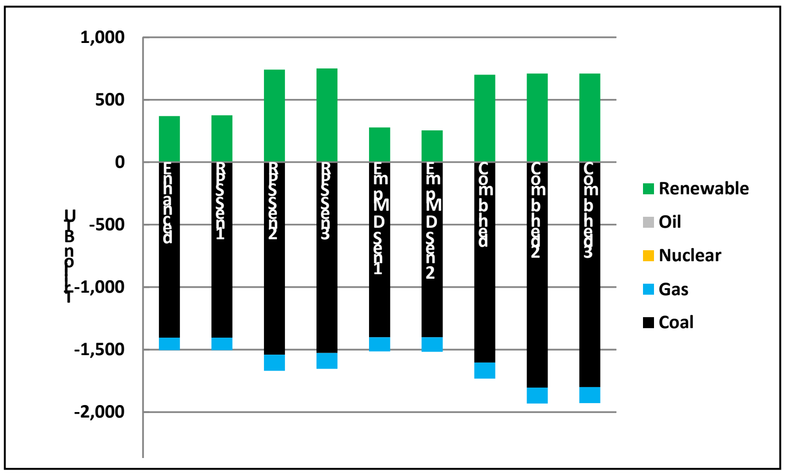



Figure 3-10 presents the cumulative change in renewable electricity generation for each sensitivity scenario relative to the reference case. The key differences between these scenarios are the overall level of renewable energy generation and the share of solar generation relative to wind. The drivers for the overall level of renewable generation are the stringency of the RPS in 2050 and the inclusion of the load mitigating effects of the EmPOWER Maryland efficiency scenarios – these effects were described above. The primary driver of new solar generation relative to wind is the assumption made about the investment cost of new utility scale solar projects. The RPS 3, Combined, and Combined 3 scenarios each assume an alternative lower investment cost for new solar plants. In these scenarios, solar energy displaces some of the market for new wind turbines. The rationale for looking at an alternative solar investment cost was to provide a cost trajectory for solar projects that is more in line with recent historical trends and the future expectations of industry experts.

**Figure 3-10. Cumulative (2008-2050) Change in Renewable Electricity Generation Relative to the Reference Case**

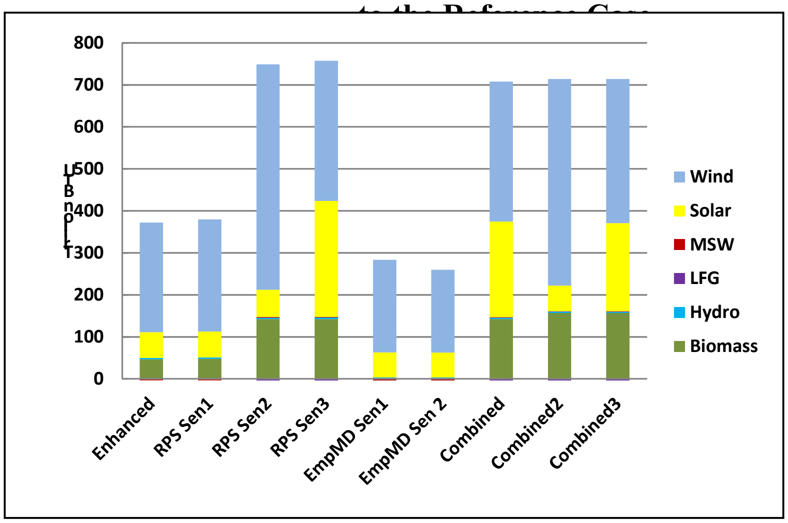
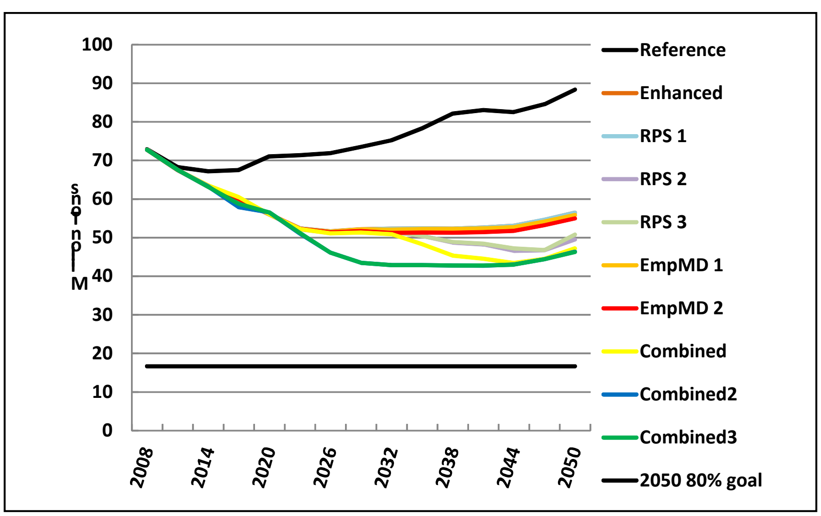



Figure 3-11 presents total carbon dioxide trends across all sectors in Maryland for each of the modeled climate sensitivity scenarios. The chart also includes a reference line that represents a hypothetical Maryland-specific 80 percent $CO_2$ reduction by 2050 relative to the 2005 Maryland reference case emissions. The greatest modeled $CO_2$ reductions in 2050 relative to the reference case are realized by adopting the suite of GGRA policies represented by the Combined 3 scenario; these reductions amount to 42 million tons of $CO_2$. The enhanced meta-scenario reductions alone accounts for 32 million tons of $CO_2$ in 2050. These reduction outcomes highlight that taken together, the climate sensitivity scenarios will at most achieve a further 10 million tons of $CO_2$ reductions beyond the enhanced meta-scenario and that even under the most aggressive sensitivity, Combined 3, $CO_2$ emissions are 30 million tons above the hypothetical 80 percent reduction goal in 2050 previously mentioned. The dominant share of those remaining emissions is from the transportation sector.

**Figure 3-11. Total Carbon Dioxide Emissions by Sensitivity Scenario**



### *3.1.7. NE-MARKAL Summary and Conclusions*

The 2009 Maryland GGRA calls for a 25 percent reduction in GHGs from 2006 levels by 2020. The multi-pollutant planning exercise demonstrated that the GGRA policies collectively made positive contributions to near-term air quality outcomes, including the 2020 GGRA climate target. Figure 3-12 presents the net $CO_2$ trends for all sectors and includes a dashed line indicating the 2020 GGRA target. The climate sensitivity analyses indicate that in order to meet a hypothetical 80 percent GHG emissions reduction target by 2050, additional mitigation measures not considered in this analysis would be needed, primarily for the transportation sector.

**Figure 3-12. Net Change in Carbon Dioxide, All Sectors**

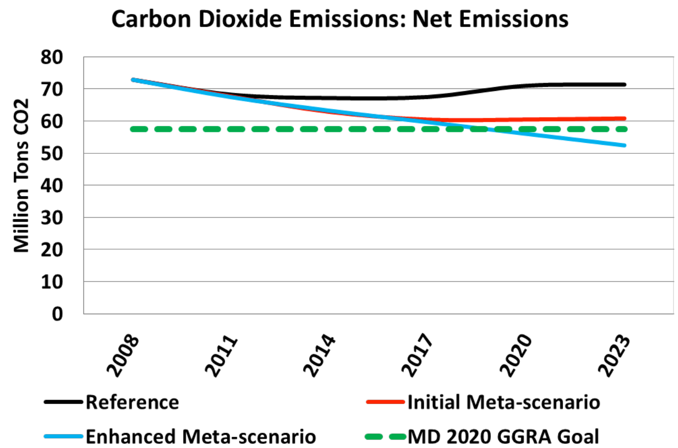



Table 3-6 presents the cumulative 2008-2023 change in air emissions across all sectors for the initial and enhanced meta-scenarios. Over this time period, the initial meta-scenario projected reductions of 63,000 tons of $NO_X$ and 399,000 tons of $SO_2$ in Maryland. Larger reductions were seen for the enhanced meta-scenario, with 70,000 tons of $NO_X$ and 492,000 tons of $SO_2$ reduced.

**Table 3-6. Net Change in Emissions 2008-2023 (thousand tons), All Sectors**

| | Initial | Enhanced |
|---|---|---|
| $NO_x$ | -63 | -70 |
| $PM_{25}$ | -1 | -1 |
| $SO_2$ | -399 | -492 |
| VOC | -2 | -5 |

## 3.2. Modeled Air Quality Changes: CMAQ Results

Emissions projections from the NE-MARKAL model were used to develop inventory growth and control factors for air quality modeling simulations carried out with the Community Multi-Scale Air Quality modeling system (CMAQ, v4.7.1) model. CMAQ is a regulatory model used to quantify impacts of emissions reduction strategies on air quality and to create the information needed to run the BenMAP model. This model has been used extensively by states that are members of the Ozone Transport Commission (OTC) as part of state and regional planning efforts. Here, CMAQ simulations are performed at a 12 km × 12 km horizontal resolution and a 34 layer vertical grid from the surface to ~20 km with hourly output. The model domain spans most of the eastern United States, including all of New England and parts of southern Canada (Figure 3-13). Meteorological fields were calculated using the Weather Research Forecasting (WRF v3.1.1) model for year 2007 and processed for use in CMAQ by the Meteorological Chemistry Interface Processor (MCIP).

**Figure 3-13. CMAQ Domain Boundary (thick black line)**

The emissions used in this study are based off of inventories for year 2007 that were developed by the Mid-Atlantic Regional Air Management Association, Inc. (MARAMA) for use in OTC modeling efforts for SIP development. Since this project began, the OTC modeling participants have begun to use the 2011 model year as a foundation for SIP modeling. However, the final version of the 2011 emissions is still being developed. Emissions from biogenic sources are based on output from the Model of Emissions of Gases and Aerosols in Nature (MEGAN v2.04).[20] Emissions from on-road mobile sources were developed using the Motor Vehicle Emission Simulator (MOVES) while off–road emissions were supplied by the National Mobile Inventory Model (NMIM). Emission inventories and WRF/MCIP meteorology are merged and gridded using the Sparse Operator Kernel Emissions (SMOKE v3.1) model to generate the

[20] Guenther, A. B., Karl, T., Harley, P., Wiedinmyer, C., Palmer, P. I., and Geron, C.: Estimates of global terrestrial isoprene emissions using MEGAN (Model of Emissions of Gases and Aerosols from Nature), Atmos. Chem. Phys., 6, 3181–3210, doi:10.5194/acp-6-3181-2006, 2006.

CMAQ ready emission fields. CMAQv4.7.1 uses the 2005 Carbon Bond (CB05) chemical mechanism.[21]

Recent studies have shed light on possible improvements to the standard CMAQ framework. A comparison of $NO_X$ ($NO_X = NO + NO_2$) from emission inventories for 2011 to measurements taken during the NASA DISCOVER-AQ field mission highlights a potential overestimation of mobile $NO_X$.[22] The ratio of $CO/NO_Y$ from observations was roughly a factor of two greater than the ratio based on the National Emissions Inventory data used in CMAQ. Model carbon monoxide (CO) is only ~15 percent greater than observed for this time period, indicative of a large overestimate of mobile $NO_X$ emissions.[22]

Observations of tropospheric column $NO_2$ from the Ozone Monitoring Instrument (OMI) show that CMAQ overestimates urban $NO_2$ and underestimates rural $NO_2$ in the U.S. Northeast. The CB05 chemical mechanism represents all organic nitrate species, such as alkyl nitrates, as a single species called NTR.[21] In CB05, NTR is created by the breakdown of isoprene and isoprene products and is lost through photolytic and oxidation processes. The photolysis of NTR is based on isopropyl nitrate and produces $NO_2$ and $HO_2$, important precursors to surface $O_3$ formation.[23] Analysis of aircraft observations, however, indicates the speciation of NTR is not well described in CMAQ using CB05, with the most abundant species in this family being hydroxynitrates with lifetimes on order ~1 day or less.[24,25,26] With a lifetime of 10 days, NTR is a long term reservoir of $NO_2$ and CMAQ under-estimates both ozone production and the regional nature of ozone.[27]

Finally, recent updates to biogenic emissions models such as MEGAN and Biogenic Emission Inventory System (BEIS) lead to better representation of ozone precursors such as isoprene, the most reactive volatile organic compound in the mid-Atlantic region. The version of MEGAN used for this study is biased high based on comparison with aircraft observations of isoprene and comparison to tropospheric column formaldehyde (HCHO), a product of isoprene

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[21] Yarwood, G., S. Rao, M. Yocke, and G. Z. Whitten, Updates to the Carbon Bond Chemical Mechanism: CB05, ENVIRON International Corp, 2005.

[22] Anderson, D.C., Loughner, C.P., Weinheimer, A., Diskin, D., Canty, T.P., Salawitch, R.J., Worden, H., Freid, A., Mikoviny, T., Wisthaler, A., and Dickerson, R.R.: Measured and modeled CO and NOy in DISCOVER-AQ: An evaluation of emissions and chemistry over the eastern US, Atmos. Environ., 96, 78–87, 2014.

[23] Yu, S. C., Mathur, R. Pleim, J., Pouliot, G., Wong, D., Eder, B., Schere, K., Gilliam, R., and Rao, S.T.,: Comparative evaluation of the impact of WRF-NMM and WRF-ARW meteorology on CMAQ simulations for O3 and related species during the 2006 TexAQS/GoMACCS campaign, Atmos. Poll. Res., 3(2), 149–162, doi:10.5094/APR.2012.015, 2012.

[24] Horowitz, L. W., Fiore, A. M., Milly, G. P., Cohen, R. C., Perring, A., Wooldridge, P. J., Hess, P. G., Emmons, L. K., and Lamarque, J.: Observational constraints on the chemistry of isoprene nitrates over the eastern United States, J. Geophys. Res., 112(12), D12S08, doi:10.1029/2006JD007747, 2007.

[25] Perring, A. E., Bertram, T. H., Wooldridge, P. J., Fried, A., Heikes, B. G., Dibb, J., Crounse, J. D., Wennberg, P. O., Blake, N. J., Blake, D. R., Brune, W. H., Singh, H. B., and Cohen, R. C.: Airborne observations of total RONO2: new constraints on the yield and lifetime of isoprene nitrates, Atmos. Chem. Phys., 9, 1451-1463, doi:10.5194/acp-9-1451-2009, 2009.

[26] Beaver, M.R., St. Clair, J.M., Paulot, E., Spencer, K.M., Crounse, J.M., LaFranchi, B.W., Min, K.E., Pusede, S.E., Woolridge, P.J., Cohen, R.C., Wennberg, P.O.: Importance of biogenic precursors to the budget of organic nitrates: observations of multifunctional organic nitrates by CIMS and TD-LIF during BEARPEX 2009, Atmos. Chem. Phys., 12(13), 5773-5785, 2012.

[27] Canty, T.P., Hembeck, L., Vinciguerra, T.P., Anderson, D.C., Goldberg, D.L., Carpenter, S.F., Allen, D.J., Loughner, C.P., Salawitch, R.J., and Dickerson, R.R.: Ozone and NOx chemistry in the eastern US: Evaluation of CMAQ/CB05 with satellite (OMI) data, Atmos. Chem. Phys. Dis., 2014.

oxidation. Improvements to isoprene emissions would lead to an overall decrease in ozone due to a decrease in the $HO_2$ and $RO_2$ ozone precursors.

In total, these issues highlight that the "off the shelf" version of CMAQ does not properly represent the regional nature of pollution episodes and the modeling scenarios presented in this study may underestimate improvement in downwind states.

Emissions for the year 2020 were created for the three different emissions scenarios defined through the NE-MARKAL analysis: reference case, initial meta-scenario, and enhanced meta-scenario. Emissions of $NO_X$, VOC, CO, $SO_2$, and $PM_{2.5}$ were projected using MARAMA's 2007 Level 3 emissions platform. The NE-MARKAL runs provided reduction values for the six New England states, New York, New Jersey, Pennsylvania, Delaware, Maryland, and Washington, D.C. for each of the three scenarios. Compared to the reference case, the initial meta-scenario reduced area, point, and EGU emissions in Maryland as well as mobile emissions in the NE-MARKAL region. These reductions were further decreased for the enhanced meta-scenario, and EGU emissions from the other NE-MARKAL states were also decreased. For the rest of the modeling domain, 2018 emission projections were used. The tabulated state and outside region emissions changes for each of the three scenarios are given in Appendix C.

Full year CMAQ simulations were performed for each meta-scenario. Average maximum 8-hour ozone was calculated for the ozone season (April-October). Differences between the reference case and the two meta-scenarios are shown in Figure 3-14. Reductions in ozone precursors and particulate matter lead to modest changes in ozone, with the maximum benefit predicted by the enhanced meta-scenario of over 0.8 ppb centered on Maryland with further benefit in southeastern Pennsylvania, New Jersey, New York City, and Connecticut. A closer look at the Maryland region (Figure 3-15) shows widespread benefit over most of the State.

**Figure 3-14. Difference between Average Maximum Daily 8-hour Average Ozone Calculated for the Initial and Enhanced Meta-scenarios and Reference Case**

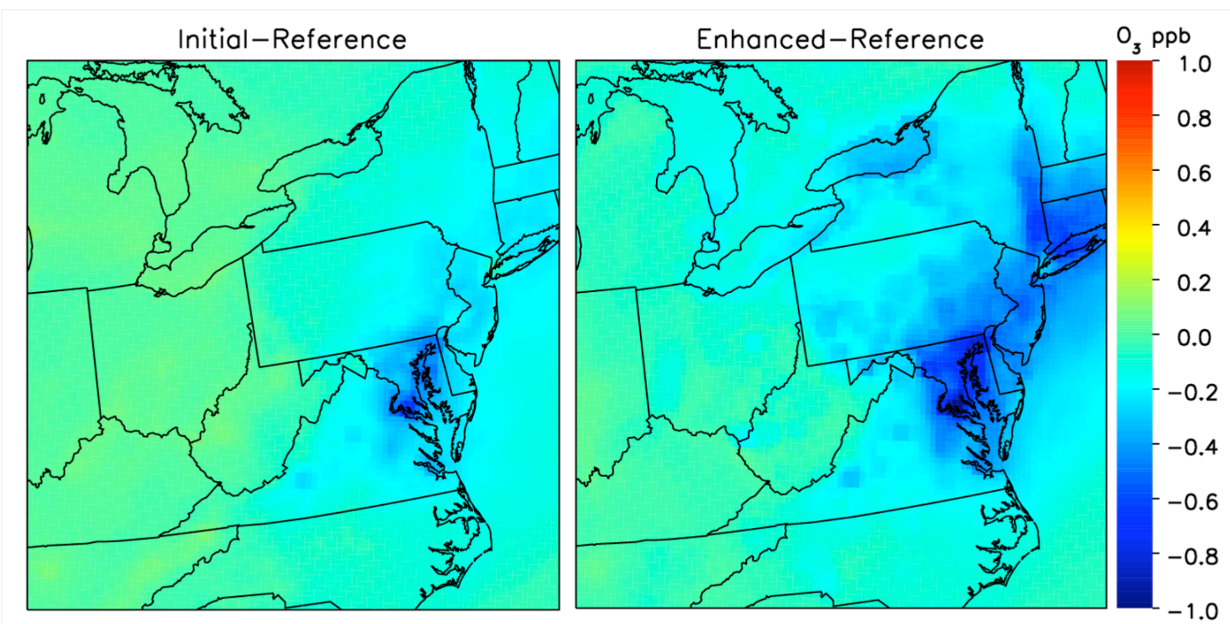
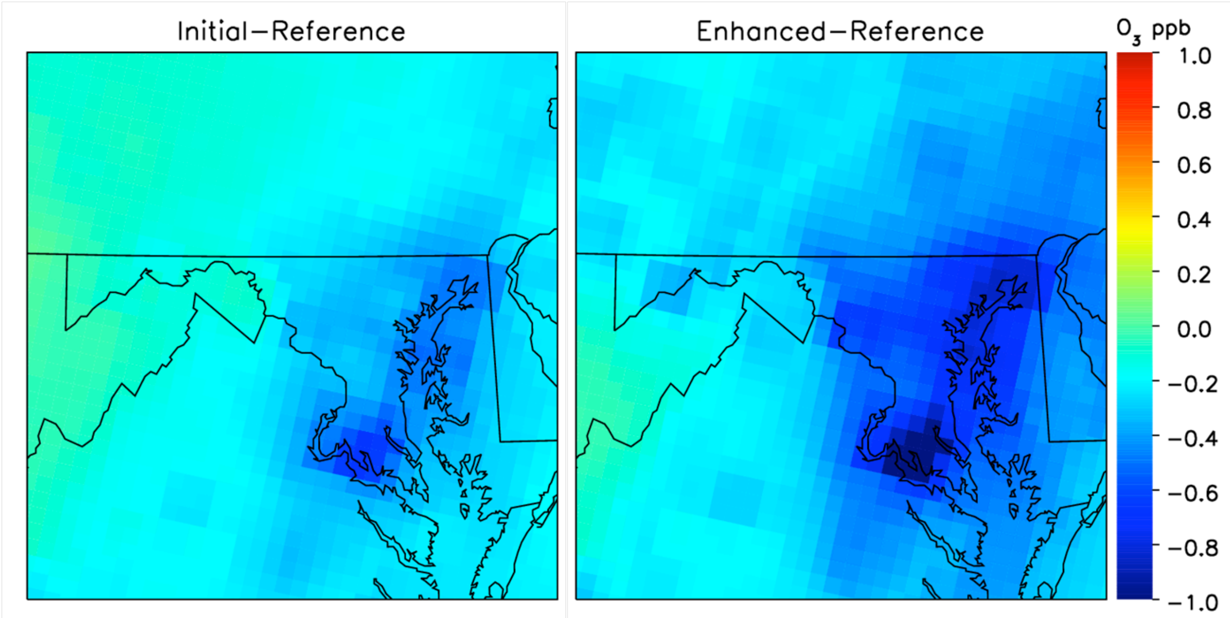


**Figure 3-15. Difference between Average Maximum Daily 8-hour Average Ozone Calculated for the Initial and Enhanced Meta-scenarios and Reference Case for Maryland**




The greatest reductions in particulate matter are centered in Maryland (Figure 3-16). The largest decreases in Maryland are found near Baltimore/Edgewood and in the vicinity of power plants within the State (Figure 3-17).

**Figure 3-16. Difference between Average 24-hour Mean $PM_{2.5}$ Calculated for the Initial and Enhanced Meta-scenarios and Reference Case**

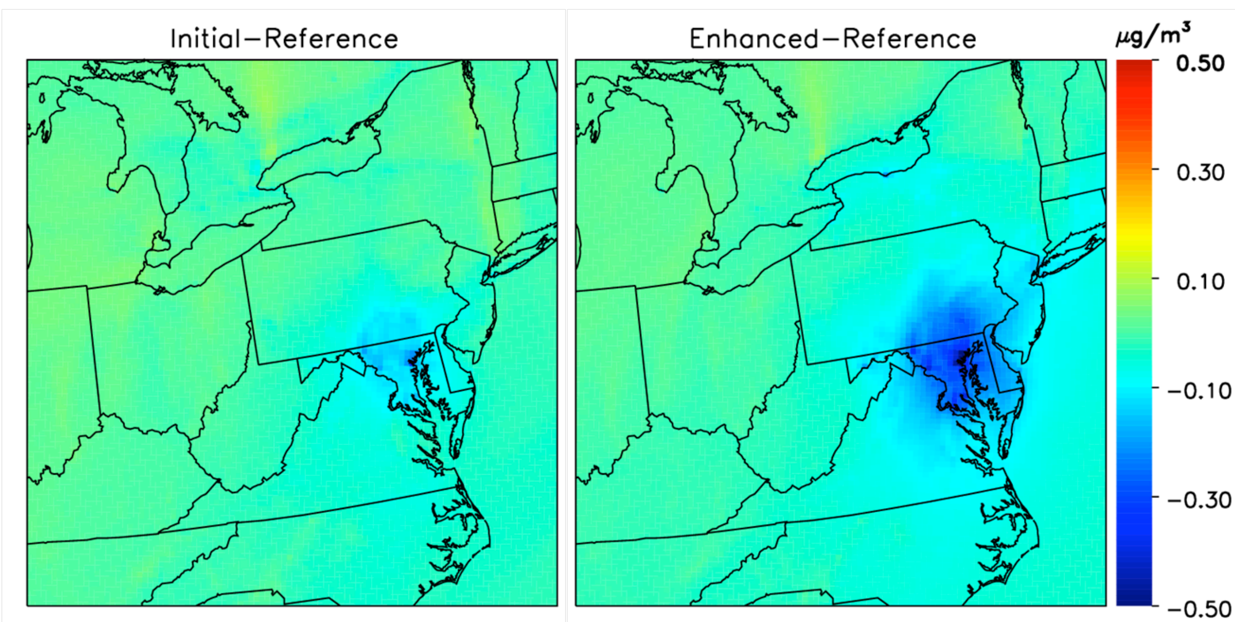
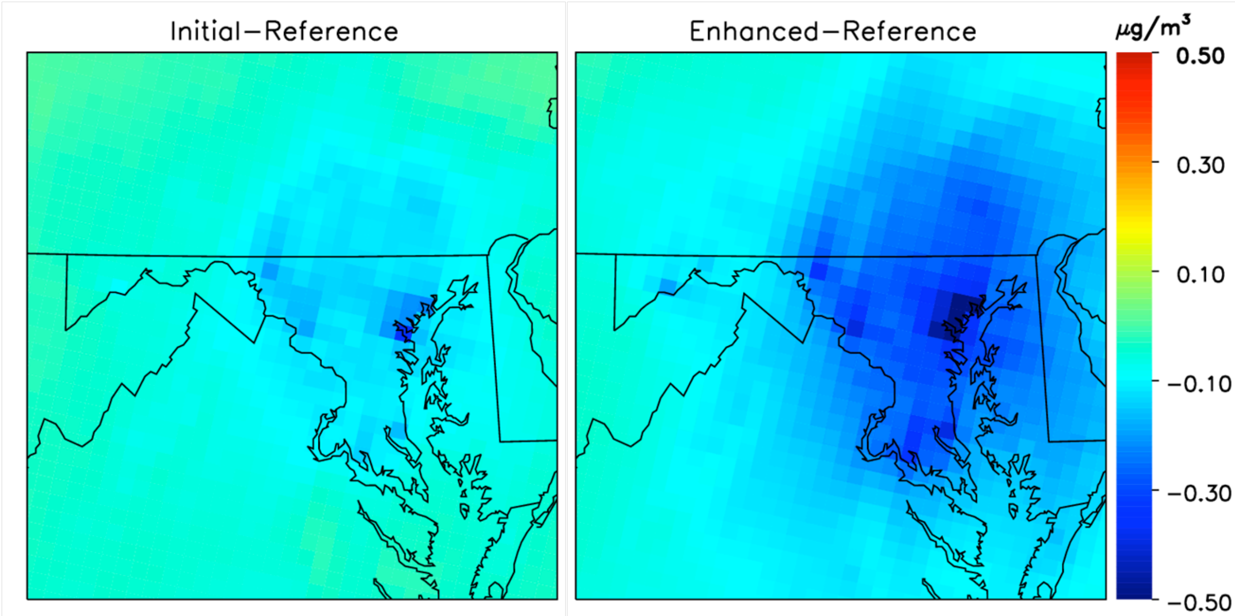


**Figure 3-17. Difference between Average 24-hour Mean $PM_{2.5}$ Calculated for the Initial and Enhanced Meta-scenarios and Reference Case for Maryland**




Decreases in $SO_2$ emissions are primarily seen around coal burning power plants in New York State, specifically the Kodak Park Plant near Rochester, and in Maryland in the enhanced meta-scenario (Figure 3-18). In Maryland, these decreases are most noticeable around city centers and power plants, such as those in western (Dickerson) and southern (Chalk Point) Maryland (Figure 3-19).

**Figure 3-18. Difference between Average 1-hour Mean $SO_2$ Calculated for the Initial and Enhanced Meta-scenarios and Reference Case**

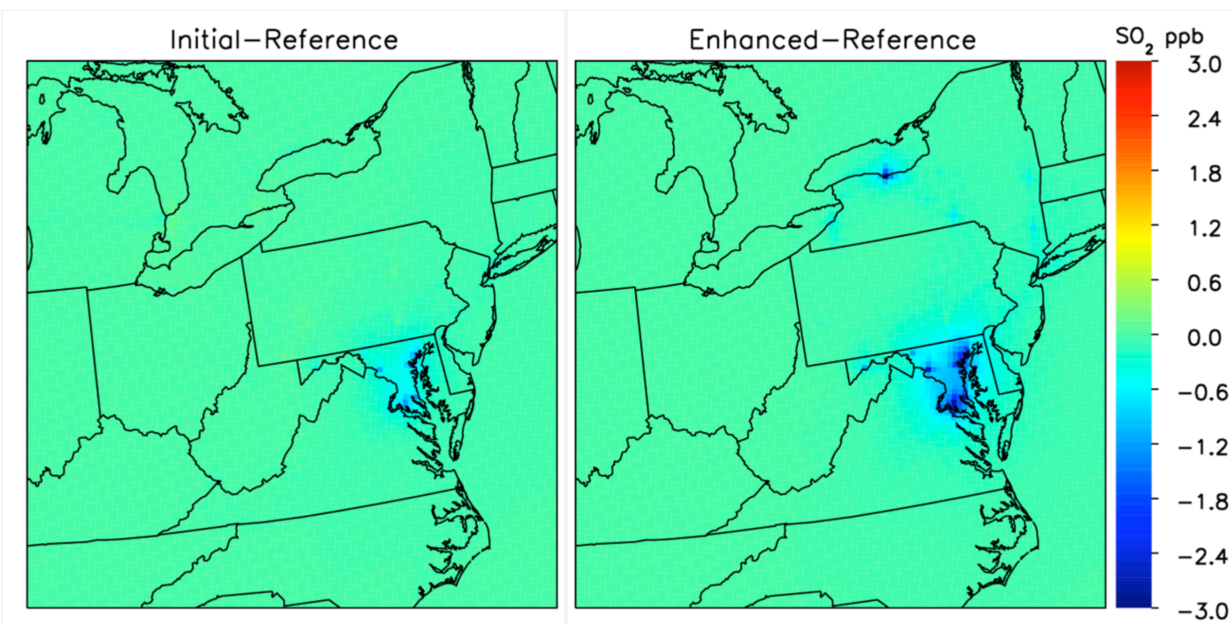
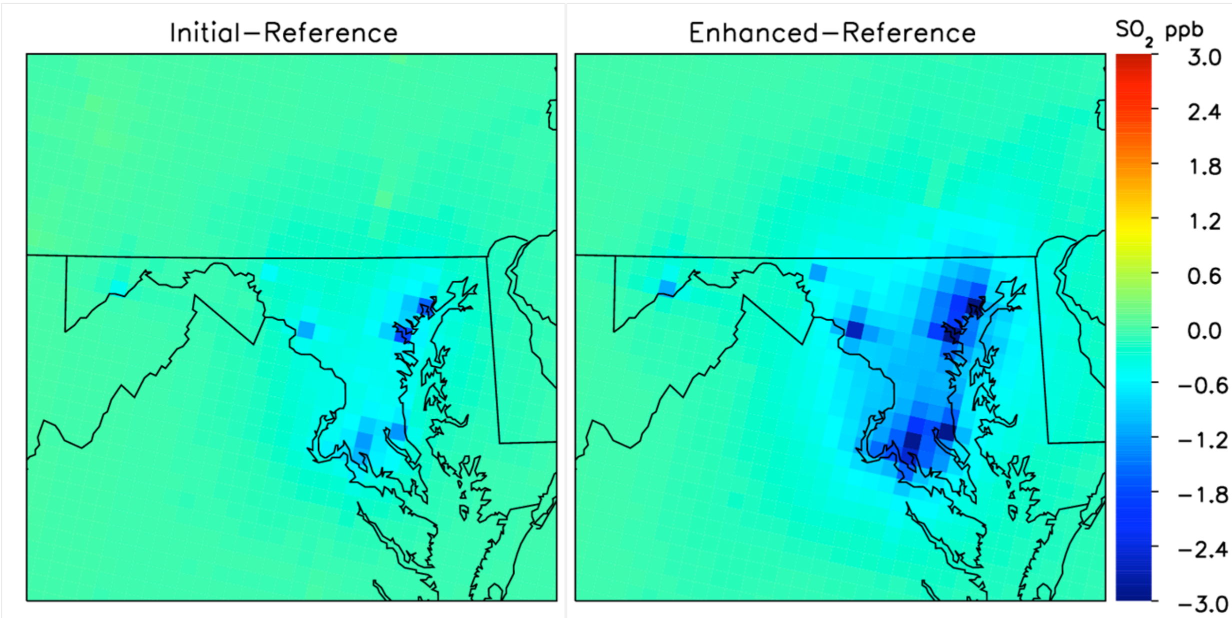


**Figure 3-19. Difference between Average 1-hour Mean $SO_2$ Calculated for the Initial and Enhanced Meta-scenarios and Reference Case in Maryland**




## 3.3. Modeled Health Benefits Assessment: BenMAP Results

The changes in ambient air quality values projected for the two meta-scenarios by the CMAQ model were used as inputs in the BenMAP model to estimate specific increases and decreases in incidences of air quality-related health effects. The BenMAP model was developed to assess the average benefits to a population from changes in ozone and $PM_{2.5}$ ambient air pollution levels. It provides quantitative and monetized estimates of the public health benefits of the GGRA programs that were simulated in NE-MARKAL and modeled in CMAQ. The changes in ambient air quality values projected for the initial and enhanced meta-scenarios by the CMAQ model were used as inputs in the BenMAP model to estimate specific increases and decreases in incidences of health effects. The same technology shifts that led to reductions in GHGs also reduced ozone and $PM_{2.5}$ over much of the Ozone Transport Region (OTR). The model indicated that there will be substantial public health benefits in Maryland and throughout the region due to the reduced incidence of adverse health impacts associated with ozone and $PM_{2.5}$.

Table 3-7 presents summary monetized results of the modeled health effects of implementing the initial meta-scenario in 2020 for $PM_{2.5}$ and ozone; Table 3-8 presents the analogous results for the enhanced meta-scenario. We present a range of monetary valuation results for premature mortality and various morbidity health endpoints. We present results using 3 percent and 7 percent discount rates for estimating future year health effects. Morbidity health endpoints are presented together rather than expressed individually. See Appendix D for more detailed information on the incidence and valuation methodology and results, including the $95^{th}$ percentile confidence interval around a central point estimate. Monetary results are presented in millions of dollars.

**Table 3-7. Summary Health Impact and Valuation Changes in 2020 from Reference Case to Initial Meta-scenario, Combined Ozone and $PM_{2.5}$ Results**

| *Monetized total benefits (millions of 2010$)* | *Maryland* | *OTR (excluding Maryland and Virginia)* | *Beyond OTR* | *Total* |
|---|---|---|---|---|
| Krewski et al. (2009) PM mortality and Bell et al. (2004) ozone mortality | | | | |
| 3% discount rate | $418 | $2,080 | $871 | $2,951 |
| 7% discount rate | $321 | $1,647 | $674 | $2,321 |
| Lepeule et al. (2012) PM mortality and Levy et al. (2005) ozone mortality | | | | |
| 3% discount rate | $851 | $4,382 | $1,834 | $6,216 |
| 7% discount rate | $742 | $3,827 | $1,613 | $5,440 |
| Total morbidity health effects (lower end estimate) | | | | |
| 3% discount rate | $6 | $32 | $15 | $48 |
| 7% discount rate | $6 | $32 | $15 | $47 |
| Total morbidity health effects (upper end estimate) | | | | |
| 3% discount rate | $10 | $53 | $24 | $77 |
| 7% discount rate | $10 | $53 | $24 | $76 |

Notes: Values represent the central "point" estimate of health benefits (i.e., value saved from reduced incidence) attributable to the meta-scenario.

**Table 3-8. Summary Health Impact and Valuation Changes in 2020 from Reference Case to Enhanced Meta-scenario, Combined Ozone and $PM_{2.5}$ Results**

| *Monetized total benefits (millions of 2010$)* | *Maryland* | *OTR (excluding Maryland and Virginia)* | *Beyond OTR* | *Total* |
|---|---|---|---|---|
| Krewski et al. (2009) PM mortality and Huang et al. (2005) ozone mortality | | | | |
| 3% discount rate | $811 | $4,107 | $1,214 | $5,320 |
| 7% discount rate | $622 | $3,217 | $939 | $4,156 |
| Lepeule et al. (2012) PM mortality and Levy et al. (2005) ozone mortality | | | | |
| 3% discount rate | $1,631 | $8,401 | $2,492 | $10,893 |
| 7% discount rate | $1,419 | $7,275 | $2,185 | $9,459 |
| Total morbidity health effects (lower end estimate) | | | | |
| 3% discount rate | $13 | $57 | $21 | $78 |
| 7% discount rate | $12 | $57 | $21 | $78 |
| Total morbidity health effects (upper end estimate) | | | | |
| 3% discount rate | $20 | $97 | $30 | $127 |
| 7% discount rate | $20 | $96 | $29 | $125 |

Notes: Values represent the central "point" estimate of health benefits (i.e., value saved from reduced incidence) attributable to the meta-scenario.

Figure 3-20 and Figure 3-21 show the modeled distribution of upper-end estimates of changes in premature mortality incidence for Maryland and surrounding areas for $PM_{2.5}$ and ozone, respectively, for the initial meta-scenario. Figure 3-22 and Figure 3-23 show the analogous results for the enhanced meta-scenario. The incidence of adverse health effects (e.g., school loss days and other estimates of premature mortality) is expected to scale similarly with population levels for each grid cell, thus the resulting health benefits tend to accrue in the major population centers within the region of improved air quality (e.g., D.C., Baltimore, Philadelphia).

The CMAQ model predicts slightly higher ozone concentrations in New York City (and the immediate surrounding area) likely due to local $NO_X$ scavenging of ozone in the model results. The atmospheric formation of ozone has a non-linear relationship with $NO_X$ levels. Areas of high $NO_X$ concentrations relative to VOCs, such as some urban cores, can suppress ozone levels because $NO_X$ chemistry under these conditions tends to destroy ("scavenge") ozone. The modeled ozone levels in these locations may increase incrementally as $NO_X$ emissions decrease because $NO_X$ scavenging decreases with decreasing $NO_X$ emissions. Downwind from major emission centers, $NO_X$ levels become lower relative to VOCs as the pollution plume ages, and the overall effect of $NO_X$ on ozone formation switches from destruction to formation. As a result, the same decline in $NO_X$ emissions leading to increased ozone nearby results in lower ozone in areas farther away, and these downwind areas typically experience the highest regional ozone concentrations. The aggregate magnitude of the health effects associated with the lower downwind ozone concentrations is greater than the adverse effect associated with reduced $NO_X$ scavenging in urban cores like New York City.

The magnitude of the $NO_X$ scavenging effect is also far lower than the health benefits arising from related $PM_{2.5}$ reductions. For ozone, the health effects are greater in the suburbs surrounding the cities, while for $PM_{2.5}$ the effects are highest in the city cores. The overall result of this analysis is that the major population areas within Maryland and in the OTR will experience substantial health benefits, while less populated areas see lower (but still substantial) decreases in health incidence.

**Figure 3-20. Distribution of Upper End (Levy *et al.* 2005) Estimate of Premature Mortality in Maryland from Changes in Ozone Concentrations from Reference Case to Initial Meta-scenario**

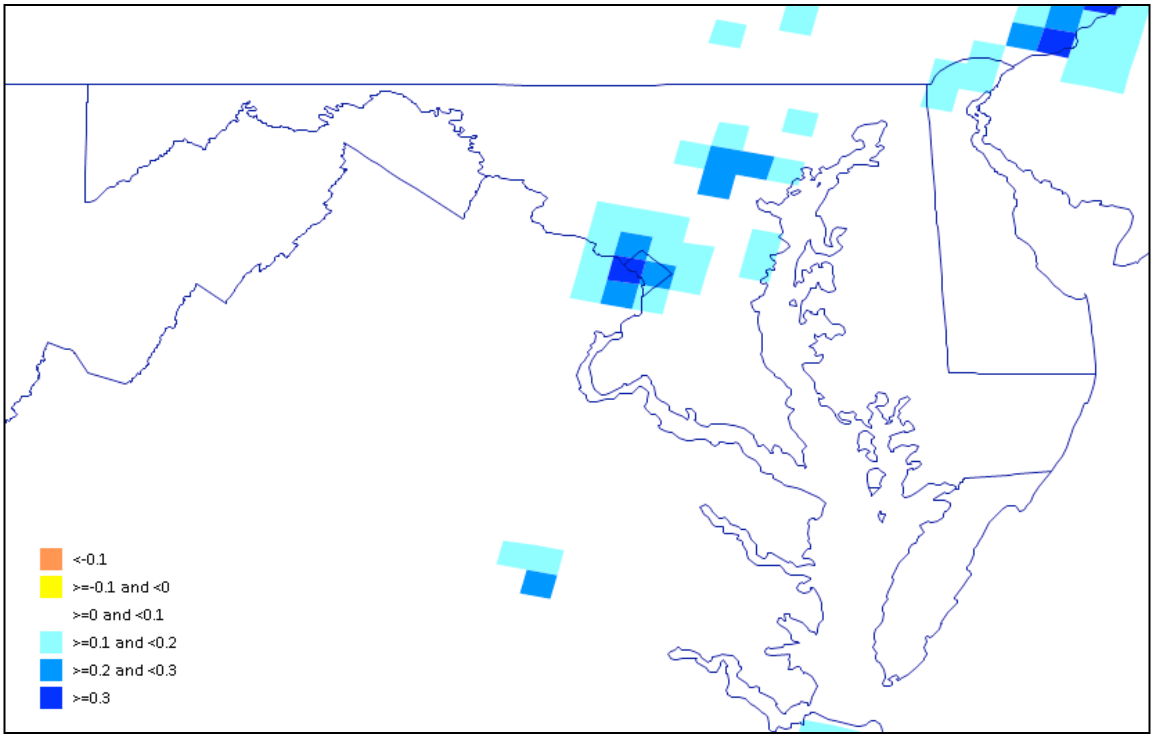


**Figure 3-21. Distribution of Upper End (Lepeule *et al.* 2012) Estimate of Premature Mortality in Maryland from Changes in $PM_{2.5}$ Concentrations from Reference Case to Initial Meta-scenario**

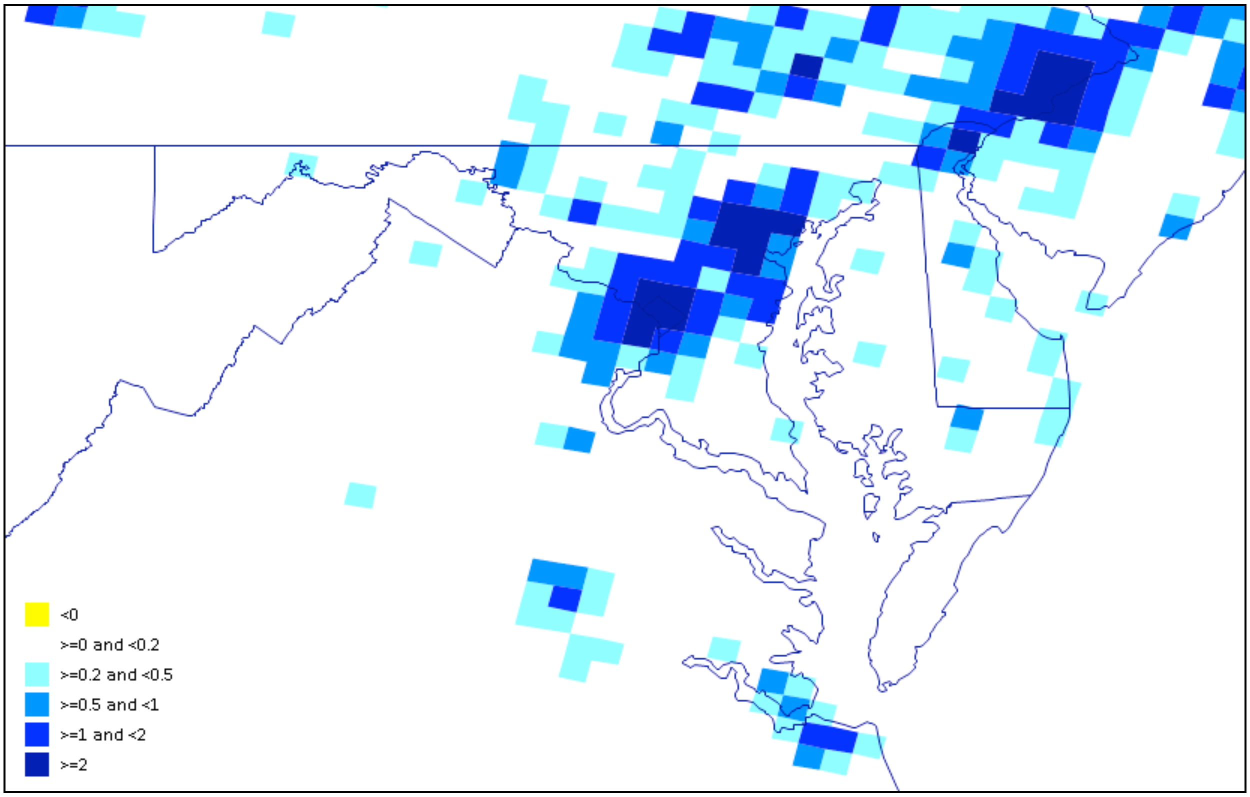


**Figure 3-22. Distribution of Upper End (Levy *et al.* 2005) Estimate of Premature Mortality in Maryland from Changes in Ozone Concentrations from Reference Case to Enhanced Meta-scenario**

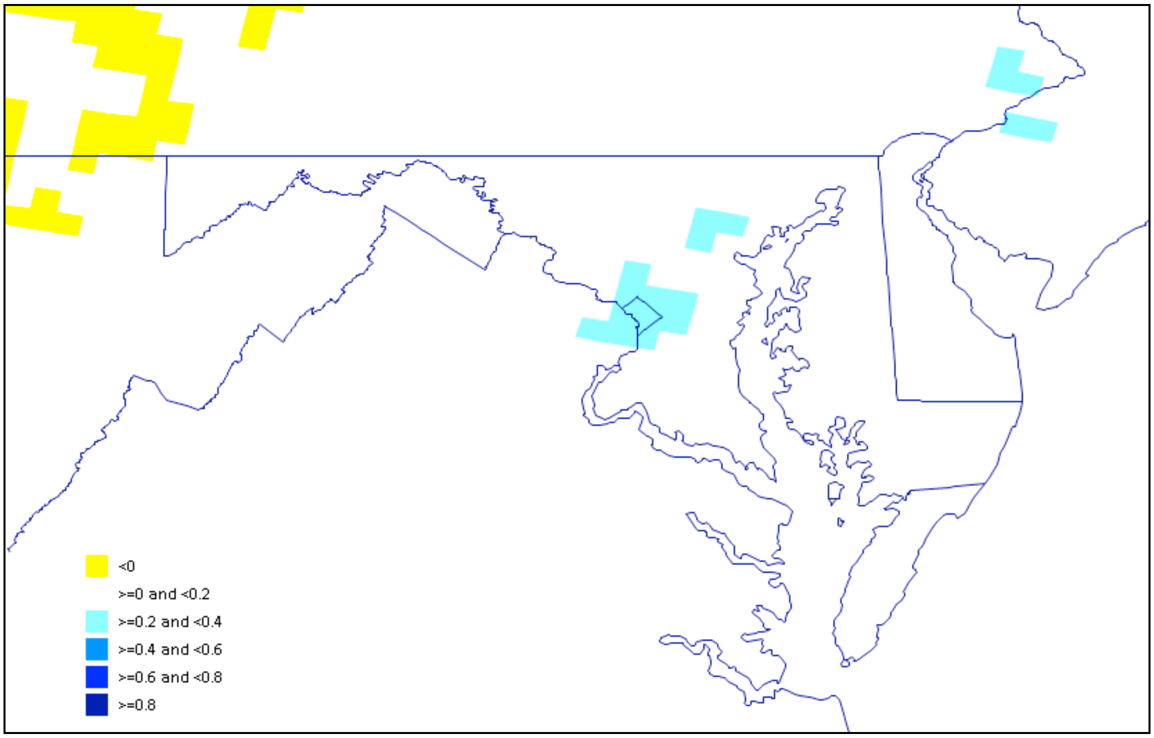
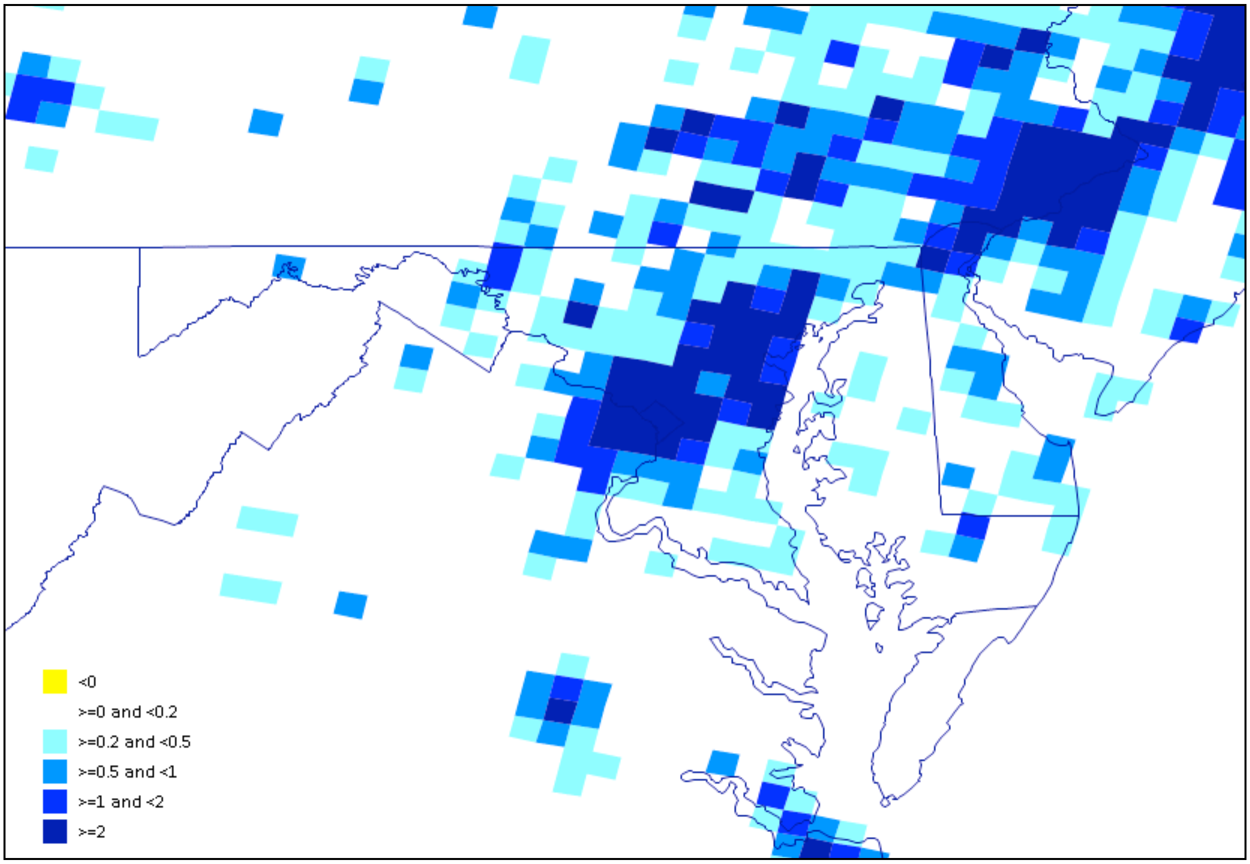


**Figure 3-23. Distribution of Upper End (Lepeule *et al.* 2012) Estimate of Premature Mortality in Maryland from Changes in $PM_{2.5}$ Concentrations from Reference Case to Enhanced Meta-scenario**




The net result of these modeled public health benefits include many reduced incidences of respiratory ailment, asthma attack, heart attack, hospital room visits, and lost work and school days. The monetary benefits of these public health improvements are driven largely by the reduced mortality, which includes (within Maryland) 43 to 100 avoided deaths per year due to reduced ozone and $PM_{2.5}$ under the initial meta-scenario, and 84 to 192 avoided deaths per year under the enhanced meta-scenario.

The monetized value of avoided mortality within Maryland ranges between $420 million to $850 million per year under the initial meta-scenario, and between $810 million to $1.6 billion per year under the enhanced meta-scenario, assuming a 3 percent discount rate for future health effects. With a 7 percent discount rate, the value is $320 million to $740 million per year under the initial meta-scenario, and $620 million to $1.4 billion under the enhanced meta-scenario. Substantial additional public health benefits are expected across the OTR and beyond. Appendix D presents additional detail on the BenMAP results.

## 3.4. Modeled Economic Assessment: REMI Results

### *3.4.1. Introduction*

In this section, the Regional Economic Studies Institute (RESI) of Towson University describes the results of a regional economic assessment of the GGRA meta-scenarios using the Regional Economic Models, Inc. (REMI) PI+ model. The REMI PI+ model is a dynamic economic modeling framework based on general equilibrium theory. It is a peer-reviewed model for evaluating the effects of policy initiatives and similar changes on the economies of local regions. The model incorporates Bureau of Economic Analysis economic impact multipliers specific to Maryland. One area of focus with the REMI PI+ model is to discern trends in the energy, industrial, and commercial sectors' activity levels and employment in Maryland under the meta-scenarios. The REMI PI+ analysis examined the broader economic impacts, such as employment changes and gross state product impacts, of implementing Maryland's climate strategies.

RESI linked REMI PI+ to the NE-MARKAL results to generate estimates of economic impacts to Maryland associated with the various climate and air quality programs incorporated in the meta-scenarios. To calculate the potential economic benefits of the meta-scenarios, RESI used the REMI PI+ 1.6 version to provide an annual impact analysis associated with the NE-MARKAL results. RESI built a sophisticated model that is calibrated to the specific relationships between industrial sectors within the Maryland economy. The REMI PI+ model features the ability to capture price effects, wage changes, and behavioral effects through time. RESI set up the modeling inputs to ensure that no double-counting of costs and benefits occurred in the REMI PI+ model. The model has some unavoidable limitations, such as its use of Bureau of Economic Analysis data from 2012. Given these limitations, benefits in industries for future years may not be as significant as those for 2012 or may be slightly overstated.

This section presents REMI PI+ results for 2020 and 2050. The analysis uses 2020 as the year by which the measures are expected to be implemented. The full measure of their costs and benefits, however, will accrue over a longer period. Therefore, to provide more comprehensive long-term economic impacts in Maryland, RESI also provides REMI PI+ economic impacts in 2050 in this section.

### *3.4.2. Modeling Approach*

To analyze the economic benefits of the GGRA meta-scenarios to Maryland, RESI first identified the industries that were most likely to be impacted. For most policies, RESI used cost data in terms of the outlay of funding necessary to achieve the results for a given policy that Maryland state agencies provided. RESI used NE-MARKAL results for fuel reductions in conjunction with their corresponding policies to gauge the changes in economic impacts. The only exception where RESI did not use data from Maryland agencies was Building and Trade Codes. Instead, RESI used technology costs from the NE-MARKAL model to estimate results. Analysis and data assumptions were carefully guided through discussions between NESCAUM, MDE, and RESI staff.

In addition to considering the potential costs and benefits associated with investments in new technology, the model also considered health benefits as a factor. Referencing the CMAQ air quality modeling results, RESI reviewed the potential increase in wages from employees who may have otherwise missed work for sick leave as well as the benefits of a potential decrease in the mortality rate associated with a decrease in air pollution exposure. Both prospects allow for Maryland's workforce to be healthier and often contribute to lower labor costs for employers through improved worker productivity over time.

RESI approached each policy with two key questions:

1. Who (industry-specific, commercial overall, or households) would benefit from this policy's indicated savings?
2. Who (private industry, government, or households) would be responsible for the costs of implementation?

To answer the first question, RESI discussed the NE-MARKAL results with NESCAUM to determine the potential benefits. Policies such as RGGI, EmPOWER Maryland, RPS, and Offshore Wind will likely bring benefits largely to the electrical distribution, generation, and transmission sectors.[28] Policies such as RGGI have a dual effect—electricity generators operating in the region incur costs, but the collected funds are used to promote energy efficiency initiatives such as EmPOWER. RESI determined that the largest benefits to Maryland came in the form of reduced energy consumption under programs (such as EmPOWER) that seek to minimize consumers' energy consumption. Consumers may include businesses or private households since EmPOWER includes business grants to help reduce regional businesses' energy use. Benefits to Maryland from Offshore Wind mostly come in the form of potential jobs associated with the maintenance of the wind turbines and transformers.

RESI determined all other policies' effects on consumer spending with respect to the policies' ultimate goal. For example, policies such as new transit projects seek to reduce household consumption of motor fuels; therefore, RESI considered this impact as a reduction to consumer spending for motor fuels. Although the gas tax is considered as a separate policy in the NE-MARKAL analysis, RESI included it within the transportation modeling as a method of funding for state transit programs. For more information regarding this assumption, please refer to Section 3.0 below.

The second question of who bears the implementation costs was more challenging to answer. Policies such as RGGI create a sharing of costs between the energy sectors (to purchase credits) and the government (to manage auctions). Overall, the costs are placed on the private sector, with Maryland investing RGGI auction proceeds back into the economy to fund programs aimed at increasing energy efficiency.[29] Funds collected by the private industry through RGGI auctions are used to incentivize private households and businesses to invest in energy reduction initiatives, such as weatherization or new

[28] Offshore wind is included in Maryland's Renewable Energy Portfolio Standard (RPS). Under the economic analysis, the initiative has been analyzed separately from the RPS, and, to avoid double-counting wind, was not considered in the analysis for RPS.
[29] "Private sector" refers to the business community not affiliated with government.

energy star appliances. RESI captured this reallocation of funding into the program to minimize consumer's costs in this analysis.

In other cases, such as EmPOWER Maryland, the private energy sector bears a share of the costs to provide incentives for energy efficiency measures. Households and commercial sectors seeking to implement these investments for future returns then take on further investment.

Table 3-9 describes a list of those policies that RESI determined would lead to benefits and costs by sector.

**Table 3-9. Benefits and Costs Assignment by Policy for GGRA**

| Policy | Who takes on the cost? | Who would benefit? |
|---|---|---|
| RGGI | Producers of electric transmission, distribution, and generation | Producers of electric transmission, distribution, and generation; and, Households (through government investment) |
| RPS | Producers of electric transmission, distribution, and generation | Producers of electric transmission, distribution, and generation |
| EmPOWER MD | Producers of electric transmission, distribution, and generation; Households; and, commercial industries | Households and commercial industries |
| Main Street | Households and commercial industries | Households and commercial entities |
| EE Affordable | Household and commercial industries | Households and commercial industries |
| Public Transportation Projects | Government | Households |
| Building and Trade Codes | Households and commercial industries | Households and commercial industries |

Source: RESI

RESI includes two different meta-scenarios associated with the GGRA:

1. The initial meta-scenario assessed the GGRA in Maryland's economy between 2010 and 2050. The reported totals are the additional benefits (costs) associated with implementation of the GGRA measures in the initial meta-scenario between 2010 and 2050.
2. The enhanced meta-scenario incorporated the policies under their enhanced greenhouse gas reduction criteria. Under this scenario, the policies would continue through 2050, but the reduction in GHG would be higher than under the initial meta-scenario.

### *3.4.3. Caveats to the Analysis*

RESI determined the required investment and ongoing costs for the GGRA measures using Maryland-provided data and the NE-MARKAL results. The respective Maryland agencies' cost estimates may vary from the NE-MARKAL model's cost estimates. In some cases, agencies' cost estimates may be more reflective of the current costs incurred to complete tasks under a GGRA initiative, and costs may be over- or understated in the NE-MARKAL model as the NE-MARKAL does not take into account certain areas of specific contract costs.

Programs such as EmPOWER Maryland seek to reduce consumption of energy within Maryland. However, this aim may alter the number of renewable energy credits needed to meet the guidelines of the RPS. RPS could increase some costs in the energy sector by increasing the number of renewable energy credits (RECs). To mitigate for this potential effect, RESI created a "shadow price" based on the current value of renewable energy credits and Maryland's level of imported energy to date. This shadow price is captured as an indirect cost that is not necessarily borne from the direct generation of power but rather the indirect costs associated with compliance under RPS. These costs may be over- or understated depending on the inflation and actual purchases of renewable energy credits between 2010 and 2050. The level of energy consumption reduced through programs such as EmPOWER Maryland may also cause this indirect cost to be over- or understated within the model. For example, if the generated power needed in Maryland is less than that for the previous year, the percentage to meet the RPS of renewable energy would be less. This lower amount would then potentially lower the necessary RECs needed to meet the RPS goal.

NE-MARKAL analyzed Maryland's gas tax and its air quality benefits for the State of Maryland. Under RESI's analysis, the gas tax is a driver for providing funding to public transit programs. Therefore, the transfer of dollars spent on motor fuels by households affected by the tax to the government is balanced and offsets the State's total additional costs for transit programs. Given these assumptions, RESI could potentially double-count the jobs, output, and wages associated with the gas tax and overstate impacts associated with increased public transit programs if the tax were analyzed separately. Therefore, RESI included the gas tax as a cost to households and captured the transfer of funds through the state government into road construction programs under the "Public Transit Programs."

RESI highly encourages additional analysis of State-proposed programs and NE-MARKAL modeling results to better gauge the potential future economic impacts of the GGRA measures. Alternative methods for achieving the GGRA reductions may need to be considered to help decrease the costs associated with implementing the GGRA.

### *3.4.4. Results*

**Initial Meta-scenario**

RESI's initial meta-scenario analysis reviews the GGRA measures and benefits or costs that may be associated with them. Figures 2 through 6 show the annual distribution between 2010 and 2050 for the GGRA measures as a whole in employment, wages, output, value added, and real disposable income. The key concept captured in Figures 2 through 6 is how economic stimulus is generated throughout the economy.

Each figure reports the direct, spinoff, and total impacts. A direct impact is an impact directly related to the operations of an industry. For example, if a construction firms hires 100 site workers to resurface a road, then there would be 100 new direct jobs. If this construction project requires the firm to purchase materials such as concrete, and the supplier hires 10 new delivery drivers to meet the increased product demand, then these 10 jobs are indirect jobs. Finally, as these 100 new direct employees and 10 new indirect employees have increased income as a result of this construction project, those employees may go out to eat more often. A local restaurant may need to increase staff by 5 employees to meet the new demand from the increased lunchtime crowds. This increase in the number of restaurant employees would be induced jobs. Therefore, the project would generate 100 new direct jobs, 10 new indirect jobs, and 5 new induced jobs for a total of 115 new jobs in the economy. It should be noted, however, that REMI PI+ does not differentiate between indirect and induced jobs. RESI reports these jobs as a combined "spinoff" effect in Table 3-10 through Table 3-14.

RESI evaluated the benefits and costs of the measures from implementation to 2020. However, the full impact of a program's costs and benefits may accrue over a longer period. Therefore, to provide more comprehensive long-term economic impacts in Maryland, RESI extended the REMI PI+ analysis to 2050.

**Table 3-10. Employment Benefits (Costs) for GGRA Initial Meta-scenario, 2010–2050**

| Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | 1,020.4 | 574.0 | 1,594.4 |
| 2015 | 696.0 | 391.5 | 1,087.5 |
| 2020 | 2,498.7 | 1,405.5 | 3,904.2 |
| 2025 | 1,499.2 | 843.3 | 2,342.5 |
| 2030 | 1,019.5 | 573.5 | 1,592.9 |
| 2035 | 407.8 | 229.4 | 637.2 |
| 2040 | 285.4 | 160.6 | 446.0 |
| 2045 | 141.6 | 79.6 | 221.2 |
| 2050 | 137.2 | 77.1 | 214.3 |

Sources: REMI PI+, RESI

**Table 3-11. Wage Benefits (Costs) for GGRA Initial Meta-scenario, 2010–2050**

| Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $22,457,500 | $12,092,500 | $34,550,000 |
| 2015 | -$10,102,950 | -$5,440,050 | -$15,543,000 |
| 2020 | $80,720,900 | $43,465,100 | $124,186,000 |
| 2025 | $44,999,500 | $24,230,500 | $69,230,000 |
| 2030 | -$29,341,000 | -$15,799,000 | -$45,140,000 |
| 2035 | -$13,019,500 | -$7,010,500 | -$20,030,000 |
| 2040 | $8,560,500 | $4,609,500 | $13,170,000 |

| | | | |
|---|---|---|---|
| 2045 | $12,480,000 | $6,720,000 | $19,200,000 |
| 2050 | $18,193,500 | $9,796,500 | $27,990,000 |

Sources: REMI PI+, RESI

**Table 3-12. Output Benefits (Costs) for GGRA Initial Meta-scenario, 2010–2050**

| Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | -$924,950 | -$498,050 | -$1,423,000 |
| 2015 | -$143,611,000 | -$77,329,000 | -$220,940,000 |
| 2020 | -$4,325,750 | -$2,329,250 | -$6,655,000 |
| 2025 | $6,110,000 | $3,290,000 | $9,400,000 |
| 2030 | $17,810,000 | $9,590,000 | $27,400,000 |
| 2035 | $18,070,000 | $9,730,000 | $27,800,000 |
| 2040 | $17,433,000 | $9,387,000 | $26,820,000 |
| 2045 | $19,532,500 | $10,517,500 | $30,050,000 |
| 2050 | $19,623,500 | $10,566,500 | $30,190,000 |

Sources: REMI PI+, RESI

**Table 3-13. Value Added Benefits (Costs) for GGRA Initial Meta-scenario, 2010–2050**

| Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | -$22,033,050 | -$11,863,950 | -$33,897,000 |
| 2015 | -$133,812,250 | -$72,052,750 | -$205,865,000 |
| 2020 | -$75,143,250 | -$40,461,750 | -$115,605,000 |
| 2025 | -$24,745,500 | -$13,324,500 | -$38,070,000 |
| 2030 | $3,607,500 | $1,942,500 | $5,550,000 |
| 2035 | $11,167,000 | $6,013,000 | $17,180,000 |
| 2040 | $11,485,500 | $6,184,500 | $17,670,000 |
| 2045 | $11,258,000 | $6,062,000 | $17,320,000 |
| 2050 | $12,850,500 | $6,919,500 | $19,770,000 |

Sources: REMI, RESI

**Table 3-14. Real Disposable Income Benefits (Costs) for GGRA Initial Meta-scenario, 2010–2050**

| Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $41,616,900 | $22,409,100 | $64,026,000 |
| 2015 | $60,262,800 | $32,449,200 | $92,712,000 |
| 2020 | $146,770,000 | $79,030,000 | $225,800,000 |
| 2025 | $37,745,500 | $20,324,500 | $58,070,000 |
| 2030 | $24,277,500 | $13,072,500 | $37,350,000 |
| 2035 | $25,070,500 | $13,499,500 | $38,570,000 |
| 2040 | $29,276,000 | $15,764,000 | $45,040,000 |
| 2045 | $33,566,000 | $18,074,000 | $51,640,000 |
| 2050 | $40,150,500 | $21,619,500 | $61,770,000 |

Sources: REMI, RESI

Overall, the GGRA measures as analyzed under the initial meta-scenario will benefit Maryland's economy with respect to jobs, wages, and real disposable income growth. However, the output and value added to Maryland's economy may decline given the large declines in demand for energy and maintenance associated with the electric power sector in the short term. The movement from labor-intensive industries, such as fuel extraction and dealers, to more high-skilled capital-intensive industries, such as engineering and research, will continue into 2020. The spinoff employment (which includes indirect and induced employment associated with the policies) would represent the loss of some low-skilled employment in the industries associated with extraction and service.

Traditional retail sector jobs, such as gasoline station employees, would be displaced as the economy begins to shift consumption patterns from fossil fuel-based energy technologies toward less fossil fuel-intensive technologies, such as plug-in electric vehicles. Suppliers and businesses associated with these products would need to seek alternative methods to stay competitive.

**Enhanced Meta-scenario**

RESI analyzed the enhanced meta-scenario of the GGRA for benefits or costs that may be associated with implementation of the enhanced measures. The enhanced meta-scenario analyzes the impacts from the enhanced versions of EmPOWER Maryland and the Public Transportation programs. A major difference between the initial meta-scenario and the enhanced meta-scenario is the increased investment in the Public Transportation Programs.[30] The enhanced version of the Public Transportation Programs includes full funding of projects such as the Red and Purple Lines. Table 3-15 through Table 3-19 show the annual distribution between 2010 and 2050 for the GGRA as a whole in employment, wages, output, value added, and real disposable income.

**Table 3-15. Employment Benefits (Costs) for GGRA Enhanced Meta-scenario, 2010–2050**

| Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 1,350.4 | 759.6 | 2,110.0 |
| 2015 | 2,013.7 | 1,132.7 | 3,146.5 |
| 2020 | 2,296.6 | 1,291.9 | 3,588.5 |
| 2025 | 1,607.6 | 904.3 | 2,512.0 |
| 2030 | 1,045.0 | 587.8 | 1,632.8 |
| 2035 | 574.7 | 323.3 | 898.0 |
| 2040 | 373.6 | 210.1 | 583.7 |
| 2045 | 176.3 | 99.2 | 275.5 |
| 2050 | 170.8 | 96.1 | 267.0 |

Sources: REMI PI+, RESI

[30] Some transportation programs as slated for delayed construction and may not begin full operation until after 2020. Furthermore, some transit programs are still contingent on funding, or additional funding. The meta-scenarios account for these programs being funded, such as the Red Line and Purple Line.

**Table 3-16. Wage Benefits (Costs) for GGRA Enhanced Meta-scenario, 2010–2050**

| Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $41,860,000 | $22,540,000 | $64,400,000 |
| 2015 | $71,838,000 | $38,682,000 | $110,520,000 |
| 2020 | $63,895,000 | $34,405,000 | $98,300,000 |
| 2025 | $39,344,500 | $21,185,500 | $60,530,000 |
| 2030 | -$15,561,000 | -$8,379,000 | -$23,940,000 |
| 2035 | $2,821,000 | $1,519,000 | $4,340,000 |
| 2040 | $10,861,500 | $5,848,500 | $16,710,000 |
| 2045 | $15,730,000 | $8,470,000 | $24,200,000 |
| 2050 | $23,894,000 | $12,866,000 | $36,760,000 |

Sources: REMI PI+, RESI

**Table 3-17. Output Benefits (Costs) for GGRA Enhanced Meta-scenario, 2010–2050**

| Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $48,275,500 | $25,994,500 | $74,270,000 |
| 2015 | $33,501,000 | $18,039,000 | $51,540,000 |
| 2020 | -$36,471,500 | -$19,638,500 | -$56,110,000 |
| 2025 | -$52,058,500 | -$28,031,500 | -$80,090,000 |
| 2030 | $7,150,000 | $3,850,000 | $11,000,000 |
| 2035 | $22,067,500 | $11,882,500 | $33,950,000 |
| 2040 | $22,691,500 | $12,218,500 | $34,910,000 |
| 2045 | $22,087,000 | $11,893,000 | $33,980,000 |
| 2050 | $26,175,500 | $14,094,500 | $40,270,000 |

Sources: REMI PI+, RESI

**Table 3-18. Value Added Benefits (Costs) for GGRA Enhanced Meta-scenario, 2010–2050**

| Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $8,281,000 | $4,459,000 | $12,740,000 |
| 2015 | -$34,203,000 | -$18,417,000 | -$52,620,000 |
| 2020 | -$94,334,500 | -$50,795,500 | -$145,130,000 |
| 2025 | -$32,708,000 | -$17,612,000 | -$50,320,000 |
| 2030 | $4,329,000 | $2,331,000 | $6,660,000 |
| 2035 | $13,916,500 | $7,493,500 | $21,410,000 |
| 2040 | $14,475,500 | $7,794,500 | $22,270,000 |
| 2045 | $14,274,000 | $7,686,000 | $21,960,000 |
| 2050 | $17,153,500 | $9,236,500 | $26,390,000 |

Sources: REMI, RESI

**Table 3-19. Real Disposable Income Benefits (Costs) for GGRA Enhanced Meta-scenario, 2010–2050**

| Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $58,181,500 | $31,328,500 | $89,510,000 |
| 2015 | $133,718,000 | $72,002,000 | $205,720,000 |
| 2020 | $141,258,000 | $76,062,000 | $217,320,000 |
| 2025 | $150,163,000 | $80,857,000 | $231,020,000 |
| 2030 | $77,837,500 | $41,912,500 | $119,750,000 |
| 2035 | $36,855,000 | $19,845,000 | $56,700,000 |
| 2040 | $39,754,000 | $21,406,000 | $61,160,000 |
| 2045 | $44,830,500 | $24,139,500 | $68,970,000 |
| 2050 | $55,783,000 | $30,037,000 | $85,820,000 |

Sources: REMI, RESI

Private, state, and households' continual structured investments in the economy toward GGRA goals under the enhanced meta-scenario mitigated some loss reported in the initial meta-scenario. Specifically, programs associated with increasing public transit helped to offset the later declines. The initial work creates construction jobs within the region, but the longer benefits associated with reduced motor fuel purchases and maintenance of private vehicles provide additional disposable income to households in the form of savings. Given this newly acquired disposable income, consumers are more likely to spend it locally, thereby creating additional induced impacts. Overall, the benefits with regard to value added and real disposable income are evident in Table 3-18 and Table 3-19. Review of both scenarios indicates there will be a short-term negative impact incurred for implementation, but Maryland's economy benefits from nearly 20 additional years of increased jobs, wages, and output in the long-term.

# 4. PLACING THE ANALYSIS IN CONTEXT

## 4.1. Maryland Climate Context

The 2012 Greenhouse Gas Emissions Reduction Act (GGRA) Plan seeks to achieve a 25 percent statewide reduction in greenhouse gas (GHG) emissions by 2020, while also spurring job creation and helping improve the economy.[31] In the multi-pollutant planning context, it is part of a "multi-pollutant" planning approach for selecting and analyzing control programs to address multiple public health and environmental goals. The 2012 GGRA Plan will not only help reduce emissions of GHGs, but will also help Maryland to: (1) further clean up the Chesapeake Bay; (2) meet and maintain the NAAQS for ground-level ozone, fine particles, sulfur dioxide, and nitrogen dioxide; and (3) meet federal and state requirements to further reduce regional haze as well as mercury and other air toxics.

There are some critical linkages between GHGs and other air pollutants. First, studies have indicated that climate change, if unaddressed, could result in increased ozone and fine particle levels, or reduce the effectiveness of current pollution control strategies ("climate penalty").[32] Second, many programs that are designed to lower GHG emissions, such as energy efficiency programs, may also reduce emissions of nitrogen oxides, sulfur dioxide, mercury, other toxic metals, diesel exhaust, and black carbon.[33] Third, some policies that are designed to lower GHG emissions, when otherwise unconstrained, may result in increases in other air pollutant emissions.[34] Working on

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[31] For more on Maryland's GGRA Plan, *see* "Climate Change Maryland," State of Maryland, http://climatechange.maryland.gov/publications/greenhouse-gas-emissions-reduction-act-plan/ (accessed September 30, 2014).

[32] *See, e.g.,* Trail, M., A.P. Tsimpidi, P. Liu, K. Tsigaridis, J. Rudokas, P. Miller, A. Nenes, Y. Hu, and A.G. Russell, "Sensitivity of Air Quality to Potential Future Climate Change and Emissions in the United States and Major Cities," *Atmospheric Environment*, **94** 552-563 (2014), doi:10.1016/j.atmosenv.2014.05.079; Rasmussen, D.J., J. Hu, A. Mahmud, and M.J. Kleeman, "The Ozone−Climate Penalty: Past, Present, and Future," *Environmental Science & Technology*, **47** 14258−14266 (2013), doi:10.1021/es403446m; Dawson, J.P., P.N. Racherla, B.H. Lynn, P.J. Adams, and S.N. Pandis, "Impacts of Climate Change on Regional and Urban Air Quality in the Eastern United States: Role of Meteorology," *Journal of Geophysical Research*, **114** D05308 (2009), doi:10.1029/2008JD009849; Jacob, D.J. and D.A. Winner, "Effect of Climate Change on Air Quality," *Atmospheric Environment*, **43** 51-63 (2009), doi:10.1016/j.atmosenv.2008.09.051; Tagaris, E., K. Manomaiphiboon, K. Liao, L.R. Leung, J. Woo, S. He, P. Amar, and A.G. Russell, "Impacts of Global Climate Change and Emissions on Regional Ozone and Fine Particulate Matter Concentrations over the United States," *Journal of Geophysical Research*, **112** D14312 (2007), doi:10.1029/2006JD008262.

[33] *See, e.g.,* Thompson, T.M., S. Rausch, R.K. Saari, and N.E. Selin, "A Systems Approach to Evaluating the Air Quality Co-benefits of US Carbon Policies," *Nature Climate Change* (published online August 24, 2014), doi:10.1038/NCLIMATE2342.

[34] *See, e.g.,* Babaee, S., A.S. Nagpure, and J.F. DeCarolis, "How Much Do Electric Drive Vehicles Matter to Future U.S. Emissions?," *Environmental Science & Technology*, **48** 1382-1390 (2014), doi:10.1021/es4045677; Driscoll, C.T, J. Buonocore, S. Reid, H. Fakhraei, and K.F. Lambert, "Co-benefits of Carbon Standards Part 1: Air Pollution Changes under Different 111d Options for Existing Power Plants," Syracuse University, Syracuse, NY and Harvard University, Cambridge, MA (2014), 34 pp, http://eng-cs.syr.edu/carboncobenefits (accessed October 1, 2014).

climate, energy, criteria pollutant, and toxics issues together helps maximize benefits while also ensuring that any adverse effects are minimized.

The multi-pollutant planning exercise demonstrated that the GGRA policies collectively made positive contributions to near-term air quality outcomes, including the 2020 GGRA climate target.

The analysis also indicated that further reductions in $CO_2$ emissions are needed to meet a hypothetical 80 percent reduction goal by 2050. In order to meet longer-term emission reduction goals, more measures involving the transportation sector would need to be considered. The climate sensitivity analyses found that in 2050, the combination of the most aggressive modeled GGRA policies alone lowered Maryland's reference case 2050 GHG emissions from almost 90 million tons[35] to about 46 million tons. This is still about 30 million tons short of a 2050 80 percent GHG reduction target of 17 million tons (relative to 2006 emissions). Of the 46 million tons, about 35 million tons comes from the transportation sector. This is not surprising, as the sensitivity analyses focused on more aggressive options for RE and EE, while more aggressive transportation policies were not considered.

The decreases in $NO_X$ and $SO_2$ emissions occurring under the GGRA meta-scenarios resulted in modeled ozone and $PM_{2.5}$ air quality improvements. Using CMAQ, average maximum 8-hour ozone was calculated for the ozone season (April-October). Reductions in ozone precursors and particulate matter lead to modest changes in ozone, with the maximum benefit predicted by the enhanced meta-scenario of over 0.8 ppb centered on Maryland with further benefit in southeastern Pennsylvania, New Jersey, New York City, and Connecticut. The greatest reductions in particulate matter in Maryland are found near Baltimore/Edgewood and in the vicinity of power plants within the State. Decreases in $SO_2$ emissions in Maryland are most noticeable around city centers and power plants, such as those in western (Dickerson) and southern (Chalk Point) Maryland.

The modeled reductions in air pollution arising from the GGRA measures were input into the BenMAP model to estimate specific increases and decreases in incidences of health effects. BenMAP found positive net health benefits from the modeled changes in air quality in terms of avoided adverse health outcomes, including premature mortality. Within Maryland, BenMAP estimated 43 to 100 avoided deaths per year due to reduced ozone and $PM_{2.5}$ under the initial meta-scenario, and 84 to 192 avoided deaths per year under the enhanced meta-scenario.

The monetized value of avoided mortality within Maryland ranges between $420 million to $850 million per year under the initial meta-scenario, and between $810 million to $1.6 billion per year under the enhanced meta-scenario, assuming a 3 percent discount rate for future health effects. With a 7 percent discount rate, the value is $320 million to $740 million per year under the initial meta-scenario, and $620 million to $1.4 billion under the enhanced meta-scenario.

The regional economic assessment using REMI found that overall, the GGRA measures as analyzed under the initial meta-scenario will benefit Maryland's economy

[35] Amounts reflect carbon dioxide only. Other GHGs were not considered in the analysis.

with respect to jobs, wages, and real disposable income growth. However, the output and value added to Maryland's economy may decline given the large declines in demand for energy and maintenance associated with the electric power sector in the short term. Private, state, and households' continual structured investments in the economy toward GGRA goals under the enhanced meta-scenario mitigated some loss reported in the initial meta-scenario. Specifically, programs associated with increasing public transit helped to offset the later declines. The initial work creates construction jobs within the region, but the longer benefits associated with reduced motor fuel purchases and maintenance of private vehicles provide additional disposable income to households in the form of savings. Given this newly acquired disposable income, consumers are more likely to spend it locally, thereby creating additional induced impacts. Review of both scenarios indicates there will be a short-term negative impact incurred for implementation, but Maryland's economy benefits from nearly 20 additional years of increased jobs, wages, and output in the long-term.

## 4.2. Maryland Ozone SIP Context

The Maryland GGRA Plan includes a number of policies that provide a basis for incorporating these as alternative (non-traditional) control strategies in the Maryland ozone SIP. In the context of ozone, the precursor pollutant of interest is $NO_X$, which has a large regional impact on ozone formation across the eastern United States. GGRA policies involving energy efficiency and renewable energy to reduce GHGs can also reduce ozone-forming $NO_X$ emissions when displacing fossil fuel combustion. For example, reductions in $NO_X$ emissions from the electric power sector under the $NO_X$ SIP Call have successfully reduced ozone levels in Maryland and across the eastern United States since the inception of the program during the 1990s.

In July 2012, the U.S. EPA released its *Roadmap for Incorporating Energy Efficiency and Renewable Energy Policies and Programs into State and Tribal Implementation Plans* (hereinafter "Roadmap").[36] With its Roadmap, the EPA is encouraging states to consider incorporating energy efficiency and renewable energy programs into their SIPs. The EPA recognizes that states have adopted and are continuing to pursue a range of energy efficiency and renewable energy programs that can reduce SIP-relevant pollutant emissions, such as $NO_X$. In addition, the EPA recognizes that with strengthened air quality standards occurring over time, energy efficiency and renewable energy measures can help states find the greater emission reductions they need to achieve the standards.

The Roadmap builds upon EPA's 2004 guidance on how states may account for energy efficiency and renewable energy programs in their SIPs.[37] The Roadmap clarifies how states might include these programs in SIPs as emerging and voluntary measures, or using three other pathways: (1) baseline emissions forecast; (2) control strategy quantification; and (3) weight-of-evidence. As described earlier, the Ozone Transport Commission asked EPA to modify the weight-of-evidence pathway to include a robust

[36] U.S. EPA. *Roadmap for Incorporating EE/RE in SIPs/TIPs*, USEPA OAQPS, Research Triangle Park, NC, EPA-456/D-12-001a (July 2012). Available at http://epa.gov/airquality/eere/pdfs/EEREmanual.pdf.
[37] U.S. EPA, *Incorporating Emerging and Voluntary Measures in a State Implementation Plan (SIP)* (September 2004). Available at http://www.epa.gov/ttncaaa1/t1/memoranda/ereseerem_gd.pdf.

technical approach that combines traditional air quality modeling with less traditional assessment tools. [38] This is the approach being used by Maryland in its ozone SIP as it seeks to obtain the multi-pollutant benefits from the energy efficiency and renewable energy policies in its GGRA Plan.

The ozone SIP sensitivity analysis presented in section 3.1.6 provides an expanded weight-of-evidence approach for projecting total $NO_X$ reductions from GGRA measures not currently captured in SIP baseline forecasts or in ozone control strategies. These are estimated to be in the range of 1,200 to 1,600 tons in 2017, which is Maryland's ozone attainment deadline for the 0.075 ppb ozone NAAQS (current NAAQS at the time of this analysis). Additional $NO_X$ reductions in the range of 2,200 to 2,600 tons are projected in 2023, which is relevant to maintaining the current ozone NAAQS, as well as achieving a possible future revised ozone NAAQS, as EPA proposed at the end of 2014.[39]

To give context for these the projected annual $NO_X$ emission reductions from Maryland's GGRA policies, NESCAUM previously estimated state-level $NO_X$ reductions from the introduction of low sulfur gasoline (10 parts per million sulfur) under the EPA's then potential Tier 3 rule for gasoline-powered vehicles. Assuming an introduction year of 2017, NESCAUM estimated a 5,000 ton annual $NO_X$ reduction in Maryland.[40] The $NO_X$ reductions projected under the ozone SIP sensitivity scenarios in the range of 1,200 to 2,600 tons of $NO_X$ indicate the potential for additional $NO_X$ reductions somewhat less than, but comparable to, projected Tier 3 reductions in Maryland. The Tier 3 program represents one of the largest, if not the largest, measure in Maryland for reducing $NO_X$ emissions in 2017 and beyond, and the results of the ozone sensitivity runs indicate the potential for additional $NO_X$ reductions of a similar magnitude from the modeled GGRA policies.

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[38] *OTC Recommendations: Expanded Weight-of-Evidence (WOE) for Attainment Demonstrations*, OTC letter to C. Wayland and S. Mathias, U.S. EPA Office of Air Quality Planning and Standards (June 17, 2011). Available at http://www.otcair.org/upload/Interest/Modeling/OTC%20Expanded%20Weight-of-Evidence%20Letter%20and%20Recommendation.pdf (accessed September 19, 2014).

[39] *National Ambient Air Quality Standards for Ozone*, 79 Fed. Reg. 75234-75411 (December 17, 2014).

[40] NESCAUM White Paper, *Assessment of Clean Gasoline in the Northeast and Mid-Atlantic States*, NESCAUM (Boston, MA) November 21, 2011 (Table 4-2), available at http://www.nescaum.org/documents/nescaum-tier-3-low-s-gasoline-20111121.pdf.

# 5. SUMMARY

The 2009 Maryland Greenhouse Gas Emissions Reduction Act (GGRA) calls for a 25 percent reduction in GHGs from 2006 levels by 2020. A multi-pollutant analysis using the Multi-pollutant Policy Analysis Framework (MPAF) provides insight on a range of potential air quality, energy, and economic impacts arising from GHG mitigation programs undertaken in response to the GGRA. Through the MPAF integrated process, this analysis has provided insight to the Maryland Department of the Environment (MDE) on potential co-benefits these reduction measures can have in achieving the State's climate and air quality goals.

The MPAF consists of the following model components to provide a broad view of climate and air quality program impacts:

5. NE-MARKAL, a Northeast version of the MARKet ALlocation (MARKAL) model, an energy model that is widely used in Europe. EPA has a nine-region national version of this model, called US9r;
6. Regional Economic Models, Inc. (REMI), a 12-state model that evaluates the effects of policies and programs on the economies of local regions;
7. EPA's Community Multi-scale Air Quality (CMAQ) model, which assesses future air quality changes for a set of policies and programs;
8. EPA's Environmental Benefits Mapping and Analysis Program (BenMAP), which estimates health impacts and associated monetized values resulting from changes in ambient air pollution.

NESCAUM worked with MDE to select policies for analysis from the GGRA Plan of 2012 that were of key interest from a policy perspective and were most appropriate for characterizing in the NE-MARKAL model. After selecting the policies, the next step was to characterize and calibrate them within NE-MARKAL.

Two meta-scenarios, an initial and an enhanced, were developed and analyzed through the MPAF. Each meta-scenario combined all of the selected policies into a single NE-MARKAL run that captured their interactive effects. The initial meta-scenario was comprised of selected policies as they were defined in the GGRA Plan of 2012. The enhanced meta-scenario was comprised of a combination of individual policies, some of which had enhanced goals defined either in the GGRA Plan or by MDE. Initial and enhanced policy definitions were provided either in the GGRA Plan or by MDE. Note that enhanced policies not based on the GGRA Plan are for analytical exercise purposes only, and may not reflect current Maryland policy.

The multi-pollutant planning exercise demonstrated that the GGRA policies collectively made positive contributions to near-term air quality outcomes, including the 2020 GGRA climate target..

The analysis also indicated that further reductions in $CO_2$ emissions are needed to meet a hypothetical 80 percent reduction goal by 2050. In order to meet longer-term emission reduction goals, more measures involving the transportation sector would need to be considered. Climate sensitivity analyses undertaken as an extension of the meta-scenarios analyses found that in 2050, the combination of the most aggressive modeled GGRA policies alone lowered Maryland's reference case 2050 GHG emissions from almost 90 million tons of $CO_2$ to about 46 million tons (other GHGs were not considered in these analyses). This is still about 30 million tons short of a 2050 80 percent GHG reduction target of 17 million tons (relative to 2006 emissions). Of the 46 million tons, about 35 million tons comes from the transportation sector. This is not surprising, as the sensitivity analyses focused on more aggressive options for renewable energy and energy efficiency, while more aggressive transportation policies were not considered.

The GGRA measures in the two meta-scenarios also led to projected emission reductions in $NO_X$ and $SO_2$, key precursor pollutants for the criteria pollutants ozone ($NO_X$) and $PM_{2.5}$ ($NO_X$ and $SO_2$) over the modeling timeframe through 2023. Cumulatively over this time period, the initial meta-scenario projected reductions of 63,000 tons of $NO_X$ and 399,000 tons of $SO_2$ in Maryland. Larger reductions were seen for the enhanced meta-scenario, with 70,000 tons of $NO_X$ and 492,000 tons of $SO_2$ reduced.

A selected set of GGRA measures that were included in an ozone SIP sensitivity analysis demonstrated promise for achieving additional $NO_X$ reductions relevant to Maryland's ozone SIP timelines (2017 to 2023). These $NO_X$ reductions go beyond current ozone SIP baseline projections and enforceable control strategies, thus they provide the technical basis for an expanded weight-of-evidence demonstration of reasonably foreseeable $NO_X$ reductions in excess of those attributable to traditional ozone SIP measures.

The estimated additional $NO_X$ reductions from the GGRA measures are in the range of 1,200 to 1,600 tons in the year 2017, which is Maryland's ozone attainment deadline for the 0.075 ppb ozone NAAQS (current NAAQS at the time of this analysis). Additional $NO_X$ reductions in the range of 2,200 to 2,600 annual tons are projected for the year 2023, which is relevant to maintaining the current ozone NAAQS, as well as achieving a possible future revised ozone NAAQS. By way of comparison, the annual $NO_X$ reductions projected under the ozone SIP sensitivity scenarios are somewhat less than, but comparable to, projected annual $NO_X$ reductions from gasoline passenger vehicles in Maryland expected from implementation of EPA's Tier 3 motor vehicle program. The Tier 3 program represents one of the largest, if not the largest, measure in Maryland for reducing $NO_X$ emissions in 2017 and beyond, and the results of the ozone sensitivity runs indicate the potential for additional $NO_X$ reductions of a similar magnitude from the modeled GGRA policies.

The projected changes in emissions estimated by NE-MARKAL give rise to modeled air quality improvements for ozone and $PM_{2.5}$ in Maryland and in regions outside of the State. In the enhanced meta-scenario, CMAQ projected a maximum ozone reduction benefit of over 0.8 ppb centered on Maryland with further benefit in southeastern Pennsylvania, New Jersey, New York City, and Connecticut. The greatest reductions in particulate matter in Maryland are found near Baltimore/Edgewood and in the vicinity of power plants within the State. Decreases in $SO_2$ emissions in Maryland are most noticeable around city centers and power plants, such as those in western (Dickerson) and southern (Chalk Point) Maryland.

The improvements in modeled ozone and $PM_{2.5}$ air quality give rise to positive net health benefits in terms of avoided adverse health outcomes, including premature mortality. These avoided health incidences were quantified, along with their monetized benefits, using EPA's BenMAP tool coupled with the modeled air quality changes in ozone and $PM_{2.5}$ from CMAQ for each of the meta-scenarios.

As a result of the air quality changes attributable to the GGRA meta-scenarios, the BenMAP analysis found many reduced incidences of respiratory ailment, asthma attack, heart attack, hospital room visits, and lost work and school days. The monetary benefits of these public health improvements were driven largely by the reduced mortality, which includes (within Maryland) 43 to 100 avoided deaths per year due to reduced ozone and $PM_{2.5}$ under the initial meta-scenario, and 84 to 192 avoided deaths per year under the enhanced meta-scenario.

The monetized value of avoided mortality within Maryland ranges between $420 million to $850 million per year under the initial meta-scenario, and between $810 million to $1.6 billion per year under the enhanced meta-scenario, assuming a 3 percent discount rate for future health effects. With a 7 percent discount rate, the value is $320 million to $740 million per year under the initial meta-scenario, and $620 million to $1.4 billion under the enhanced meta-scenario.

The regional economic assessment using REMI found that overall, the GGRA measures as analyzed under the initial meta-scenario will benefit Maryland's economy with respect to jobs, wages, and real disposable income growth. However, the output and value added to Maryland's economy may decline given the large declines in demand for energy and maintenance associated with the electric power sector in the short term. Private, state, and households' continual structured investments in the economy toward GGRA goals under the enhanced meta-scenario mitigated some loss reported in the initial meta-scenario. Specifically, programs associated with increasing public transit helped to offset the later declines. The initial work creates construction jobs within the region, but the longer benefits associated with reduced motor fuel purchases and maintenance of private vehicles provide additional disposable income to households in the form of savings. Given this newly acquired disposable income, consumers are more likely to spend it locally, thereby creating additional induced impacts. Review of both scenarios indicates there will be a short-term negative impact incurred for implementation, but Maryland's economy benefits from nearly 20 additional years of increased jobs, wages, and output in the long-term.

# Appendix A: NE-MARKAL Input Assumptions, Scenario Descriptions, and Methodology

## A.1. Introduction

Appendix A describes the core database input assumptions for the Northeast version of the MARKet ALlocation (NE-MARKAL) model[41] and reviews the specific scenarios and data developed for the Maryland weight-of-evidence planning exercise. We introduce the model, describe basic NE-MARKAL data structures and input assumptions—including tables with key data elements that constitute a typical MARKAL energy model—and document the Maryland-specific weight-of-evidence reference case calibration. We then define each strategy simulation run for the weight-of-evidence multi-pollutant exercise in terms of its specific NE-MARKAL modeling representation. It is important to note that while the timeframe for the GGRA analysis was 2008-2023 and the timeframe for the sensitivity analysis was 2008-2050, the full NE-MARKAL database is specified over the 2005-2053 timeframe. All tables and charts in this section will cover the 2005-2053 timeframe. In addition, all cost data were deflated to 2005 dollars to be consistent with the NE-MARKAL database, which was normalized across all sectors and technologies to a 2005 dollar basis.

## A.2. The NE-MARKAL Model

NE-MARKAL is an economy-wide model that encompasses the entire energy infrastructure of the Northeast; it is capable of modeling all energy demand and supply in the transportation, commercial, industrial, residential, and power generation sectors.[42] The model contains highly-detailed depictions of energy technologies and their associated economic factors, such that each generated technology combination is based on the relative costs of the various energy technology options and constraints on the energy system.

As a linear programming model that optimizes outcomes based on cost, NE-MARKAL's strength is in exploring the relative cost-effectiveness of meeting various policy goals, such as limits on $CO_2$ emissions from power generation or minimum performance requirements on vehicles. NE-MARKAL is not a computable general equilibrium model that generates estimates of economy-wide price and welfare effects (i.e., gains or losses of producer and consumer surplus) associated with introducing various policies. It is, however, one of the few models of its kind that considers all energy-consuming sectors and characterizes energy use, emissions of GHGs and criteria air pollutants, technology deployment, and costs at a high level of detail. This formulation provides a powerful tool for decision-makers to assess the relative benefits of environmental policies, viewed individually or collectively.

In the NE-MARKAL modeling framework, the energy infrastructure is configured to meet the estimated demand for energy using the most cost-effective technologies and fuel sources. The model can be configured to represent enforceable

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[41] For information on the MARKAL model, *see* Loulou, R., G. Goldstein, and K. Noble, The MARKAL Family of Models, Energy Technology Systems Analysis Programme (ETSAP), October 2004. See www.etsap.org.

[42] NE-MARKAL currently includes the six New England states, New York, New Jersey, Pennsylvania, Delaware, Maryland, and Washington, D.C., and focuses primarily on the power generation, transportation, and buildings sectors.

requirements as well as incentives, such as energy efficiency programs, carbon mitigation strategies, and vehicle performance standards. The NE-MARKAL model currently begins in 2005 and models state and regional energy decision-making out to 2053 in three year time increments. For the core GGRA analysis, the modeling timeframe ranged between the years 2008 and 2023. For the climate sensitivity analysis, however, the timeframe was extended to 2050. Modeled outcomes from NE-MARKAL include: GHG and criteria pollutant emissions, energy consumption, and a variety of cost metrics.

There are a number of important caveats to keep in mind when assessing modeled NE-MARKAL results. (1) NE-MARKAL is best suited for "what-if" exploratory analysis of climate and air quality policies that probes a variety of possible technological and resource outcomes; the modeled results do not represent simulation-based forecasts of future energy, technology, and emissions trends. (2) NE-MARKAL is focused on a region's energy infrastructure and as such is best suited to assess policies aimed at technology and resource choices in this domain. The model, for example, is not well suited to assess policies aimed at land-use, agriculture, or waste management practices. (3) The electricity sector in NE-MARKAL uses a simplified load duration curve representation which breaks a typical year into 6 aggregate time-slices. This precludes analysis of policies aimed at affecting peak-generation resources and other scenarios aimed at shifting short-term load.

## A.3. Core NE-MARKAL Database Input Assumptions

This section describes the database inputs required to run a baseline NE-MARKAL reference case scenario. The core NE-MARKAL database was constructed from several data sources. Foremost of these was the U.S. Department of Energy's Energy Information Administration (EIA) Annual Energy Outlook (AEO) and the Environmental Protection Agency's (EPA's) US 9 Region MARKAL database (US9R). Technology characterizations were extracted from the US9R database, along with data on base year technology stocks, resource supply options, and the sectoral growth rates used in developing demand projections for each model region (state). Other data sources included: the State Energy Data System (SEDS), which provides final energy use for each demand sector by fuel type; Gross State Product data from the Bureau of Economic Analysis; EIA's three sectoral energy consumption surveys; and EPA's eGRID emissions database.

The data presented in the following sections characterize the cost, operation, and configuration of the various components of the region's energy infrastructure, from basic energy resource supply and electricity generation to all end-use demands and demand technologies. The baseline reference case is typically not calibrated to specific policies; rather, energy supply outcomes and technology choices are based solely on the objective of satisfying the projected demand through least-cost optimization.

This policy-neutral reference case was then examined and compared against state and regional energy and environmental policy trends to understand where least-cost projections may have differed from conventional wisdom or known policy direction. In areas where the baseline reference case needed adjustment, the choice of technology deployment and fuel share constraints were tailored to better reflect a reasonable "business as usual" reference for specific state and regional policy analysis exercises. The calibrated Maryland-specific NE-MARKAL reference case used in the weight-of-evidence is described in section A.4.

## A.3.1. Energy Supply Input Assumptions

**Table A-1** lists the updates and data sources for the NE-MARKAL energy supply and emissions characterization. In the NE-MARKAL database, energy supply refers to all of the data necessary to characterize the core fuel supply infrastructure in the NE-MARKAL region. In the model, $CO_2$ and all building sector emissions factors are tracked at the fuel consumption level. These factors are presented in this section. Criteria emissions for all other sectors are tracked at the technology-specific level, and are discussed in the sector-specific sections that follow.

**Table A-1. Data Sources for Energy Supply Inputs**

| Model Input | Data Sources |
|---|---|
| Energy Price Projections | U.S. Department of Energy's (DOE's) Annual Energy Outlook (AEO) 2012 Reference Case Price Forecasts by Region |
| Carbon Dioxide Emissions Factors | Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model (GREET), version 1.8.c.0, ANL, 2009 / U.S. DOE's Energy Information Administration (EIA) Carbon Dioxide Emissions Coefficients by Fuel, 2013 |
| Residential and Commercial Criteria Emissions Factors | U.S. Environmental Protection Agency (EPA) US9R MARKAL database, version 1.1, 2012 |
| Biomass Resource Bounds | U.S. DOE Billion Ton Study, 2011 Update |

**Figures A-1** through **A-4** display the 2012 AEO energy price projections for the Mid-Atlantic region that were used in the NE-MARKAL analysis. AEO 2012 was the latest EIA forecast available when the NE-MARKAL database was set up and calibrated for this analysis.

After the calibration process was complete, AEO 2013 became available and the project team was interested in assessing whether there would be major implications for the outcomes of the project if AEO 2012 fuel price projections were updated to AEO 2013. NESCAUM collaborated with MDE to investigate differences between AEO 2012 and AEO 2013 fuel price projections. The investigation did not reveal any compelling reasons to replace AEO 2012 fuel price projections with AEO 2013 projections.

**Figure A-1. Commercial Sector Energy Price Projections, 2005–2053**

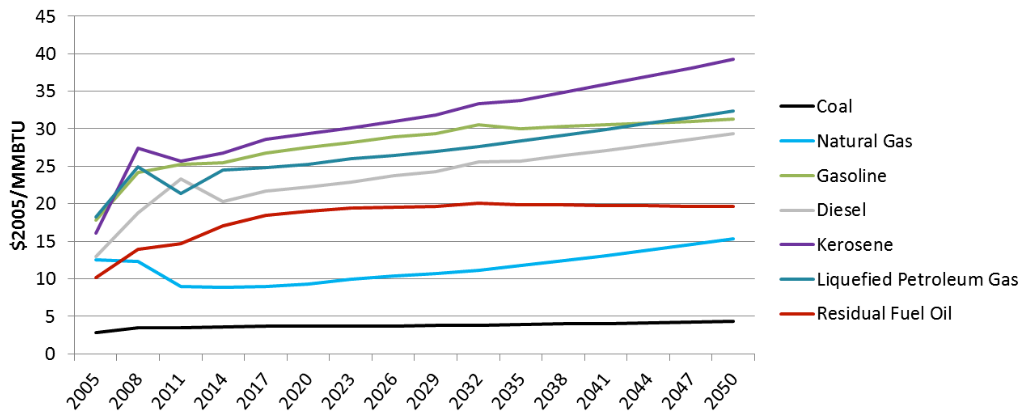



**Figure A-2. Residential Sector Energy Price Projections, 2005–2053**

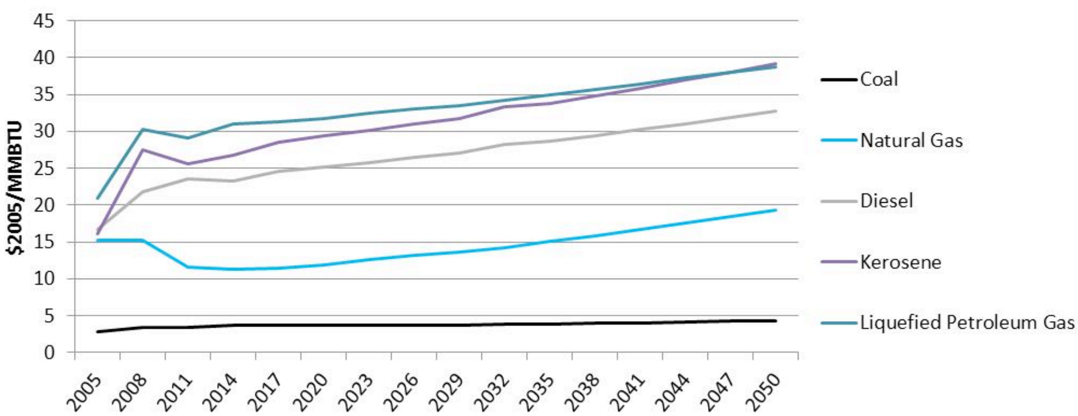



**Figure A-3. Power Sector Energy Price Projections, 2005–2053**

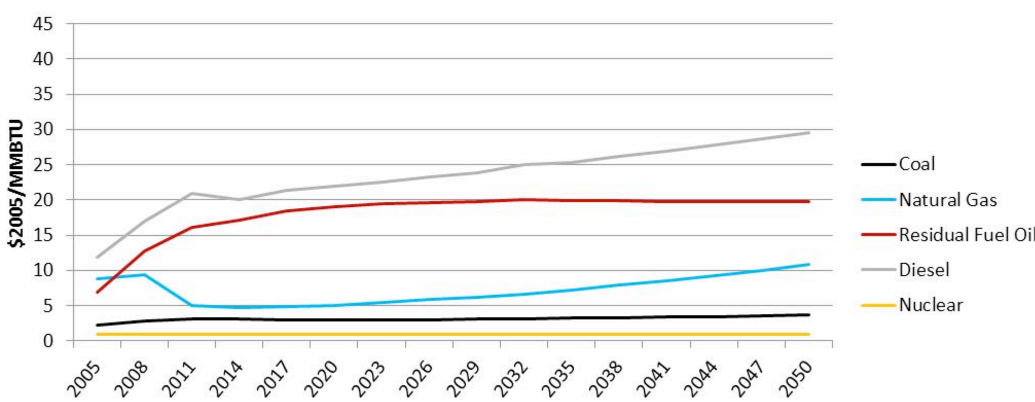



**Figure A-4. Transportation Sector Energy Price Projections, 2005–2053**

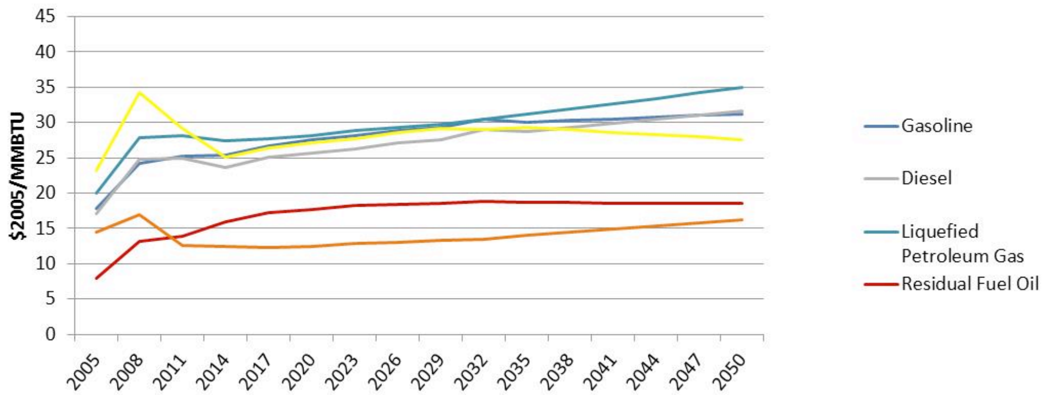



**Table A-2** presents $CO_2$ emissions factors used in the MARKAL model. The data sources for these emissions factors are: (1) the 2009 Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model developed by Argonne National Laboratory for the transportation sector ;[43] and (2) the EIA's *Carbon Dioxide Emissions Coefficients by Fuel 2013*[44] data set for all other sectors.

**Table A-2. $CO_2$ Emission Factors (in kT/tBTU)**

| Fuel | | Commerical Sector | Power Sector | Residential Sector | Transportation Sector |
|---|---|---|---|---|---|
| Coal | Bituminous | 95.35 | 93.31 | 95.35 | NA |
| | Sub-Bituminous | | 97.21 | | |
| Diesel | | 73.17 | NA | 73.17 | 70.91 |
| Gasoline | | 70.91 | NA | NA | 71.09 |
| Kerosene | | 72.30 | NA | 72.30 | NA |
| LPG | | 64.01 | NA | 64.01 | 62.68 |
| Natural Gas | | 53.07 | 53.14 | 53.07 | NA |
| Residual Fuel Oil | | 78.79 | 78.83 | NA | NA |
| Distillate Fuel Oil | | NA | 70.91 | NA | NA |
| Landfill Gas | | NA | 13.97 | NA | NA |
| MSW | | NA | 31.36 | NA | NA |
| Fossil Fuel Waste | | NA | 72.62 | NA | NA |
| E85 | | NA | NA | NA | 67.04 |
| CNG | | NA | NA | NA | 53.14 |
| B20X | | NA | NA | NA | 74.06 |
| LNG | | NA | NA | NA | 52.08 |
| RFH | | NA | NA | NA | 78.83 |
| JTF | | NA | NA | NA | 70.90 |

**Table A-3** presents criteria emissions factors for the residential and commercial sectors. These emissions factors came from the EPA US9R MARKAL database. Only the commercial and residential sectors track criteria emissions at the fuel level; the other sectors track criteria emissions at the technology-specific level.

**Table A-3. Commercial and Residential Criteria Emission Factors (in kT/tBTU)**

[43] https://greet.es.anl.gov/.
[44] http://www.eia.gov/environment/emissions/co2_vol_mass.cfm.

| | Fuel | SO2 | NOX | VOC | PM25 | CO |
|---|---|---|---|---|---|---|
| Commercial | Coal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | Diesel | 0.140 | 0.050 | 0.001 | 0.007 | 0.016 |
| | Gasoline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | Kerosene | 0.143 | 0.065 | 0.001 | 0.007 | 0.016 |
| | LPG | 0.000 | 0.066 | 0.003 | 0.000 | 0.019 |
| | Natural Gas | 0.000 | 0.044 | 0.002 | 0.003 | 0.037 |
| | Residual Fuel | 1.070 | 0.162 | 0.003 | 0.268 | 0.015 |
| Residential | Biomass-wood | 0.000 | 0.044 | 0.002 | 0.003 | 0.037 |
| | Coal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | Diesel | 0.139 | 0.059 | 0.002 | 0.007 | 0.016 |
| | Kerosene | 0.143 | 0.060 | 0.002 | 0.007 | 0.017 |
| | LPG | 0.000 | 0.066 | 0.003 | 0.000 | 0.019 |
| | Natural Gas | 0.000 | 0.041 | 0.002 | 0.000 | 0.018 |

**Table A-4** presents Maryland-specific biomass resource bounds between 2012 and 2030. For this analysis, "biomass" refers to dedicated biomass-fueled electric generating plants, and does not include disaggregated wood burning for residential heating or in outdoor wood-fired boilers. The values represent the maximum amount of biomass available for use in applications ranging from direct combustion in the power sector to thermal heating applications in the buildings sector. Within NE-MARKAL, each resource is also broken out into a number of cost categories (typically 10). The cost categories deployed first are the cheapest and easiest-to-recover types of each resource, and later include the more expensive and difficult-to-collect biomass resources. The data for the biomass resource bounds come from the U.S. DOE's Billion Ton Study, 2011 Update.[45]

**Table A-4. Biomass Resource Bounds (in million tons)**

| | 2012 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|
| Agricultural Residues | 2.1 | 2.1 | 2.4 | 2.8 | 3.0 |
| Annual Energy Crops | 0.000 | 0.022 | 0.022 | 0.022 | 0.022 |
| Grassy Energy Crops | 0.0 | 1.8 | 4.1 | 2.4 | 4.2 |
| Woody Energy Crops | 0.0 | 0.5 | 1.5 | 3.1 | 4.0 |
| Soybeans | 137.6 | 129.1 | 135.3 | 136.6 | 139.0 |
| Forest Residues | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 |
| Mill Residues | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| C&D Waste | 3.1 | 3.1 | 3.2 | 3.3 | 3.4 |
| MSW | 1.6 | 1.7 | 1.7 | 1.8 | 1.8 |

## A.3.2. Power Sector Input Assumptions

The power sector updates were divided into two categories: existing and new power plants. The key differences in characterizing new versus existing power plants are that existing plants are represented by the residual capacity of each generating unit in the NE-MARKAL region, and thus do not require investment cost parameters. New power plants are represented from a suite of technologies in the database available for future investment. The database contains groupings of new power plant types that are broader than those of existing power plants.

[45] https://bioenergykdf.net/content/billiontonupdate.

### *A.3.2.1. Existing Power Plants*

**Table A-5** presents the inputs and data sources used to model the existing power plants in NE-MARKAL. The set of power plants represented in the NE-MARKAL model was mined from EPA's National Electric Energy Data System (NEEDS) Base Case, version 4.10. The database was developed by EPA's Clean Air Markets Division, and contains operational characteristics and emissions information for all power plants in the United States. It is also used as a key data source for EPA to analyze electric sector-related impacts from air quality programs, such as the National Ambient Air Quality Standards (NAAQS), the Clean Air Interstate Rule (CAIR), the Cross State Air Pollution Rule (CSAPR), and various regional haze regulations. The NEEDS database was the primary source of operational and emissions data for the NE-MARKAL database. Supplemental data sources for emissions and operational characteristics included the EPA US9R MARKAL database and EIA Forms 860 and 923. Operating cost data were mined from the EIA report *Updated Estimates of Power Plant Capital and Operating Costs*.

**Table A-5. Data Sources for Existing Power Plant Inputs**

| Model Input | Data Sources |
|---|---|
| Existing Plants in the NE-MARKAL States<br>• Capacity<br>• Heat Rate<br>• Start Year<br>• Nitrogen Oxides, Mercury, and Sulfur Dioxide Emissions Factors | EPA National Electric Energy Data System (NEEDS) Version 4.10 Database |
| Carbon Monoxide, Volatile Organic Compounds, and Fine Particulate Emissions Factors | EPA US9R MARKAL database, version 1.1, 2012 |
| Capacity Factors | EIA Forms 860 & 923, 2005-2011 |
| Fixed and Variable Operation and Maintenance Costs | EIA Updated Estimates of Power Plant Capital and Operating Costs, 2012 |

**Tables A-6** through **A-9** list all of the existing power plants in Maryland that were represented in the multi-pollutant planning exercise. The tables are sorted by primary plant fuel type, and present the operational and emissions characteristics used in the NE-MARKAL optimization framework to determine the electricity generation mix and emissions profile over the modeled timeframe.

**Table A-6. Existing Maryland Coal Power Plants**

| Unit Name | Fuel | Start Year | Life | Retirement | Efficiency | Capacity (MW) | Emission Factors (kt/TBtu) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | SO2 | NOX | VOC | PM25 | CO |
| MD - R Paul Smith Power Station - 9 | Coal | 1947 | 60 | 2007 | 28.9% | 28 | 1.800 | 0.311 | 0.000 | 0.004 | 0.001 |
| MD - R Paul Smith Power Station - 11 | Coal | 1958 | 60 | 2018 | 23.1% | 87 | 1.800 | 0.422 | 0.000 | 0.004 | 0.136 |
| MD - Dickerson - 1 | Coal | 1959 | 60 | 2019 | 31.5% | 182 | 2.800 | 0.200 | 0.000 | 0.004 | 0.136 |
| MD - Herbert A Wagner - 2 | Coal | 1959 | 60 | 2019 | 26.2% | 135 | 1.450 | 0.320 | 0.000 | 0.004 | 0.129 |
| MD - Dickerson - 2 | Coal | 1960 | 60 | 2020 | 31.6% | 182 | 2.800 | 0.200 | 0.000 | 0.004 | 0.136 |
| MD - C P Crane - 1 | Coal | 1961 | 60 | 2021 | 30.0% | 200 | 3.500 | 0.250 | 0.000 | 0.004 | 0.129 |
| MD - Dickerson - 3 | Coal | 1962 | 60 | 2022 | 31.3% | 182 | 2.800 | 0.200 | 0.000 | 0.004 | 0.136 |
| MD - C P Crane - 2 | Coal | 1963 | 60 | 2023 | 30.6% | 200 | 3.500 | 0.250 | 0.000 | 0.004 | 0.129 |
| MD - Chalk Point LLC - 1 | Coal | 1964 | 60 | 2024 | 30.2% | 341 | 3.500 | 0.060 | 0.000 | 0.004 | 0.136 |
| MD - Chalk Point LLC - 2 | Coal | 1965 | 60 | 2025 | 30.2% | 342 | 3.500 | 0.060 | 0.000 | 0.004 | 0.136 |
| MD - Herbert A Wagner - 3 | Coal | 1966 | 60 | 2026 | 31.5% | 324 | 1.450 | 0.071 | 0.000 | 0.004 | 0.129 |
| MD - Morgantown Generating Plant - 1 | Coal | 1970 | 60 | 2030 | 33.2% | 624 | 3.500 | 0.059 | 0.000 | 0.004 | 0.136 |
| MD - Morgantown Generating Plant - 2 | Coal | 1971 | 60 | 2031 | 33.8% | 620 | 3.500 | 0.060 | 0.000 | 0.004 | 0.136 |
| MD - Brandon Shores - 1 | Coal | 1984 | 60 | 2044 | 34.8% | 643 | 1.200 | 0.078 | 0.000 | 0.004 | 0.001 |
| MD - Brandon Shores - 2 | Coal | 1991 | 60 | 2051 | 33.3% | 643 | 1.200 | 0.082 | 0.000 | 0.004 | 0.001 |
| MD - AES Warrior Run Cogeneration Facility - BLR1 | Coal | 2000 | 60 | 2060 | 28.1% | 180 | 0.420 | 0.053 | 0.000 | 0.004 | 0.001 |

# Table A-7. Existing Maryland Distillate Power Plants

| Unit Name | Fuel | Start Year | Life | Retirement | Efficiency | Capacity (MW) | Emission Factors (kt/TBtu) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | SO2 | NOX | VOC | PM25 | CO |
| MD - Easton - 8 | Distillate | 1957 | 60 | 2017 | 29.8% | 2 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Easton - 9 | Distillate | 1961 | 60 | 2021 | 29.8% | 3 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Berlin - 1A | Distillate | 1961 | 60 | 2021 | 23.1% | 1 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Chalk Point LLC - GT1 | Distillate | 1967 | 60 | 2027 | 19.9% | 18 | 0.300 | 0.807 | 0.001 | 0.006 | 0.136 |
| MD - Dickerson - GT1 | Distillate | 1967 | 60 | 2027 | 18.3% | 13 | 0.300 | 0.807 | 0.001 | 0.006 | 0.136 |
| MD - C P Crane - GT1 | Distillate | 1967 | 60 | 2027 | 16.5% | 14 | 1.053 | 0.807 | 0.001 | 0.006 | 0.136 |
| MD - Herbert A Wagner - GT1 | Distillate | 1967 | 60 | 2027 | 18.2% | 14 | 1.053 | 0.807 | 0.001 | 0.006 | 0.136 |
| MD - Easton - 11 | Distillate | 1968 | 60 | 2028 | 29.8% | 4 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Crisfield - CRS4 | Distillate | 1968 | 60 | 2028 | 28.7% | 3 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Crisfield - CRS3 | Distillate | 1968 | 60 | 2028 | 28.7% | 3 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Crisfield - CRS2 | Distillate | 1968 | 60 | 2028 | 28.7% | 3 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Crisfield - CRIS | Distillate | 1968 | 60 | 2028 | 28.7% | 3 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Vienna Operations - 10 | Distillate | 1968 | 60 | 2028 | 19.4% | 16 | 2.106 | 0.807 | 0.001 | 0.006 | 0.080 |
| MD - Smith Island - 2 | Distillate | 1969 | 60 | 2029 | 18.7% | 0 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Morgantown Generating Plant - GT1 | Distillate | 1970 | 60 | 2030 | 21.8% | 16 | 0.300 | 0.807 | 0.001 | 0.006 | 0.136 |
| MD - Philadelphia - GT4 | Distillate | 1970 | 60 | 2030 | 20.3% | 16 | 1.053 | 0.807 | 0.001 | 0.006 | 0.136 |
| MD - Philadelphia - GT2 | Distillate | 1970 | 60 | 2030 | 20.3% | 16 | 1.053 | 0.807 | 0.001 | 0.006 | 0.136 |
| MD - Philadelphia - GT3 | Distillate | 1970 | 60 | 2030 | 20.3% | 16 | 1.053 | 0.807 | 0.001 | 0.006 | 0.136 |
| MD - Philadelphia - GT1 | Distillate | 1970 | 60 | 2030 | 20.3% | 16 | 1.053 | 0.807 | 0.001 | 0.006 | 0.080 |
| MD - Riverside - GT7 | Distillate | 1970 | 60 | 2030 | 18.6% | 17 | 1.053 | 0.807 | 0.001 | 0.006 | 0.080 |
| MD - Riverside - GT8 | Distillate | 1970 | 60 | 2030 | 18.6% | 17 | 1.053 | 0.807 | 0.001 | 0.006 | 0.080 |
| MD - Morgantown Generating Plant - GT2 | Distillate | 1971 | 60 | 2031 | 21.8% | 16 | 0.300 | 0.807 | 0.001 | 0.006 | 0.136 |
| MD - Perryman - GT2 | Distillate | 1972 | 60 | 2032 | 18.5% | 52 | 1.053 | 0.372 | 0.001 | 0.006 | 0.136 |
| MD - Perryman - GT3 | Distillate | 1972 | 60 | 2032 | 19.5% | 52 | 1.053 | 0.490 | 0.001 | 0.006 | 0.136 |
| MD - Perryman - GT1 | Distillate | 1972 | 60 | 2032 | 20.1% | 52 | 1.053 | 0.493 | 0.001 | 0.006 | 0.136 |
| MD - Perryman - GT4 | Distillate | 1972 | 60 | 2032 | 15.7% | 52 | 1.053 | 0.700 | 0.001 | 0.006 | 0.136 |
| MD - Morgantown Generating Plant - 6 | Distillate | 1973 | 60 | 2033 | 22.0% | 54 | 0.300 | 0.560 | 0.001 | 0.006 | 0.136 |
| MD - Morgantown Generating Plant - 5 | Distillate | 1973 | 60 | 2033 | 21.7% | 54 | 0.300 | 0.665 | 0.001 | 0.006 | 0.136 |
| MD - Morgantown Generating Plant - 4 | Distillate | 1973 | 60 | 2033 | 21.0% | 54 | 0.300 | 0.792 | 0.001 | 0.006 | 0.136 |
| MD - Morgantown Generating Plant - 3 | Distillate | 1973 | 60 | 2033 | 21.9% | 54 | 0.300 | 1.263 | 0.001 | 0.006 | 0.136 |
| MD - Chalk Point LLC - GT2 | Distillate | 1974 | 60 | 2034 | 18.3% | 30 | 0.300 | 2.288 | 0.001 | 0.006 | 0.136 |
| MD - Easton 2 - 22 | Distillate | 1978 | 60 | 2038 | 29.6% | 6 | 2.106 | 3.037 | 0.001 | 0.006 | 0.080 |
| MD - Easton 2 - 21 | Distillate | 1978 | 60 | 2038 | 29.6% | 6 | 2.106 | 3.037 | 0.001 | 0.006 | 0.080 |
| MD - Berlin - 5A | Distillate | 1989 | 60 | 2049 | 28.8% | 3 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Easton 2 - 24 | Distillate | 1989 | 60 | 2049 | 24.6% | 6 | 2.106 | 3.037 | 0.001 | 0.006 | 0.080 |
| MD - Easton 2 - 23 | Distillate | 1989 | 60 | 2049 | 24.6% | 6 | 2.106 | 3.037 | 0.001 | 0.006 | 0.080 |
| MD - Smith Island - 3 | Distillate | 1994 | 60 | 2054 | 18.7% | 1 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Easton - 102 | Distillate | 1995 | 60 | 2055 | 24.8% | 2 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Easton - 101 | Distillate | 1995 | 60 | 2055 | 24.8% | 2 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Easton 2 - 201 | Distillate | 1995 | 60 | 2055 | 29.6% | 2 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Easton 2 - 202 | Distillate | 1995 | 60 | 2055 | 24.7% | 2 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Berlin - 2A | Distillate | 1999 | 60 | 2059 | 28.8% | 2 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Berlin - 3A | Distillate | 1999 | 60 | 2059 | 28.8% | 2 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |
| MD - Berlin - 4A | Distillate | 2000 | 60 | 2060 | 28.8% | 2 | 0.300 | 2.505 | 0.001 | 0.006 | 0.136 |

# Table A-8. Existing Maryland Gas/Oil Power Plants

| Unit Name | Fuel | Start Year | Life | Retirement | Efficiency | Capacity (MW) | Emission Factors (kt/TBtu) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | SO2 | NOX | VOC | PM25 | CO |
| MD - Easton - 7 | Gas / Oil | 1954 | 60 | 2014 | 29.8% | 2 | 0.300 | 2.505 | 0.001 | 0.005 | 0.000 |
| MD - Herbert A Wagner - 1 | Gas / Oil | 1956 | 60 | 2016 | 25.9% | 131 | 1.100 | 0.250 | 0.002 | 0.004 | 0.129 |
| MD - Easton - 10 | Gas / Oil | 1966 | 60 | 2026 | 29.8% | 4 | 0.300 | 2.505 | 0.001 | 0.005 | 0.000 |
| MD - Riverside - GT6 | Gas / Oil | 1970 | 60 | 2030 | 18.6% | 127 | 0.001 | 0.216 | 0.001 | 0.005 | 0.080 |
| MD - Easton - 12 | Gas / Oil | 1970 | 60 | 2030 | 29.8% | 4 | 0.300 | 2.505 | 0.001 | 0.005 | 0.000 |
| MD - Easton - 13 | Gas / Oil | 1973 | 60 | 2033 | 29.8% | 6 | 0.300 | 2.505 | 0.001 | 0.005 | 0.000 |
| MD - Easton - 14 | Gas / Oil | 1973 | 60 | 2033 | 29.8% | 6 | 0.300 | 2.505 | 0.001 | 0.005 | 0.000 |
| MD - Chalk Point LLC - 3 | Gas / Oil | 1975 | 60 | 2035 | 23.8% | 612 | 0.920 | 0.127 | 0.002 | 0.004 | 0.129 |
| MD - Chalk Point LLC - 4 | Gas / Oil | 1981 | 60 | 2041 | 23.4% | 612 | 0.800 | 0.134 | 0.002 | 0.004 | 0.129 |
| MD - Chalk Point LLC - SGT1 | Gas / Oil | 1990 | 60 | 2050 | 23.1% | 84 | 0.200 | 0.194 | 0.001 | 0.005 | 0.080 |
| MD - Chalk Point LLC - GT5 | Gas / Oil | 1991 | 60 | 2051 | 20.8% | 109 | 0.200 | 0.045 | 0.001 | 0.005 | 0.080 |
| MD - Chalk Point LLC - GT6 | Gas / Oil | 1991 | 60 | 2051 | 20.3% | 109 | 0.200 | 0.071 | 0.001 | 0.005 | 0.080 |
| MD - Chalk Point LLC - GT4 | Gas / Oil | 1991 | 60 | 2051 | 23.0% | 86 | 0.200 | 0.076 | 0.001 | 0.005 | 0.080 |
| MD - Chalk Point LLC - GT3 | Gas / Oil | 1991 | 60 | 2051 | 23.4% | 86 | 0.200 | 0.082 | 0.001 | 0.005 | 0.080 |
| MD - Dickerson - GT2 | Gas / Oil | 1992 | 60 | 2052 | 28.9% | 147 | 0.300 | 0.135 | 0.001 | 0.005 | 0.080 |
| MD - Dickerson - GT3 | Gas / Oil | 1992 | 60 | 2052 | 27.6% | 147 | 0.300 | 0.172 | 0.001 | 0.005 | 0.000 |
| MD - Perryman - GT5 | Gas / Oil | 1995 | 60 | 2055 | 24.5% | 152 | 0.001 | 0.243 | 0.001 | 0.005 | 0.080 |
| MD - Panda Brandywine LP - 3 | Gas / Oil | 1996 | 60 | 2056 | 37.7% | 73 | 0.424 | 0.041 | 0.001 | 0.005 | 0.080 |
| MD - Panda Brandywine LP - 2 | Gas / Oil | 1996 | 60 | 2056 | 37.7% | 79 | 0.424 | 0.041 | 0.001 | 0.005 | 0.080 |
| MD - Panda Brandywine LP - 1 | Gas / Oil | 1996 | 60 | 2056 | 37.7% | 79 | 0.424 | 0.041 | 0.001 | 0.005 | 0.080 |
| MD - Millennium Hawkins Point - 2A | Gas / Oil | 2000 | 60 | 2060 | 39.6% | 1 | 0.424 | 0.031 | 0.001 | 0.005 | 0.080 |
| MD - Millennium Hawkins Point - 2B | Gas / Oil | 2000 | 60 | 2060 | 39.6% | 1 | 0.424 | 0.031 | 0.001 | 0.005 | 0.080 |
| MD - Millennium Hawkins Point - 1B | Gas / Oil | 2000 | 60 | 2060 | 39.6% | 1 | 0.424 | 0.031 | 0.001 | 0.005 | 0.080 |
| MD - Millennium Hawkins Point - 1A | Gas / Oil | 2000 | 60 | 2060 | 39.6% | 1 | 0.424 | 0.031 | 0.001 | 0.005 | 0.080 |
| MD - Millennium Hawkins Point - 3A | Gas / Oil | 2000 | 60 | 2060 | 39.6% | 1 | 0.424 | 0.031 | 0.001 | 0.005 | 0.080 |
| MD - Millennium Hawkins Point - ST1 | Gas / Oil | 2000 | 60 | 2060 | 39.6% | 1 | 0.424 | 0.031 | 0.001 | 0.005 | 0.080 |
| MD - Millennium Hawkins Point - 3B | Gas / Oil | 2002 | 60 | 2062 | 39.6% | 1 | 0.424 | 0.031 | 0.001 | 0.005 | 0.080 |
| MD - UMCP CHP Plant - 3 | Gas / Oil | 2003 | 60 | 2063 | 39.6% | 2 | 0.424 | 0.031 | 0.001 | 0.005 | 0.080 |
| MD - UMCP CHP Plant - 2 | Gas / Oil | 2003 | 60 | 2063 | 39.6% | 9 | 0.424 | 0.031 | 0.001 | 0.005 | 0.080 |
| MD - UMCP CHP Plant - 1 | Gas / Oil | 2003 | 60 | 2063 | 39.6% | 9 | 0.424 | 0.031 | 0.001 | 0.005 | 0.080 |
| MD - Easton 2 - 203 | Gas / Oil | 2004 | 60 | 2064 | 22.6% | 5 | 0.300 | 0.256 | 0.001 | 0.005 | 0.000 |
| MD - Easton 2 - 204 | Gas / Oil | 2004 | 60 | 2064 | 22.6% | 5 | 0.300 | 0.256 | 0.001 | 0.005 | 0.000 |

# Table A-9. Existing Maryland Hydro Power Plants

| Unit Name | Fuel | Start Year | Life | Retirement | Efficiency | Capacity (MW) | Emission Factors (kt/TBtu) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | SO2 | NOX | VOC | PM25 | CO |
| MD - Deep Creek - 1 | Hydro | 1925 | 60 | N/A | 100.0% | 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| MD - Deep Creek - 2 | Hydro | 1925 | 60 | N/A | 100.0% | 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| MD - Conowingo - 4 | Hydro | 1928 | 60 | N/A | 100.0% | 48 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| MD - Conowingo - 7 | Hydro | 1928 | 60 | N/A | 100.0% | 36 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| MD - Conowingo - 5 | Hydro | 1928 | 60 | N/A | 100.0% | 36 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| MD - Conowingo - 3 | Hydro | 1928 | 60 | N/A | 100.0% | 48 | 0.000 | 0.000 | 0.000 | 0.000 | 0.095 |
| MD - Conowingo - 2 | Hydro | 1928 | 60 | N/A | 100.0% | 36 | 0.000 | 0.000 | 0.000 | 0.000 | 0.095 |
| MD - Conowingo - 1 | Hydro | 1928 | 60 | N/A | 100.0% | 48 | 0.000 | 0.000 | 0.000 | 0.000 | 0.095 |
| MD - Conowingo - 6 | Hydro | 1928 | 60 | N/A | 100.0% | 36 | 0.000 | 0.000 | 0.000 | 0.000 | 0.095 |
| MD - Conowingo - 9 | Hydro | 1964 | 60 | N/A | 100.0% | 65 | 0.000 | 0.000 | 0.000 | 0.000 | 0.095 |
| MD - Conowingo - 8 | Hydro | 1964 | 60 | N/A | 100.0% | 65 | 0.000 | 0.000 | 0.000 | 0.000 | 0.095 |
| MD - Conowingo - 11 | Hydro | 1964 | 60 | N/A | 100.0% | 65 | 0.000 | 0.000 | 0.000 | 0.000 | 0.095 |
| MD - Conowingo - 10 | Hydro | 1964 | 60 | N/A | 100.0% | 65 | 0.000 | 0.000 | 0.000 | 0.000 | 0.095 |

## Table A-10. Existing Maryland Landfill Gas Power Plants

| Unit Name | Fuel | Start Year | Life | Retirement | Efficiency | Capacity (MW) | Emission Factors (kt/TBtu) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | SO2 | NOX | VOC | PM25 | CO |
| MD - Prince Georges County Brown Station Road - 3972 | LFG | 1987 | 60 | 2047 | 23.0% | 1 | 0.171 | 0.043 | 0.002 | 0.004 | 0.129 |
| MD - Prince Georges County Brown Station Road - 9314 | LFG | 1987 | 60 | 2047 | 23.0% | 1 | 0.171 | 0.043 | 0.002 | 0.004 | 0.129 |
| MD - Prince Georges County Brown Station Road - 9340 | LFG | 1987 | 60 | 2047 | 23.0% | 1 | 0.171 | 0.043 | 0.002 | 0.004 | 0.129 |
| MD - PG Cnty Brown Station Road II - 4 | LFG | 2003 | 60 | 2063 | 23.0% | 1 | 0.171 | 0.043 | 0.002 | 0.004 | 0.095 |
| MD - PG Cnty Brown Station Road II - 1 | LFG | 2003 | 60 | 2063 | 23.0% | 1 | 0.171 | 0.043 | 0.002 | 0.004 | 0.095 |
| MD - PG Cnty Brown Station Road II - 3 | LFG | 2003 | 60 | 2063 | 23.0% | 1 | 0.171 | 0.043 | 0.002 | 0.004 | 0.095 |
| MD - PG Cnty Brown Station Road II - 2 | LFG | 2003 | 60 | 2063 | 23.0% | 1 | 0.171 | 0.043 | 0.002 | 0.004 | 0.095 |
| MD - Eastern Landfill Gas LLC - 3 | LFG | 2006 | 60 | 2066 | 23.0% | 1 | 0.171 | 0.043 | 0.002 | 0.004 | 0.095 |
| MD - Eastern Landfill Gas LLC - 1 | LFG | 2006 | 60 | 2066 | 23.0% | 1 | 0.171 | 0.043 | 0.002 | 0.004 | 0.129 |
| MD - Eastern Landfill Gas LLC - 2 | LFG | 2006 | 60 | 2066 | 23.0% | 1 | 0.171 | 0.043 | 0.002 | 0.004 | 0.129 |
| MD - Newland Park SLF - 1 | LFG | 2007 | 60 | 2067 | 29.9% | 3 | 0.171 | 0.090 | 0.002 | 0.004 | 0.129 |
| MD - MACS_MD_Landfill Gas - 1 | LFG | 2011 | 60 | 2071 | 23.0% | 5 | 0.171 | 0.090 | 0.002 | 0.004 | 0.024 |
| MD - MACE_MD_Landfill Gas - 1 | LFG | 2011 | 60 | 2071 | 23.0% | 2 | 0.171 | 0.090 | 0.002 | 0.004 | 0.024 |

## Table A-11. Existing Maryland Municipal Solid Waste Power Plants

| Unit Name | Fuel | Start Year | Life | Retirement | Efficiency | Capacity (MW) | Emission Factors (kt/TBtu) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | SO2 | NOX | VOC | PM25 | CO |
| MD - Wheelabrator Baltimore Refuse - BLR2 | MSW | 1984 | 60 | 2044 | 16.2% | 20 | 0.344 | 0.310 | 0.005 | 0.006 | 0.024 |
| MD - Wheelabrator Baltimore Refuse - BLR1 | MSW | 1984 | 60 | 2044 | 16.2% | 20 | 0.344 | 0.310 | 0.005 | 0.006 | 0.024 |
| MD - Wheelabrator Baltimore Refuse - BLR3 | MSW | 1984 | 60 | 2044 | 16.2% | 20 | 0.344 | 0.310 | 0.005 | 0.006 | 0.024 |
| MD - Montgomery County Resource Recovery - 1 | MSW | 1995 | 60 | 2055 | 16.2% | 18 | 0.344 | 0.330 | 0.005 | 0.006 | 0.024 |
| MD - Montgomery County Resource Recovery - 3 | MSW | 1995 | 60 | 2055 | 16.2% | 18 | 0.344 | 0.340 | 0.005 | 0.006 | 0.024 |
| MD - Montgomery County Resource Recovery - 2 | MSW | 1995 | 60 | 2055 | 16.2% | 18 | 0.344 | 0.340 | 0.005 | 0.006 | 0.024 |

## Table A-12. Existing Maryland Natural Gas Power Plants

| Unit Name | Fuel | Start Year | Life | Retirement | Efficiency | Capacity (MW) | Emission Factors (kt/TBtu) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | SO2 | NOX | VOC | PM25 | CO |
| MD - Riverside - 4 | Natural Gas | 1951 | 60 | 2011 | 22.6% | 78 | 0.001 | 0.443 | 0.001 | 0.003 | 0.024 |
| MD - Notch Cliff - GT1 | Natural Gas | 1969 | 60 | 2029 | 18.0% | 16 | 0.001 | 0.476 | 0.001 | 0.003 | 0.024 |
| MD - Westport - GT5 | Natural Gas | 1969 | 60 | 2029 | 16.8% | 121 | 0.001 | 0.635 | 0.001 | 0.003 | 0.024 |
| MD - Notch Cliff - GT6 | Natural Gas | 1969 | 60 | 2029 | 18.0% | 16 | 0.300 | 0.476 | 0.001 | 0.003 | 0.024 |
| MD - Notch Cliff - GT3 | Natural Gas | 1969 | 60 | 2029 | 18.0% | 16 | 0.300 | 0.476 | 0.001 | 0.003 | 0.000 |
| MD - Notch Cliff - GT4 | Natural Gas | 1969 | 60 | 2029 | 18.0% | 16 | 0.300 | 0.476 | 0.001 | 0.003 | 0.000 |
| MD - Notch Cliff - GT5 | Natural Gas | 1969 | 60 | 2029 | 18.0% | 16 | 0.300 | 0.476 | 0.001 | 0.003 | 0.000 |
| MD - Notch Cliff - GT8 | Natural Gas | 1969 | 60 | 2029 | 18.0% | 16 | 0.300 | 0.476 | 0.001 | 0.003 | 0.000 |
| MD - Notch Cliff - GT2 | Natural Gas | 1969 | 60 | 2029 | 18.0% | 16 | 0.300 | 0.476 | 0.001 | 0.003 | 0.012 |
| MD - Notch Cliff - GT7 | Natural Gas | 1969 | 60 | 2029 | 18.0% | 16 | 0.300 | 0.476 | 0.001 | 0.003 | 0.012 |
| MD - Rock Springs Generation Facility - 2 | Natural Gas | 2003 | 60 | 2063 | 28.5% | 190 | 0.300 | 0.032 | 0.001 | 0.003 | 0.024 |
| MD - Rock Springs Generation Facility - 1 | Natural Gas | 2003 | 60 | 2063 | 27.5% | 190 | 0.300 | 0.037 | 0.001 | 0.003 | 0.024 |
| MD - Rock Springs Generation Facility - 3 | Natural Gas | 2003 | 60 | 2063 | 28.7% | 190 | 0.300 | 0.038 | 0.001 | 0.003 | 0.024 |
| MD - Rock Springs Generation Facility - 4 | Natural Gas | 2003 | 60 | 2063 | 26.9% | 190 | 0.300 | 0.040 | 0.001 | 0.003 | 0.024 |
| MD - Gould Street - 3 | Natural Gas | 2008 | 60 | 2068 | 28.6% | 100 | 0.354 | 0.150 | 0.001 | 0.003 | 0.000 |
| MD - MACS_MD_Combustion Turbine - 1 | Natural Gas | 2011 | 60 | 2071 | 29.5% | 30 | 0.354 | 0.080 | 0.001 | 0.003 | 0.012 |

## Table A-13. Existing Maryland Other Power Plants

| Unit Name | Fuel | Start Year | Life | Retirement | Efficiency | Capacity (MW) | Emission Factors (kt/TBtu) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | SO2 | NOX | VOC | PM25 | CO |
| MD - Calvert Cliffs Nuclear Power Plant - 1 | Nuclear | 1975 | 30 | N/A | 30.1% | 885 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| MD - Calvert Cliffs Nuclear Power Plant - 2 | Nuclear | 1977 | 32 | N/A | 30.1% | 874 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| MD - Vienna Operations - 8 | Residual Oil | 1971 | 60 | 2031 | 27.2% | 153 | 3.500 | 0.300 | 0.002 | 0.005 | 0.001 |
| MD - Herbert A Wagner - 4 | Residual Oil | 1972 | 60 | 2032 | 23.7% | 397 | 0.600 | 0.250 | 0.002 | 0.005 | 0.001 |
| MD - MACS_MD_Solar PV - 1 | Solar | 2011 | 60 | 2071 | 100.0% | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## *A.3.2.2. New Power Plants*

**Table A-14** presents key inputs and data sources for the new power plants that were modeled in the multi-pollutant planning exercise. These plants were characterized similarly to existing plants except for residual capacity, as new power plants do not have residual capacity in their base year.

**Table A-14. Data Sources for New Power Plant Inputs**

| Model Input | Data Sources |
|---|---|
| New Plant Types<br>• Operating Cost<br>• Investment Cost<br>• Capacity Factor<br>• Heat Rate | EIA Updated Estimates of Power Plant Capital and Operating Costs, 2012 |
| Criteria Pollutant Emission Factors | EPA US9R MARKAL database, version 1.1, 2012 |

**Table A-15** presents the operational characteristics of new power plants available to the model for investment in future years. The field entitled "Average Annual Percentage Change" represents the annual yearly decrease in the cost of investing in new power plants. Investment cost decline factors were based on the EIA's *Updated Estimates of Power Plant Capital and Operating Costs, 2012*.[46]

**Table A-15. New Power Plant Operating Characteristics**

| Technology | 2014 Investment Cost (2005$) | Average Annual % Change | Variable O&M Cost (2005$/MWh) | Fixed O&M Cost (2005$/kW) | Capacity Factor | Heatrate nth (BTU/kwh) |
|---|---|---|---|---|---|---|
| Scrubbed Coal New | $2,377 | -0.7% | 1.13 | 27.03 | 0.85 | 8,740 |
| Integrated Coal- Gasification Comb Cycle (IGCC) | $3,065 | -0.8% | 1.83 | 44.54 | 0.85 | 7,450 |
| Pulverized Coal with Carbon Sequestration | $4,113 | -0.9% | 1.13 | 57.61 | 0.85 | 9,316 |
| Conventional Gas/Oil Combined Cycle | $757 | -0.7% | 0.91 | 11.42 | 0.82 | 6,800 |
| Advanced Gas/Oil Combined Cycle | $821 | -0.8% | 0.83 | 13.32 | 0.82 | 6,333 |
| Advanced Combined Cycle with Carbon Sequestration | $1,617 | -0.9% | 1.72 | 27.55 | 0.85 | 7,493 |
| Conventional Combustion Turbine | $803 | -0.7% | 3.92 | 6.36 | 0.92 | 10,450 |
| Advanced Combustion Turbine | $558 | -0.9% | 2.63 | 6.10 | 0.92 | 8,550 |
| Municipal Solid Waste - Landfill Gas | $6,932 | 0.0% | 2.20 | 336.75 | 0.85 | 13,648 |
| Fuel Cells | $5,333 | 0.0% | 0.00 | 315.34 | 0.92 | 6,960 |
| Advanced Nuclear | $4,146 | -0.9% | 0.54 | 80.85 | 0.90 | 10,452 |
| Biomass | $3,251 | -0.9% | 1.34 | 91.56 | 0.85 | 13,500 |
| Geothermal | $2,156 | 0.0% | 0.00 | 97.87 | 0.50 | 9,756 |
| Conventional Hydropower | $1,922 | 0.0% | 0.67 | 12.85 | 0.90 | 9,756 |
| Wind | $1,793 | -1.2% | 0.00 | 34.28 | 0.00 | 9,756 |
| Wind Offshore | $3,927 | -0.6% | 0.00 | 64.14 | 0.00 | 9,756 |

**Table A-16** presents the emissions factors for new fossil fuel power plants available in future years. These factors came from the EPA US9R MARKAL database.

[46] http://www.eia.gov/forecasts/capitalcost/.

**Table A-16. New Power Plant Criteria Emissions Factors (kT/tBTU)**

| Technology | SO2 | NOX | VOC | PM25 | CO |
|---|---|---|---|---|---|
| Scrubbed Coal New | 1.197 | 0.056 | 0.000 | 0.004 | 0.001 |
| Integrated Coal- Gasification Comb Cycle (IGCC) | 1.197 | 0.056 | 0.000 | 0.004 | 0.001 |
| Pulverized Coal with Carbon Sequestration | 1.197 | 0.056 | 0.000 | 0.004 | 0.001 |
| Conventional Gas/Oil Combined Cycle | 0.739 | 0.051 | 0.001 | 0.003 | 0.027 |
| Advanced Gas/Oil Combined Cycle | 0.739 | 0.051 | 0.001 | 0.003 | 0.027 |
| Advanced Combined Cycle with Carbon Sequestration | 0.177 | 0.002 | 0.001 | 0.003 | 0.024 |
| Conventional Combustion Turbine | 0.177 | 0.002 | 0.001 | 0.003 | 0.024 |
| Advanced Combustion Turbine | 0.177 | 0.002 | 0.001 | 0.003 | 0.024 |
| Municipal Solid Waste - Landfill Gas | 0.172 | 0.077 | 0.005 | 0.006 | 0.129 |

## A.3.3. Commercial and Residential Sector Input Assumptions

The commercial and residential sectors collectively make up the end-use demands for the buildings sector, which is one of the two main end-use sectors modeled in this analysis. The other end-use sector, transportation, is covered in section A.3.4.
**Table A-17** presents key inputs and data sources for the NE-MARKAL buildings sector. Updates for this sector came primarily from the EPA US9R database.

**Table A-17. Data Sources for Commercial and Residential Building Inputs**

| Model Input | Data Sources |
|---|---|
| Energy Demand | EPA US9R MARKAL database, version 1.1, 2012<br>EIA State Energy Data System (SEDS) Database, 2012 |
| Technology Definitions<br>• Investment Costs<br>• Residual Capacity<br>• Operating Costs<br>• Lifetime<br>• Efficiency | EPA US9R MARKAL database, version 1.1, 2012<br>EIA SEDS Database, 2012 *(for residual capacity)* |

**Table A-18** summarizes Maryland-specific residential demand shares and growth rates over the modeled timeframe. These data are key inputs into the NE-MARKAL model and have a large impact on modeled energy consumption trends. The "Units" field indicates how particular demands are measured. Most demands are measured in energy units of trillion British Thermal Units (tBTU), with the exception of cooling and heating, which are measured in millions of units installed, and lighting, which is measured in billion lumens per year (bn-lum-yr).

**Table A-18. Summary of Residential Demand Shares and Growth**

| Demand | Units | % of Total Demand in 2005 | % of Total Demand in 2011 | % of Total Demand in 2053 | Average Annual Growth Rate from 2005-2011 | Average Annual Growth Rate from 2011-2053 |
|---|---|---|---|---|---|---|
| Space Cooling | tBTU | 38.0% | 45.8% | 49.3% | 6.9% | 1.7% |
| Space Heating | tBTU | 29.1% | 23.9% | 18.2% | 0.0% | 0.5% |
| Other Appliances - Electricity | tBTU | 18.2% | 15.9% | 21.0% | 4.9% | 2.6% |
| Other Appliances - Gas | tBTU | 2.7% | 2.2% | 2.0% | 0.2% | 1.0% |
| Other Appliances - LPG | tBTU | 1.4% | 1.3% | 1.5% | 11.5% | 2.1% |
| Water Heating | tBTU | 10.6% | 10.9% | 8.1% | 19.4% | 0.5% |
| Refrigeration | million units | 25.3% | 26.8% | 24.7% | 2.7% | 2.1% |
| Freezing | million units | 74.7% | 73.2% | 75.3% | 9.0% | 2.6% |
| Residential | bn-lum-yr | 100.0% | 100.0% | 100.0% | 1.0% | 2.1% |

**Table A-19** summarizes Maryland-specific commercial demand shares and growth rates over the modeled timeframe. As with the residential sector, these are important data inputs for the multi-pollutant modeling exercise. Most of these demands are measures in energy units (tBTU), except for commercial ventilation, which is tracked in trillion cubic feet per meter per hour (tcfm-hr).

**Table A-19. Summary of Commercial Demand Shares and Growth**

| Demand | Units | % of Total Demand in 2005 | % of Total Demand in 2011 | % of Total Demand in 2053 | Average Annual Growth Rate from 2005-2011 | Average Annual Growth Rate 2011-2053 |
|---|---|---|---|---|---|---|
| Space Cooling | tBTU | 32% | 31.5% | 27.6% | 0.6% | 1.2% |
| Office Equipment | tBTU | 6% | 5.2% | 6.6% | -1.8% | 2.8% |
| Space Heating | tBTU | 10% | 11.5% | 8.1% | 2.7% | 0.5% |
| Cooking | tBTU | 2% | 2.5% | 2.6% | 2.5% | 1.9% |
| Other - Diesel | tBTU | 5% | 4.9% | 2.0% | 0.5% | -0.6% |
| Other - Electricity | tBTU | 13% | 12.2% | 20.5% | 0.4% | 4.5% |
| Other - Gas | tBTU | 16% | 16.0% | 16.4% | 0.9% | 1.8% |
| Other - LPG | tBTU | 1% | 1.3% | 1.1% | 9.1% | 1.0% |
| Other - RFO | tBTU | 0% | 0.2% | 0.1% | -4.0% | 0.4% |
| Refrigeration | tBTU | 9% | 9.1% | 9.1% | 1.2% | 1.8% |
| Water Heating | tBTU | 5% | 5.6% | 5.8% | 1.6% | 1.9% |
| Lighting | bn-lum-yr | 100% | 100% | 100% | 2.1% | 1.8% |
| Ventilation | tcfm-hr | 100% | 100% | 100% | 1.3% | 1.9% |

**Tables A-20** and **A-21** present economic and operating characteristics of the residential and commercial technologies within the model. The sectors in each table correspond to the demand sectors in **Tables A-18** and **A-19**. Typically, within each technology group, a number of distinct technologies are represented. The distinct technologies are differentiated by the year they become available. Technology groups with larger numbers of distinct technologies generally represent groups with larger enhancements in efficiency.

## Table A-20. Summary of Residential Technology Characteristics

| Sector | Technology Group | # of Technologies | Investment Cost ($/MMBtu) | | Efficiency | |
|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max |
| Cooling | Central Air Conditioner | 4 | 9.1 | 14.7 | 4.1 | 6.7 |
| | Electric Heat Pump | 4 | 6.6 | 11.0 | 4.0 | 6.9 |
| | Geothermal Heat Pump | 2 | 11.5 | 15.0 | 4.1 | 7.8 |
| | Natural Gas Heat Pump | 1 | 12.2 | 12.2 | 0.7 | 0.7 |
| | Room Air Conditioner | 3 | 2.8 | 4.6 | 3.0 | 3.6 |
| Freezing | Freezer | 4 | 494.2 | 729.5 | 0.4 | 1.0 |
| Heating | Distillate Furnace | 3 | 6.6 | 9.0 | 0.8 | 1.0 |
| | Distillate Radiant | 3 | 9.2 | 11.5 | 0.9 | 1.0 |
| | Electric Heat Pump | 4 | 6.6 | 11.1 | 2.3 | 3.2 |
| | Electric Radiant | 1 | 3.7 | 3.7 | 1.0 | 1.0 |
| | Geothermal Heat Pump | 2 | 11.5 | 15.0 | 3.3 | 5.0 |
| | Kerosene Furnace | 3 | 6.6 | 9.1 | 0.8 | 1.0 |
| | Liquid Gas Furnace | 5 | 4.9 | 7.2 | 0.8 | 1.0 |
| | Natural Gas Furnace | 5 | 4.9 | 7.2 | 0.8 | 1.0 |
| | Natural Gas Heat Pump | 1 | 12.2 | 12.2 | 1.4 | 1.4 |
| | Natural Gas Radiant | 3 | 6.6 | 8.3 | 0.8 | 1.0 |
| Lighting | Compact Fluorescent Lighting | 1 | 3.0 | 3.0 | 2.1 | 2.1 |
| | Halogen Lighting | 1 | 0.5 | 0.5 | 0.6 | 0.6 |
| | Incandescent Lighting | 1 | 2.0 | 2.0 | 0.5 | 0.5 |
| | Linear Fluorescent | 1 | 1.3 | 1.3 | 2.6 | 2.6 |
| | Reflector Lamps | 3 | 2.0 | 6.8 | 0.3 | 1.5 |
| | Solid State | 1 | 96.0 | 96.0 | 4.0 | 4.0 |
| Refrigeration | Refrigeration | 8 | 482.4 | 1776.8 | 0.4 | 0.8 |
| Water Heating | Wood | 1 | 7.9 | 7.9 | 1.0 | 1.0 |
| | Distillate | 3 | 15.0 | 17.7 | 0.5 | 0.7 |
| | Electric Base | 5 | 4.7 | 15.0 | 0.9 | 2.4 |
| | Liquid Gas | 4 | 7.2 | 16.1 | 0.6 | 0.9 |
| | Natural Gas | 4 | 7.2 | 16.3 | 0.6 | 0.9 |

# Table A-21. Summary of Commercial Technology Characteristics

| Sector | Technology Group | # of Technologies | Investment Cost ($/MMBtu) | | Efficiency | |
|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max |
| Cooking | Electric Range | 2 | 4.1 | 4.7 | 0.7 | 0.8 |
| | Natural Gas Range | 2 | 2.9 | 4.0 | 0.5 | 0.6 |
| Cooling | Electric Air Source Heat Pump | 2 | 7.8 | 9.8 | 3.2 | 3.5 |
| | Electric Central Air Conditioner | 3 | 4.6 | 19.8 | 3.0 | 7.0 |
| | Electric Centrifugal Chiller | 2 | 1.8 | 4.5 | 7.2 | 9.4 |
| | Electric Ground Source Heat Pump | 2 | 14.3 | 17.3 | 4.1 | 8.1 |
| | Electric Reciprocating Chiller | 3 | 4.6 | 5.4 | 3.1 | 4.4 |
| | Electric Rooftop Air Conditioner | 2 | 9.4 | 26.0 | 3.3 | 4.1 |
| | Electric Wall/Window room Air Conditioner | 2 | 2.7 | 3.9 | 3.1 | 3.4 |
| | Natural Gas Heat Pump | 6 | 7.0 | 22.2 | 0.6 | 1.8 |
| Heating | Diesel Boiler | 2 | 1.8 | 2.6 | 0.8 | 0.9 |
| | Diesel Furnace | 1 | 1.4 | 1.4 | 0.8 | 0.8 |
| | Electric Air Source Heat Pump | 2 | 7.8 | 9.8 | 3.3 | 3.4 |
| | Electric Boiler | 2 | 1.6 | 1.6 | 0.9 | 0.9 |
| | Electric Groud Source Heat Pump | 2 | 14.3 | 17.3 | 3.5 | 4.9 |
| | Natural Gas Boiler | 2 | 3.1 | 3.9 | 0.8 | 1.0 |
| | Natural Gas Furnace | 2 | 1.0 | 1.1 | 0.8 | 0.9 |
| | Natural Gas Heat pump | 1 | 22.2 | 22.2 | 1.4 | 1.4 |
| Lighting | Fluorescent | 8 | 11.6 | 30.6 | 1.6 | 3.0 |
| | Halogen | 2 | 60.4 | 63.7 | 0.4 | 0.5 |
| | High Pressure Sodium | 2 | 24.1 | 73.4 | 1.4 | 2.2 |
| | Incandescent | 3 | 35.3 | 84.1 | 0.3 | 1.3 |
| | Light Emitting Diode | 1 | 179.0 | 179.0 | 4.0 | 4.0 |
| | Mercury Vapor | 2 | 21.5 | 62.2 | 0.8 | 0.9 |
| | Metal Halide | 2 | 22.5 | 41.8 | 1.5 | 1.7 |
| Refrigeration | Refrigeration | 16 | 17.5 | 267.0 | 0.5 | 7.5 |
| Ventilation | Electric CAV | 2 | 854.8 | 899.7 | 0.6 | 1.1 |
| | Electric VAV | 2 | 856.3 | 895.4 | 0.7 | 1.6 |
| Water Heating | Diesel | 3 | 2.1 | 2.2 | 0.8 | 0.8 |
| | Electric Heat Pump | 2 | 25.7 | 29.8 | 2.0 | 2.4 |
| | Solar | 2 | 23.2 | 28.7 | 2.5 | 3.0 |
| | Electric | 2 | 3.4 | 3.4 | 1.0 | 1.0 |
| | Natural Gas Instantaneous | 3 | 0.5 | 1.0 | 0.8 | 0.9 |
| | Natural Gas | 2 | 2.6 | 3.0 | 0.8 | 0.9 |

## A.3.4. Transportation Sector Input Assumptions

The transportation sector is broken out into light- and heavy-duty vehicles. Within each major class, a number of sub-categories of vehicle are represented in the NE-MARKAL model. **Table A-22** presents key inputs and data sources for the NE-MARKAL transportation sector.

**Table A-22. Data Sources for Transportation Inputs**

| Model Update | Data Sources |
|---|---|
| Energy Demand | EPA US9R MARKAL database, version 1.1, 2012<br>MOVES<br>EIA SEDS Database, 2012 |
| Technology Definitions<br>• Investment Costs<br>• Residual Capacity<br>• Operating Costs<br>• Lifetime<br>• Efficiency<br>• Criteria Emissions Factors | EPA US9R MARKAL database, version 1.1, 2012<br>EIA SEDS Database, 2012 *(for residual capacity)* |

**Table A-23** summarizes Maryland-specific transportation demand shares and growth rates over the modeled timeframe. The demands are measured in billion vehicle miles traveled (bVMT).

**Table A-23. Summary of Transportation Demand Shares and Growth**

| Demand | Units | % of Total Demand in 2005 | % of Total Demand in 2011 | % of Total Demand in 2053 | Average Annual Growth Rate from 2005-2011 | Average Annual Growth Rate 2011-2053 |
|---|---|---|---|---|---|---|
| Light-Duty | bVMT | 91.8% | 91.7% | 91.7% | 0.3% | 1.4% |
| Bus | bVMT | 0.2% | 0.2% | 0.2% | 0.2% | 0.9% |
| Medium-Duty | bVMT | 1.5% | 1.9% | 1.9% | 3.9% | 1.1% |
| Heavy-Duty | bVMT | 4.3% | 4.2% | 4.2% | 0.1% | 1.2% |
| Commercial Trucks | bVMT | 2.1% | 2.0% | 2.0% | -0.8% | 1.2% |

**Tables A-24** and **A-25** present economic and operating characteristics of light- and heavy-duty transportation technologies, respectively. The technology names represent distinct technology types within each major transportation class. The cost data in **Table A-24** are in 2005 dollars.

## Table A-24. Light-duty Vehicle Technology Characteristics

| Technology Class | Technology Name | 1st Year Investment Cost ($/bVMT) | O&M Cost ($/bVMT) | Efficiency (MPG) |
|---|---|---|---|---|
| Compact/mini | Gasoline | $2,606 | $38.5 | 25.1 |
| | Electric 100 mile range | $4,783 | $28.8 | |
| | Electric 200 mile range | $4,428 | $28.8 | |
| | Advanced Gasoline | $2,679 | $38.5 | 32.6 |
| | Diesel | $2,008 | $38.5 | 32.8 |
| | CNG | $2,357 | $34.6 | 27.6 |
| | Diesel Hybrid EV | $2,410 | $40.4 | 0.0 |
| | E85 Flex Fuel | $1,817 | $38.5 | 26.8 |
| | Hydrogen Fuel Cell | $5,859 | $40.4 | 48.5 |
| | Gasoline Hybrid EV | $2,367 | $40.4 | 46.0 |
| | LPG | $2,252 | $34.6 | 26.5 |
| | Gasoline Plug-in Hybrid EV | $2,220 | $40.4 | 67.6 |
| | Advanced E85 Flex Fuel | $2,682 | $38.5 | 32.4 |
| Fullsize | Gasoline | $2,154 | $43.3 | 25.4 |
| | Electric 100 mile range | $4,548 | $32.5 | |
| | Electric 200 mile range | $4,157 | $32.5 | |
| | Advanced Gasoline | $2,227 | $43.3 | 33.1 |
| | CNG | $2,911 | $38.9 | 25.4 |
| | Diesel Hybrid EV | $2,671 | $45.5 | |
| | Diesel | $2,322 | $43.3 | 31.4 |
| | E85 Flex Fuel | $2,162 | $43.3 | 25.7 |
| | Hydrogen Fuel Cell | $5,921 | $45.4 | 44.0 |
| | Gasoline Hybrid EV | $2,733 | $45.4 | 44.2 |
| | LPG | $2,597 | $38.9 | 25.4 |
| | Gasoline Plug-in Hybrid EV | $2,590 | $45.5 | 65.0 |
| | Advanced E85 Flex Fuel | $2,227 | $43.3 | 32.9 |
| Minivan | Gasoline | $2,052 | $43.3 | 22.3 |
| | Electric 100 mile range | $5,590 | $32.5 | |
| | Electric 200 mile range | $4,890 | $32.5 | |
| | Advanced Gasoline | $2,166 | $43.3 | 30.6 |
| | CNG | $2,696 | $38.9 | 23.1 |
| | Diesel Hybrid EV | $2,855 | $45.4 | 39.5 |
| | Diesel | $2,479 | $43.3 | 27.5 |
| | E85 Flex Fuel | $2,060 | $43.3 | 22.5 |
| | Hydrogen Fuel Cell | $6,891 | $47.6 | 34.7 |
| | Gasoline Hybrid EV | $2,564 | $45.5 | 37.0 |
| | LPG | $2,748 | $38.9 | 23.1 |
| | Gasoline Plug-in Hybrid EV | $2,646 | $45.5 | 55.3 |
| | Advanced E85 Flex Fuel | $2,166 | $43.3 | 29.2 |
| Pickup | Gasoline | $1,777 | $48.1 | 18.9 |
| | Electric 100 mile range | $5,511 | $36.1 | |
| | Electric 200 mile range | $4,781 | $36.1 | |
| | Advanced Gasoline | $1,891 | $48.1 | 25.9 |
| | CNG | $2,552 | $48.1 | 19.3 |
| | Diesel | $2,211 | $48.1 | 23.5 |
| | E85 Flex Fuel | $1,785 | $48.1 | 19.1 |
| | Gasoline Hybrid EV | $2,507 | $48.1 | 34.4 |
| | LPG | $2,598 | $48.1 | 19.3 |
| | Gasoline Plug-in Hybrid EV | $2,396 | $48.1 | 51.4 |
| | Advanced E85 Flex Fuel | $1,891 | $48.1 | 24.7 |
| Small SUV | Gasoline | $1,925 | $43.3 | 22.8 |
| | Electric 100 mile range | $5,120 | $32.5 | |
| | Electric 200 mile range | $4,516 | $32.5 | |
| | Advanced Gasoline | $2,039 | $43.3 | 31.3 |
| | Diesel Hybrid EV | $2,693 | $45.5 | 45.6 |
| | Diesel | $2,289 | $43.3 | 28.1 |
| | E85 Flex Fuel | $1,933 | $43.3 | 23.0 |
| | Hydrogen Fuel Cell | $6,358 | $45.5 | |
| | Gasoline Hybrid EV | $2,522 | $45.5 | 40.3 |
| | Gasoline Plug-in Hybrid EV | $2,519 | $45.5 | 60.3 |
| | Advanced E85 Flex Fuel | $2,063 | $43.3 | 33.2 |
| Large SUV | Gasoline | $2,907 | $43.3 | 18.3 |
| | Electric 100 mile range | $6,593 | $32.5 | |
| | Electric 200 mile range | $5,866 | $32.5 | |
| | Advanced Gasoline | $3,021 | $43.3 | 25.1 |
| | Diesel Hybrid EV | $3,737 | $45.5 | 39.1 |
| | Diesel | $3,290 | $43.3 | 22.7 |
| | E85 Flex Fuel | $2,915 | $43.3 | 18.5 |
| | Hydrogen Fuel Cell | $6,633 | $45.5 | 30.8 |
| | Gasoline Hybrid EV | $3,549 | $45.5 | 33.0 |
| | Gasoline Plug-in Hybrid EV | $3,501 | $45.5 | 49.4 |
| | Advanced E85 Flex Fuel | $3,021 | $43.3 | 24.0 |

**Table A-25. Heavy-duty Vehicle Characteristics**

| Technology Class | Technology Name | 1st Year Investment Cost ($2005/bVMT) | O&M Cost ($2005/bVMT) | Lifetime |
|---|---|---|---|---|
| Busses | Bus, Conventional/improved | $10,519 | $555.1 | 12 |
| | Bus, Advanced | $14,348 | $559.8 | 12 |
| | Bus, Conventional/improved Biodiesel | $10,808 | $524.2 | 12 |
| | Bus, Advanced | $14,348 | $544.3 | 12 |
| | Bus, Conventional/improved CNG | $12,211 | $639.7 | 12 |
| | Bus, Advanced CNG | $15,316 | $644.4 | 12 |
| | Bus, Hydrogen Fuel Cell | $63,772 | $1,317.1 | 12 |
| Commercial Trucks | Commercial Truck, Advanced Hybrid B20 | $1,905 | $55.3 | 15.5 |
| | Commercial Truck, Conventional/improved B20 | $1,420 | $56.0 | 15.5 |
| | Commercial Truck, Advanced CNG | $1,656 | $56.3 | 15.5 |
| | Commercial Truck, Conventional/improved CNG | $1,468 | $39.4 | 15.5 |
| | Commercial Truck, Advanced Hybrid Diesel | $1,905 | $31.0 | 15.5 |
| | Commercial Truck, Conventional/improved Diesel | $1,420 | $31.0 | 15.5 |
| | Commercial Truck, Advanced/hybrid E85 | $1,333 | $43.7 | 15.5 |
| | Commercial Truck, Conventional/improved E85 | $1,161 | $56.3 | 15.5 |
| | Commercial Truck, Advanced Tech Gasoline | $1,346 | $56.3 | 15.5 |
| | Commercial Truck, Conventional/improved Gasoline | $1,137 | $56.3 | 15.5 |
| | Commercial Truck, Hydrogen Fuel Cell | $2,696 | $56.3 | 15.5 |
| | Commercial Truck, Advanced/hybrid LPG | $1,612 | $56.3 | 15.5 |
| | Commercial Truck, Improved/conventional LPG | $1,436 | $56.3 | 15.5 |
| | Commercial Truck, LPG 2010 | $1,398 | $15.5 | 15.5 |
| Medium Duty Trucks | Medium Duty Truck, Advanced Tech B20 | $7,553 | $192.8 | 19 |
| | Medium Duty Truck, Conventional/improved B20 | $6,393 | $248.8 | 19 |
| | Medium Duty Truck, B20, 2010 | $6,277 | $248.8 | 19 |
| | Medium Duty Truck, Advanced Hybrid CNG | $7,844 | $248.8 | 19 |
| | Medium Duty Truck, Conventional/improved CNG | $6,834 | $207.8 | 19 |
| | Medium Duty Truck, Advanced Diesel | $7,551 | $136.8 | 19 |
| | Medium Duty Truck, Conventional/improved Diesel | $6,445 | $133.2 | 19 |
| | Medium Duty Truck, Advanced Hybrid Gasoline | $6,616 | $136.8 | 19 |
| | Medium Duty Truck, Conventional/improved Gasoline | $6,040 | $207.8 | 19 |
| | Medium Duty Truck, Advanced Hybrid LPG | $6,998 | $237.9 | 19 |
| | Medium Duty Truck, Conventional/improved LPG | $6,437 | $248.8 | 19 |
| Heavy Trucks | Heavy Truck, Short Haul, Advanced/hybrid B20 | $5,323 | $233.6 | 19 |
| | Heavy Truck, Short Haul, Conventional/improved B20 | $4,679 | $221.1 | 19 |
| | Heavy Truck, Short Haul, Advanced/hybrid CNG | $5,695 | $165.8 | 19 |
| | Heavy Truck, Short Haul, CNG existing | $5,076 | $166.0 | 19 |
| | Heavy Truck, Short Haul, Improved/conventional CNG | $5,026 | $165.9 | 19 |
| | Heavy Truck, Short Haul, Advanced/hybrid Diesel | $5,323 | $193.6 | 19 |
| | Heavy Truck, Short Haul, Conv./improved Diesel | $4,679 | $248.8 | 19 |
| | Heavy Truck, Short Haul, Gasoline, 2010 | $4,265 | $249.0 | 19 |
| | Heavy Truck, Long Haul, Diesel Conventional/improved 2010 | $1,721 | $148.9 | 12 |
| | Heavy Truck, Long Haul, Advanced/hybrid/smart way Diesel | $2,250 | $170.8 | 12 |
| | Heavy Truck, Long Haul, B20 Conventional/improved | $1,718 | $148.9 | 12 |
| | Heavy Truck, Long Haul, Advanced/hybrid/smart way B20 | $2,077 | $170.8 | 12 |
| | Heavy Truck, Long Haul, LNG 2010 | $2,389 | $289.8 | 12 |
| | Heavy Truck, Long Haul, Conventional LNG | $2,399 | $289.8 | 12 |
| | Heavy Truck, Long Haul, Advanced/hybrid/smart way LNG | $2,673 | $289.8 | 12 |

## A.4. Calibrated Maryland Reference Case

This section describes how the baseline NE-MARKAL reference case was modified or supplemented to reflect a Maryland-specific reference case for the weight-of-evidence exercise. It also presents the results for the energy and criteria emissions calibration. The calibration process was necessary for replacing the model's base default data (described in the sections above) to create the Maryland-specific reference case that was used for the analysis. **Figure A-5** qualitatively presents the NE-MARKAL calibration process.

For this analysis, the reference case NE-MARKAL energy calibration was accomplished in three phases:

(1) Aligning energy consumption in NE-MARKAL with observed historical trends between 2005 and 2011. This phase was executed by fixing NE-MARKAL energy consumption trends by sector and fuel type to Maryland-specific data reported in the EIA State Energy Data System (SEDS).

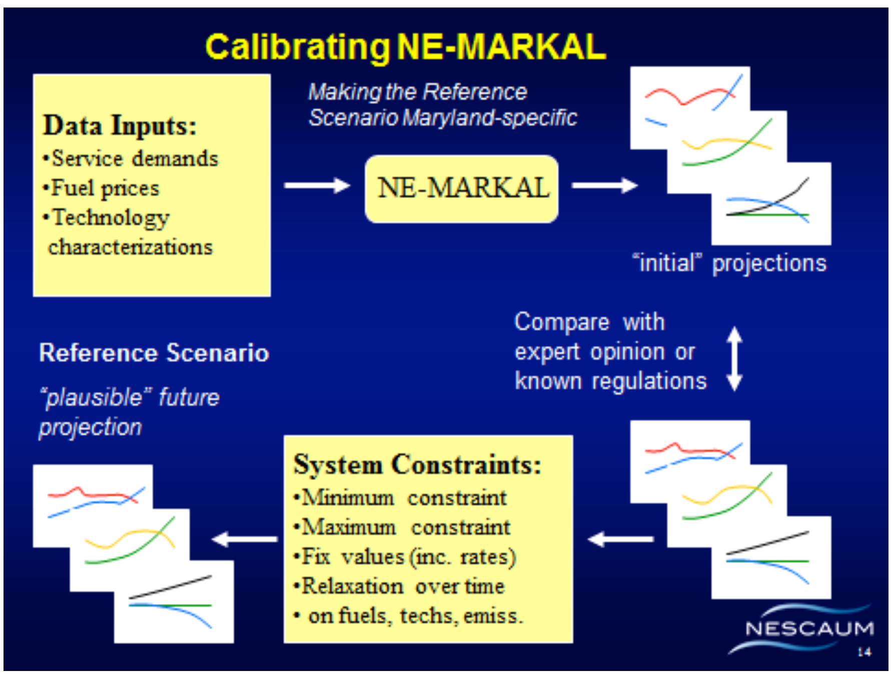
(2) Developing future NE-MARKAL reference case energy consumption trends by sector and fuel type.

a. Construct a set of benchmark future energy consumption trends that NE-MARKAL could be calibrated to by applying AEO 2012 energy consumption growth rates by sector and fuel for the 2011-2023 period to the SEDS data used in the first phase of the energy calibration.

b. Set up a series of soft constraints in NE-MARKAL by sector and fuel to ensure that the model's reference case energy consumption trends match the main features of the AEO 2012 reference case.

(3) Review full reference case energy calibration with MDE and other project stakeholders to identify potential issues.

**Figure A-5. Process for Calibrating NE-MARKAL**




NESCAUM conducted a series of weekly calls and in-person meetings to review and discuss the NE-MARKAL reference case calibration process. The review process, conducted over a 2 to 3 month period, was aimed at identifying potential issues with the energy calibration and to provide critical project partners an opportunity to provide feedback on the NE-MARKAL reference case. All modeled results were reviewed and approved by MDE, MEA, and MDOT before finalizing the multi-pollutant reference case and policy analysis scenarios. The NE-MARKAL model begins in 2005 and models state and regional energy decision-making out to 2053 in three year time increments.

For the core GGRA analysis, the modeling timeframe ranged between the years 2008 and 2023. For the climate sensitivity analysis, however, the timeframe was extended to 2050. The energy calibration was conducted over the full modeling timeframe of 2005-2053, which are presented in **Figures A-6** through **A-9**. In each of the calibration figures, the solid black line indicates the break between historical data calibration and future trend calibration. Values to the left of the black lines were fixed to historical trends while values to the right represent the AEO / SEDS benchmark future trends (dotted lines) and the calibrated NE-MARKAL future trends (solid lines). The goal of the NE-MARKAL future trend calibration was to qualitatively align with the AEO / SEDS benchmark trends while at the same time ensuring NE-MARKAL had flexibility to meet future climate and air quality modeling targets. The project partners approved the calibration as representing acceptable future trajectories for the reference case.

**Figure A-6. Commercial Sector Energy Calibration**

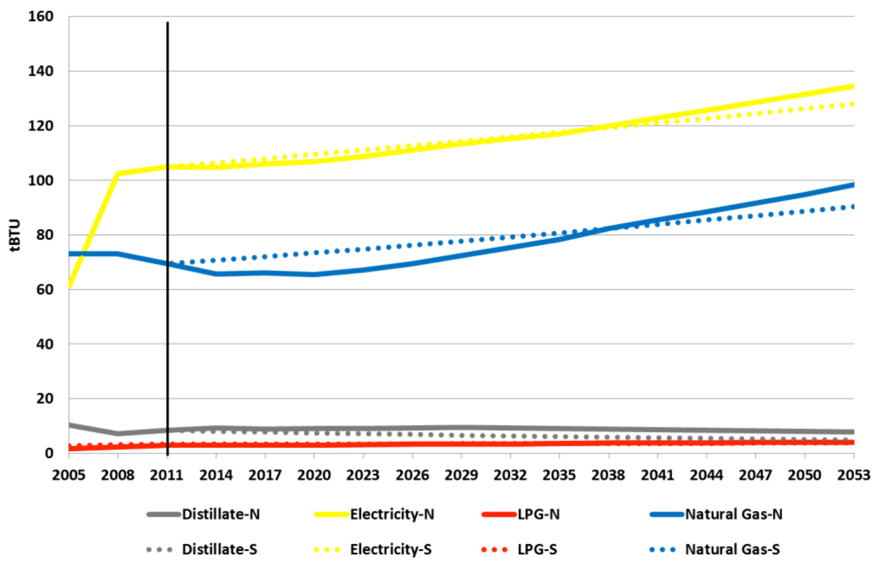


**Figure A-7. Residential Sector Energy Calibration**

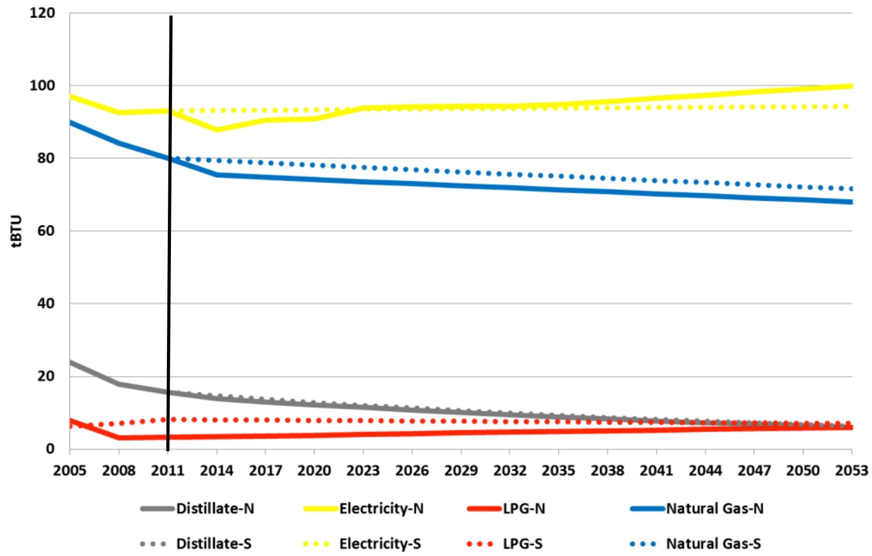



**Figure A-8. Power Sector Energy Calibration**

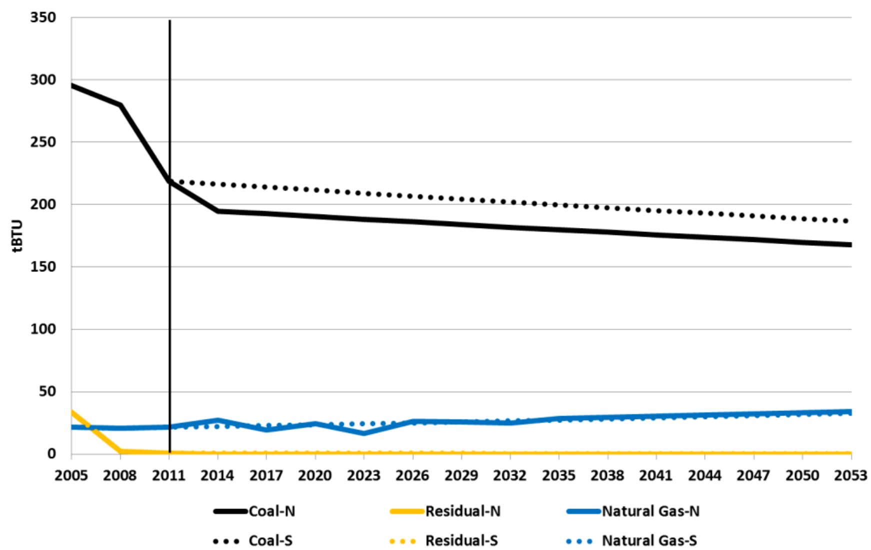


**Figure A-9. Transportation Sector Energy Calibration**

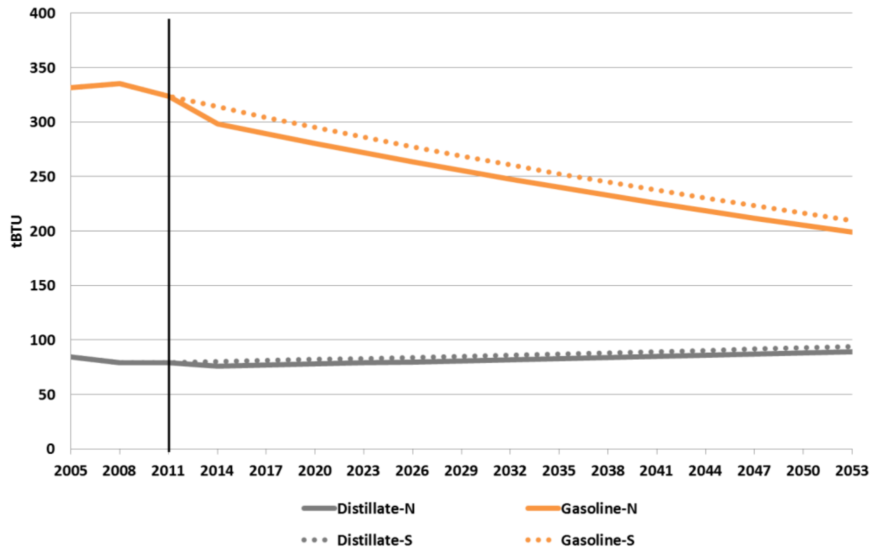



**Table A-26** presents the NE-MARKAL emissions calibration results. NESCAUM used 2008 emissions inventory data provided by MDE to benchmark the NE-MARKAL air emissions. The goal of the emissions calibration was to ensure that base year criteria emissions aligned well with the 2008 emissions inventory. We did not attempt to benchmark future NE-MARKAL air emissions to a particular set of modeled results. We felt that the energy calibration accomplished appropriate future trajectories for criteria air emissions. The results in **Table A-26** were reviewed and approved by MDE. We feel this calibration provides an acceptable starting point for the GGRA policy modeling efforts.

### Table A-26. Criteria Emissions Calibration

**Commercial Sector (2008, Thousand Tons)**

| | NE-MARKAL Output | Maryland Inventory Data | % Difference |
|---|---|---|---|
| CO | 6.6 | 6.5 | 1.3% |
| $PM_{2.5}$ | 0.1 | 0.1 | 29.8% |
| $NO_x$ | 3.8 | 3.4 | 11.2% |
| $SO_2$ | 1.8 | 1.7 | 9.2% |
| VOC | 0.3 | 0.3 | -17.2% |

**Residential Sector (2008, Thousand Tons)**

| | NE-MARKAL Output | Maryland Inventory Data | % Difference |
|---|---|---|---|
| CO | 2.4 | 2.4 | 2.0% |
| $PM_{2.5}$ | 0.2 | 0.2 | -5.1% |
| $NO_x$ | 5.5 | 5.3 | 3.4% |
| $SO_2$ | 2.5 | 2.9 | -14.1% |
| VOC | 0.3 | 0.3 | 3.2% |

**Power Sector (2008, Thousand Tons)**

| | NE-MARKAL Output | Maryland Inventory Data | % Difference |
|---|---|---|---|
| CO | 22.0 | 23.0 | -4.1% |
| $PM_{2.5}$ | 10.6 | 11.7 | -9.6% |
| $NO_x$ | 53.6 | 54.5 | -1.5% |
| $SO_2$ | 273.7 | 274.8 | -0.4% |
| VOC | 0.4 | 0.4 | -5.8% |

**Transportation Sector On-Road (Thousand Tons)**

| | NE-MARKAL Output | MARAMA MOVES | % Difference |
|---|---|---|---|
| CO | 468.4 | 471.6 | -0.7% |
| $PM_{2.5}$ | 3.7 | 3.8 | -3.5% |
| $NO_x$ | 118.8 | 124.9 | -4.9% |
| $SO_2$ | 0.8 | 1.0 | -16.6% |
| VOC | 35.0 | 35.1 | -0.1% |

## A.5. Developing Policy Scenarios for Modeling

After calibrating the reference case, MDE and NESCAUM defined policy scenarios to analyze. The goal was to identify two meta-scenarios comprised of individual GHG reduction policies that were part of Maryland's GGRA Plan. NESCAUM reviewed the GGRA Plan and identified 12 policies that were best suited for analysis within the NE-MARKAL modeling framework. NESCAUM then worked with MDE to define an initial and an enhanced meta-scenario. This required examining each policy and assessing initial and enhanced goals. For the initial meta-scenario, GGRA Plan policy goals were used. For the enhanced meta-scenario, NESCAUM used enhanced goals that were defined either in the GGRA Plan or by MDE. In some cases, especially with some of the transportation sector policies, only an initial version of the policy was defined for analysis in both meta-scenarios.

Once the initial and enhanced meta-scenarios were defined, the two meta-scenarios were translated into NE-MARKAL modeling runs. NESCAUM held a series of phone calls and in-person meetings with MDE, MEA, and MDOT to review how each meta-scenario was defined and to review the initial modeling results. After MDE approved the meta-scenario definitions and initial results, NESCAUM began to prepare a final spread sheet-based template to present the final versions of each meta-scenario.

**Table A-27** summarizes the initial and enhanced policies, and **Table A-28** summarizes which policies are contained in the two meta-scenarios, with “I” denoting initial policies and “E” denoting enhanced level policies. The scenarios highlighted in blue font, collectively referred to as the transportation bundle, remained at initial levels in both the initial and enhanced meta-scenarios.

**Table A-27. Initial and Enhanced Policy Definitions**

| Policy | Definition |
|---|---|
| **RGGI** | • Initial GGRA: model the RGGI cap before the updated model rule.<br>• Enhanced GGRA: model the 91 MT updated model rule cap (using scenario: 91cap alt bank MR). |
| **EmPOWER Maryland** | • Initial GGRA: reduce MD per capita total electricity consumption 15% by 2015 relative to 2007; represented as an energy efficiency program.<br>• Enhanced GGRA: expand energy efficiency to include natural gas |
| **MD RPS** | • Initial GGRA: require 20% qualified renewable generation regionally by 2022--only solar required in-state; the rest can come from the region.<br>• Enhanced GGRA: require 25% qualified renewable generation regionally by 2020.<br>• For both scenarios: (1) Tier 2 hydro to remain constant at 2.5% until 2018, and then sunset; (2) 2% solar by 2020. |
| **Main Street Initiatives** | • Initial GGRA: defined using the analysis of the low potential for energy efficiency provided by MDE.<br>• Enhanced GGRA: defined using the analysis of the high potential for energy efficiency provided by MDE |
| **Energy Efficiency for Affordable Housing** | • Initial GGRA: Use methodology on pp. 115-116 of the GGRA Plan at $6,500 per retrofit.<br>• Enhanced GGRA: Use methodology on pp. 115-116 of the GGRA Plan at $5,268 per retrofit. |
| **CAFE Model Year 2008-2011** | • NHTSA’s pre-existing 2008-2011 fuel efficiency standards of 20.5 mpg.<br>• No enhanced scenario. |

**Table A-27. Continued**

| Policy | Definition |
|---|---|
| **MD Clean Cars Program** | • For model years 2012-2025: assume passenger fleet achieves most recent CAFE standards (~54.5 mpg by 2025).<br>• No enhanced scenario. |
| **National Fuel Efficiency and Emissions Standards for Medium- and Heavy-Duty Trucks** | • EPA/NHTSA standards for model years 2012-2016 for medium- and heavy-duty trucks.<br>• Standard does not sunset after 2016.<br>• No enhanced scenario. |
| **Public Transportation and Intercity Transportation Initiatives** | • Initial GGRA: Assume 2.3% of Maryland's passenger vehicle fleet will be composed of BEVs and PHEVs by 2020.<br>• No enhanced scenario |
| **Building and Trade Codes** | • Commercial and residential buildings to increase energy efficiency by 15%, starting in 2012.<br>• No enhanced scenario. |
| **Gas Tax** | • Initial GGRA: Based on the documentation sent by MDOT, apply a gas tax of $0.24 per gallon.<br>• Enhanced GGRA: Based on the documentation sent by MDOT, apply a gas tax of $1.20 per gallon. |
| **Tier 3** | • Initial: Adopt new SO2, NOx, and PM standards for motor gasoline beginning in 2017.<br>• No enhanced scenario. |

**Table A-28** summarizes which policies are contained in the two meta-scenarios, with "I" denoting initial policies and "E" denoting enhanced level policies. The scenarios highlighted in blue font, collectively referred to as the transportation bundle, remained at initial levels in both the initial and enhanced meta-scenarios.

**Table A-28. Modeled Policies and Meta-scenario Definitions**

| | Scenario Definitions | |
|---|---|---|
| **Policy** | **Initial Meta-scenario** | **Enhanced Meta-scenario** |
| Regional Greenhouse Gas Initiative | I | E |
| Maryland Renewable Portfolio Standard | I | E |
| EmPOWER Maryland | I | E |
| Main Street | I | E |
| Energy Efficiency for Affordable Housing | I | E |
| **Maryland Clean Cars** | I | I |
| **CAFE 2008-2011** | I | I |
| **Fuel Efficiency for Medium and Heavy Duty Trucks** | I | I |
| **Public Transportation and Intercity Transportation Initiatives** | I | I |
| **Tier 3 Vehicle and Emission Standards** | I | I |
| Gas Tax | I | E |
| Building and Trade Codes | I | I |

## A.5.1. Individual Policy Descriptions

This section describes each policy that was included in the analysis. The initial and enhanced policy definitions were provided by either the GGRA Plan or MDE. Note that enhanced policies not based on the GGRA Plan are for analytical exercise purposes only, and may not reflect current Maryland policy.

### *A.5.1.1. The Regional Greenhouse Gas Initiative*

The initial version of the Regional Greenhouse Gas Initiative (RGGI) assumed that each RGGI state's $CO_2$ budget remained at levels determined in the 2008 model rule. The enhanced version was based on the 2012 program review carried out by RGGI, Inc.[47] For the enhanced version, the RGGI regional $CO_2$ cap in 2014 was set at 91 million metric tons; after 2014, the cap declines 2.5 percent each year, out to 2020.

### *A.5.1.2. Maryland Renewable Portfolio Standard*

The initial version of the Maryland Renewable Portfolio Standard (RPS) required 20 percent of electricity generation to come from qualified renewable sources by 2022. The enhanced RPS required 25 percent of electricity generation to come from qualified renewable sources by 2020. In both versions of the RPS, there are in-state solar and hydro carve-outs. The solar carve-out was modeled to reach 2 percent of total generation by 2020, and the hydro carve-out was modeled to reach 2.5 percent of total generation by 2018.

### *A.5.1.3. EmPOWER Maryland*

EmPOWER Maryland's initial target was to reduce per-capita electricity consumption 15 percent by 2015, relative to 2007. The electricity reduction was simulated as an energy efficiency scenario in the NE-MARKAL framework. The enhanced version of EmPOWER Maryland layered a natural gas efficiency component on top of the electric efficiency modeled in the initial version. The enhanced target for natural gas efficiency reduced forecast natural gas sales by 1.2 percent by 2020.

### *A.5.1.4. Main Street Initiative*

The initial policy for the Main Street Initiative set a savings target for residential and commercial energy efficiency in heating, cooling and lighting applications of 57,725 MMBtu between 2011 and 2020. The enhanced policy set an efficiency savings target of 94,540 MMBtu between 2011 and 2020.

### *A.5.1.5. Transportation Scenario Bundle*

The transportation bundle included five individual transportation sector policies. They were represented in both the initial and enhanced meta-scenario in their initial form, as follows:

- Maryland Clean Cars: For model years 2012-2025 all passenger vehicles were to achieve the most recent CAFE standards of 54.5 miles per gallon (mpg) by 2025.
- Corporate Average Fuel Economy (CAFE) 2008-2011: For model years 2008-2011 all passenger vehicles were to achieve 20.5 mpg.
- Fuel Efficiency for Medium- and Heavy-Duty Vehicles: Medium- and heavy-duty vehicles were to achieve the 2011 EPA/NHTSA CAFE standards.

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[47] http://www.rggi.org/rggi.

- Public Transportation and Intercity Transportation Initiatives: This policy assumed that 2.3 percent of Maryland's passenger vehicle fleet would be battery electric vehicles and plug-in hybrid electric vehicles by 2020.
- Tier 3 Motor Vehicle Emission and Fuel Standards: This policy assumed adoption of the new $NO_X$ and PM standards for all vehicles beginning in 2017, along with a low sulfur gasoline requirement.

### *A.5.1.6. Gas Tax*

The initial version of the gas tax policy assumed a $0.27 per gallon tax by 2020. The enhanced version of the gas tax assumed $1.20 per gallon tax by 2020, and a 3.3 percent reduction in VMT by 2020.

### *A.5.1.7. Energy Efficiency for Affordable Housing*

The initial policy for Energy Efficiency for Affordable Housing set a savings target for residential natural gas energy efficiency applications of 200,260 MMBtu between 2011 and 2020. The enhanced policy set a savings target for residential natural gas energy efficiency applications of 247,000 MMBtu between 2011 and 2020.

### *A.5.1.8. Building and Trade Codes*

Only an initial version of the building and trade codes policy was defined and used in both meta-scenarios. The policy assumed a 15 percent increase in the overall efficiency of commercial and residential buildings by 2020, with efficiency increases assumed to start in 2012.

## A.5.2. Policies Modeled Outside of NE-MARKAL

Two GGRA policies were important to analyze within the full Multi-pollutant Policy Analysis Framework but were not well-suited for modeling in NE-MARKAL. For these policies, emissions impacts were estimated through other methods by MDE and then incorporated into the data set that were used as inputs for CMAQ air quality modeling. The policies were:

- Zero Waste: Emission changes were treated as changes to area source emissions.
- Boiler MACT: Emission changes were applied directly to the affected boilers at the appropriate SCC level.

## A.6. References

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# Appendix B: NE-MARKAL Spreadsheet Results

Appendix B is available as a separate spreadsheet file from the Maryland Department of the Environment.

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# Appendix C: Emissions Changes for CMAQ Air Quality Modeling Analysis

**Table C-1. Domain-wide Reductions Based on a 2018 Modeling Scenario**

| SOURCE TYPE | *REGION* | *$NO_X$* | *$SO_2$* | *VOC* | *PM* | *CO* |
|---|---|---|---|---|---|---|
| ***AREA*** | **SESARM** | **-14.8%** | **-77.9%** | **-7.0%** | **-1.5%** | |
| | **CENRAP** | **-8.9%** | **-70.1%** | **-7.0%** | **-0.1%** | |
| | **LADCO** | **-10.8%** | **-61.5%** | **-7.0%** | **-0.7%** | |
| | **CANADA** | **-8.0%** | | **-7.0%** | | |
| | **2011 OIL&GAS** | | | | | |
| ***MAR*** | **DOMAIN** | **-31.0%** | | **-13.0%** | | |
| ***NONROAD*** | **DOMAIN** | **-43.0%** | | **-44.0%** | | |
| ***MOBILE*** | **DOMAIN** | **-51.4%** | **-13.4%** | **-46.9%** | **-34.6%** | **-30.1%** |
| ***NON-EGU POINT*** | **SESARM** | **-9.5%** | **-9.7%** | **-1.0%** | **-2.7%** | |
| | **CENRAP** | **-17.8%** | **-23.5%** | **-1.0%** | **-0.9%** | |
| | **LADCO** | **-13.9%** | **-28.3%** | **-1.0%** | **-3.6%** | |
| | **CANADA** | **-8.0%** | | **-1.0%** | | |
| ***EGU*** | **2018 ERTAC** | | | | | |

**Table C-2. Reference Case Percent Change in Emissions Sector by Pollutant by State**

| *Area* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -14.81% | -10.49% | -3.11% | -32.61% | -29.14% |
| DC | -0.57% | 5.71% | 15.00% | -44.74% | -22.31% |
| DE | 2.80% | 8.15% | 14.39% | -46.97% | -31.35% |
| MA | -7.53% | -5.24% | -0.17% | -14.46% | -11.95% |
| MD | 7.27% | 10.80% | 15.76% | -19.49% | -9.13% |
| ME | -3.56% | -1.25% | 2.47% | -11.00% | -8.30% |
| NH | -3.74% | -1.34% | 2.57% | -11.20% | -8.50% |
| NJ | -19.53% | -13.91% | -5.94% | -52.94% | -46.76% |
| NY | -15.92% | -11.58% | -4.78% | -38.30% | -30.58% |
| PA | -12.06% | -9.45% | -4.24% | -29.11% | -24.69% |
| RI | -22.40% | -16.50% | -7.43% | -45.85% | -41.54% |
| VT | -4.02% | -1.78% | 1.87% | -12.37% | -9.91% |

| *Non-EGU Point* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -7.60% | -2.13% | -13.79% | -59.20% | -56.55% |
| DC | 0.48% | -0.07% | 6.13% | -37.70% | -45.72% |
| DE | -79.07% | -26.28% | -5.95% | -85.25% | -72.72% |
| MA | -35.25% | -11.75% | -39.83% | -87.28% | -47.94% |
| MD | -64.62% | 13.85% | -16.51% | -88.77% | -75.95% |
| ME | 15.22% | -6.06% | 46.40% | -27.27% | -5.18% |
| NH | -53.40% | 61.29% | 60.57% | -94.13% | -29.11% |

| | | | | | |
|---|---|---|---|---|---|
| NJ | -59.81% | -4.61% | -31.30% | -93.50% | -62.27% |
| NY | -66.18% | -9.57% | -16.94% | -72.41% | -60.82% |
| PA | -75.77% | -0.14% | -17.39% | -94.78% | -60.43% |
| RI | -40.31% | -0.76% | -43.34% | -5.23% | -9.04% |
| VT | -0.44% | -23.52% | -39.70% | -24.32% | -14.74% |

| *Onroad* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| *All states* | -67.17% | -64.32% | -47.00% | -20.71% | -46.31% |

| *EGU* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -53.05% | -22.90% | 10.85% | -7.98% | -19.13% |
| DC | -95.30% | -88.90% | -98.12% | -63.32% | -93.33% |
| DE | -15.36% | -17.48% | -15.86% | -5.89% | -9.79% |
| MA | -22.13% | -0.68% | 36.52% | -10.28% | -0.19% |
| MD | -42.79% | -11.67% | -16.91% | -27.40% | -25.82% |
| ME | -55.65% | -38.60% | -19.93% | -59.52% | -41.06% |
| NH | -46.73% | -15.31% | -9.45% | -57.11% | -28.08% |
| NJ | -39.00% | -22.70% | -22.09% | -25.18% | -20.65% |
| NY | -29.45% | -10.29% | -4.32% | -16.65% | -9.34% |
| PA | -21.95% | -8.89% | -13.04% | -13.40% | -12.98% |
| RI | 5.94% | -15.70% | -9.74% | 2.15% | -14.58% |
| VT | -65.34% | -52.07% | -52.67% | -54.90% | -52.73% |

| *Nonroad* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -34.28% | -4.71% | -2.80% | -90.95% | -52.45% |
| DC | 19.86% | -0.11% | -2.49% | -92.65% | -34.77% |
| DE | -27.35% | -4.42% | -2.49% | -92.62% | -50.41% |
| MA | -34.63% | -4.73% | -2.80% | -90.95% | -52.52% |
| MD | -30.16% | -4.57% | -2.49% | -92.62% | -51.00% |
| ME | -36.69% | -4.81% | -2.80% | -90.94% | -52.92% |
| NH | -37.01% | -4.83% | -2.80% | -90.95% | -52.99% |
| NJ | -22.39% | -4.77% | -1.77% | -94.04% | -48.47% |
| NY | -18.80% | -4.47% | -1.77% | -94.04% | -47.64% |
| PA | -20.95% | -4.66% | -1.77% | -94.04% | -48.14% |
| RI | -31.87% | -4.60% | -2.80% | -90.95% | -51.98% |
| VT | -37.09% | -4.84% | -2.80% | -90.94% | -53.04% |

**Table C-3. Initial meta-scenario percent change in emissions sector by pollutant by state.**

| *Area* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -14.81% | -10.49% | -3.11% | -32.61% | -29.14% |
| DC | -0.57% | 5.71% | 15.00% | -44.74% | -22.31% |
| DE | 2.80% | 8.15% | 14.39% | -46.97% | -31.35% |
| MA | -7.53% | -5.24% | -0.17% | -14.46% | -11.95% |
| MD | -14.12% | 10.72% | 15.30% | -25.51% | -9.31% |
| ME | -3.56% | -1.25% | 2.47% | -11.00% | -8.30% |
| NH | -3.74% | -1.34% | 2.57% | -11.20% | -8.50% |
| NJ | -19.53% | -13.91% | -5.94% | -52.94% | -46.76% |
| NY | -15.92% | -11.58% | -4.78% | -38.30% | -30.58% |
| PA | -12.06% | -9.45% | -4.24% | -29.11% | -24.69% |
| RI | -22.40% | -16.50% | -7.43% | -45.85% | -41.54% |
| VT | -4.02% | -1.78% | 1.87% | -12.37% | -9.91% |

| *Non-EGU Point* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -7.60% | -2.13% | -13.79% | -59.20% | -56.55% |
| DC | 0.48% | -0.07% | 6.13% | -37.70% | -45.72% |
| DE | -79.07% | -26.28% | -5.95% | -85.25% | -72.72% |
| MA | -35.25% | -11.75% | -39.83% | -87.28% | -47.94% |
| MD | -64.75% | 13.85% | -16.51% | -88.89% | -75.97% |
| ME | 15.22% | -6.06% | 46.40% | -27.27% | -5.18% |
| NH | -53.40% | 61.29% | 60.57% | -94.13% | -29.11% |
| NJ | -59.81% | -4.61% | -31.30% | -93.50% | -62.27% |
| NY | -66.18% | -9.57% | -16.94% | -72.41% | -60.82% |
| PA | -75.77% | -0.14% | -17.39% | -94.78% | -60.43% |
| RI | -40.31% | -0.76% | -43.34% | -5.23% | -9.04% |
| VT | -0.44% | -23.52% | -39.70% | -24.32% | -14.74% |

| *Onroad* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| *All states* | -69.58% | -71.10% | -55.68% | -95.66% | -48.48% |

| *EGU* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -53.05% | -22.90% | 10.85% | -7.98% | -19.13% |
| DC | -95.30% | -88.90% | -98.12% | -63.32% | -93.33% |
| DE | -15.36% | -17.48% | -15.86% | -5.89% | -9.79% |
| MA | -22.13% | -0.68% | 36.52% | -10.28% | -0.19% |
| MD | -49.73% | -20.01% | -17.82% | -37.68% | -38.88% |
| ME | -55.65% | -38.60% | -19.93% | -59.52% | -41.06% |

| | | | | | |
|---|---|---|---|---|---|
| NH | -46.73% | -15.31% | -9.45% | -57.11% | -28.08% |
| NJ | -39.00% | -22.70% | -22.09% | -25.18% | -20.65% |
| NY | -29.45% | -10.29% | -4.32% | -16.65% | -9.34% |
| PA | -21.95% | -8.89% | -13.04% | -13.40% | -12.98% |
| RI | 5.94% | -15.70% | -9.74% | 2.15% | -14.58% |
| VT | -65.34% | -52.07% | -52.67% | -54.90% | -52.73% |

| *Nonroad* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -34.28% | -4.71% | -2.80% | -90.95% | -52.45% |
| DC | 19.86% | -0.11% | -2.49% | -92.65% | -34.77% |
| DE | -27.35% | -4.42% | -2.49% | -92.62% | -50.41% |
| MA | -34.63% | -4.73% | -2.80% | -90.95% | -52.52% |
| MD | -30.16% | -4.57% | -2.49% | -92.62% | -51.00% |
| ME | -36.69% | -4.81% | -2.80% | -90.94% | -52.92% |
| NH | -37.01% | -4.83% | -2.80% | -90.95% | -52.99% |
| NJ | -22.39% | -4.77% | -1.77% | -94.04% | -48.47% |
| NY | -18.80% | -4.47% | -1.77% | -94.04% | -47.64% |
| PA | -20.95% | -4.66% | -1.77% | -94.04% | -48.14% |
| RI | -31.87% | -4.60% | -2.80% | -90.95% | -51.98% |
| VT | -37.09% | -4.84% | -2.80% | -90.94% | -53.04% |

**Table C-4. Enhanced meta-scenario percent change in emissions sector by pollutant by state.**

| *Area* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -14.81% | -10.49% | -3.11% | -32.61% | -29.14% |
| DC | -0.57% | 5.71% | 15.00% | -44.74% | -22.31% |
| DE | 2.80% | 8.15% | 14.39% | -46.97% | -31.35% |
| MA | -7.53% | -5.24% | -0.17% | -14.46% | -11.95% |
| MD | -14.16% | 10.66% | 15.21% | -34.68% | -9.90% |
| ME | -3.56% | -1.25% | 2.47% | -11.00% | -8.30% |
| NH | -3.74% | -1.34% | 2.57% | -11.20% | -8.50% |
| NJ | -19.53% | -13.91% | -5.94% | -52.94% | -46.76% |
| NY | -15.92% | -11.58% | -4.78% | -38.30% | -30.58% |
| PA | -12.06% | -9.45% | -4.24% | -29.11% | -24.69% |
| RI | -22.40% | -16.50% | -7.43% | -45.85% | -41.54% |
| VT | -4.02% | -1.78% | 1.87% | -12.37% | -9.91% |

| *Non-EGU Point* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -7.60% | -2.13% | -13.79% | -59.20% | -56.55% |
| DC | 0.48% | -0.07% | 6.13% | -37.70% | -45.72% |
| DE | -79.07% | -26.28% | -5.95% | -85.25% | -72.72% |
| MA | -35.25% | -11.75% | -39.83% | -87.28% | -47.94% |
| MD | -65.48% | 13.85% | -16.51% | -89.59% | -76.10% |
| ME | 15.22% | -6.06% | 46.40% | -27.27% | -5.18% |
| NH | -53.40% | 61.29% | 60.57% | -94.13% | -29.11% |
| NJ | -59.81% | -4.61% | -31.30% | -93.50% | -62.27% |
| NY | -66.18% | -9.57% | -16.94% | -72.41% | -60.82% |
| PA | -75.77% | -0.14% | -17.39% | -94.78% | -60.43% |
| RI | -40.31% | -0.76% | -43.34% | -5.23% | -9.04% |
| VT | -0.44% | -23.52% | -39.70% | -24.32% | -14.74% |

| *Onroad* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| *All states* | -69.63% | -71.19% | -55.86% | -95.66% | -48.59% |

| *EGU* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -86.35% | -37.27% | 4.04% | -12.99% | -31.14% |
| DC | -95.30% | -88.90% | -98.12% | -63.32% | -93.33% |
| DE | -21.81% | -24.82% | -22.53% | -8.37% | -13.90% |
| MA | -28.49% | -0.88% | 26.03% | -13.23% | -0.24% |

| | | | | | |
|---|---|---|---|---|---|
| MD | -56.66% | -24.07% | -18.73% | -51.54% | -51.51% |
| ME | -62.87% | -43.60% | -22.51% | -67.24% | -46.38% |
| NH | -47.22% | -15.47% | -9.35% | -57.70% | -28.37% |
| NJ | -39.00% | -22.70% | -22.09% | -25.18% | -20.65% |
| NY | -47.97% | -16.75% | -7.04% | -27.13% | -15.22% |
| PA | -21.95% | -8.89% | -13.04% | -13.40% | -12.98% |
| RI | 4.76% | -18.81% | -11.67% | 1.72% | -17.46% |
| VT | -81.67% | -65.09% | -65.84% | -68.63% | -65.91% |

| *Nonroad* | $NO_X$ | VOC | CO | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| CT | -34.28% | -4.71% | -2.80% | -90.95% | -52.45% |
| DC | 19.86% | -0.11% | -2.49% | -92.65% | -34.77% |
| DE | -27.35% | -4.42% | -2.49% | -92.62% | -50.41% |
| MA | -34.63% | -4.73% | -2.80% | -90.95% | -52.52% |
| MD | -30.16% | -4.57% | -2.49% | -92.62% | -51.00% |
| ME | -36.69% | -4.81% | -2.80% | -90.94% | -52.92% |
| NH | -37.01% | -4.83% | -2.80% | -90.95% | -52.99% |
| NJ | -22.39% | -4.77% | -1.77% | -94.04% | -48.47% |
| NY | -18.80% | -4.47% | -1.77% | -94.04% | -47.64% |
| PA | -20.95% | -4.66% | -1.77% | -94.04% | -48.14% |
| RI | -31.87% | -4.60% | -2.80% | -90.95% | -51.98% |
| VT | -37.09% | -4.84% | -2.80% | -90.94% | -53.04% |

# Appendix D: BenMAP Health Benefits Assessment

## Introduction

This appendix describes the BenMAP analysis of health impacts from air quality changes associated with implementing strategies under Maryland's Greenhouse Gas Reduction Act (GGRA) Plan. It includes a detailed overview of the technical approach, summary of the results, and discussion of the conclusions and uncertainties inherent in the approach. We also provide contextual description of the health benefits model and its limitations. The analysis is part of a weight-of-evidence multi-pollutant exercise conducted for the Maryland Department of the Environment. The focus is on health benefits within Maryland, but we also present results for nearby states in the Mid-Atlantic and Northeast regions.

## Description of Assessment Tool and Approach

To assess the effects of improvement in air quality resulting from GGRA policies on human health, we used EPA's Environmental Benefits Modeling and Analysis Program, Community Edition (BenMAP-CE; USEPA 2014). BenMAP is a tool that has been extensively tested and used to determine the health impacts from air quality changes associated with many major national air quality policy initiatives. The model determines the magnitude and value of avoided adverse health endpoints associated with changes in air pollution.

Future year air quality associated with and without implementation of the GGRA control strategies were first simulated using the Community Multi-scale Air Quality modeling system (CMAQ), as described in Chapter 3. Two GGRA meta-scenarios were compared to a reference case, under which no GGRA control strategies were included. The two GGRA meta-scenarios are the initial and enhanced meta-scenarios. The initial meta-scenario included emissions reductions (compared to the reference case) for area sources, electric generating unit (EGU) point sources, and non-EGU point sources within Maryland, as well as mobile source emissions reductions in and beyond Maryland. The enhanced meta-scenario included additional in-state emissions reductions for those source sectors, as well as reductions in out-of-state EGU emissions. These policy scenarios are described in greater detail in the main body of the report and Appendix A.

BenMAP-CE is an open source and community-owned tool incorporating geographic information systems. BenMAP was designed by EPA to estimate health impacts and associated economic values resulting from changes in ambient air pollution. The model estimates health impacts by applying health impact functions that relate changes in pollutant concentrations with changes in incidence of health endpoints. It estimates economic values of those health impacts based on valuation studies. Estimates of uncertainty and variability are incorporated into the program design and are standard options for data output.

BenMAP can estimate health effects using air quality values from a monitoring network or from gridded modeling results. Population exposure estimates are based on U.S. Census data built into the model, and projected using growth factors to future years. BenMAP allows users to estimate exposure among sensitive subpopulations as well.

Users of the BenMAP program select health effects and valuation configurations that are already built into the software package to estimate incidence and monetary values of changes in air quality. The program allows also users to select various statistical methods for presenting results. The current version of the program is BenMAP-CE 1.0.8.

## Inputs and configuration options

Researchers at the University of Maryland (UMD) performed the air quality modeling and processed the resulting hourly concentration data for ozone and $PM_{2.5}$ into comma separated values (csv) text files for the reference case and the two meta-scenarios.[48] We restricted our analysis to assess the benefits from changes in ground-level concentrations of ozone and fine particulate matter (i.e., particulate matter with aerodynamic diameter of 2.5 µm or less, or $PM_{2.5}$), which generally account for the vast majority of health effects from changes in ambient air quality.

We retrieved the csv files from UMD and further processed the ozone and $PM_{2.5}$ data into timescales for health-relevant impact analysis using Python scripts and data post-processing routines developed by NESCAUM. In the final step, we processed the data for the reference case and each meta-scenario using BenMAP to generate differences in health outcome incidence (and valuation thereof) resulting from modeled implementation of the GGRA policies.

We used the 12 km eastern U.S. CMAQ modeling domain to develop gridded population estimates for 2020 based on the 2010 U.S. Census database included with BenMAP. We accomplished this population gridding through the use of the PopGrid preprocessor. The horizontal modeling domain is 172 by 172 grid cells, for a total of 29,584 discreet 12 km-square grid cells. In the final steps of the analysis, we aggregated incidence and valuation results at the state level.

For the selection of studies to estimate health impacts, we relied on current default configuration settings available from EPA.[49] For ozone, the configuration is based on analysis performed by EPA in support of the federal Transport Rule (USEPA 2010). For $PM_{2.5}$, the configuration is based on EPA's regulatory impact analysis for the 2012 revisions to the National Ambient Air Quality Standards for particulate matter (USEPA 2012). The published EPA documentation contains additional details of the health assessment options. The prevented mortality configuration was based on a broad range of studies for both effects and monetary valuation. Several morbidity configuration options also relied on results from several studies.

## Caveats and Uncertainty

The uncertainties in this type of BenMAP analysis are described in greater detail in our 2008 report on a similar health assessment (NESCAUM 2008), which we recommend as further reading for those who are interested in a more technical description. Furthermore, the methods used in this health impact assessment are based on the methods reported by EPA (2010, 2012), which we recommend as source material for additional details on the health studies included in this assessment. As described by Fann et al. (2014), it is common practice when performing a health impact assessment using BenMAP to rely on the default EPA configurations because the methods are extensively documented and are reviewed and refined by independent scientific groups.

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[48] Data for January 1 were not available because this first day was considered a spin-up day and therefore csv files were not available. Data for January 2 were used as surrogate data for January 1.
[49] See the BenMAP-CE website: http://www.epa.gov/airquality/benmap/ce.html

Each health impact function contains a central estimate (or point estimate) as well as a standard error of the estimate, which are used to generate a distribution of estimates. BenMAP generates incidence estimates that mirror the variability in the inputs to the health impact function. At each grid cell in the domain, BenMAP calculates the incidence estimate multiple times, each time adjusting the pollutant coefficient to describe a different level of the distribution. BenMAP bases the adjustment on a calculation using the standard error of the pollution coefficient, as derived from the selected published epidemiological study. The output contains the mean of the estimate as well as an estimate of the incidence at multiple levels of the distribution.

Rather than explicitly using estimates of uncertainty and variability in the results for each study, we present results as the point estimate from each study along with the range (minimum to maximum point estimates) from each study used to assess health endpoints. Accounting for the full range of uncertainty and variability from each study results in a broader range of benefits estimates. We also included the $5^{th}$ and $95^{th}$ percentile values for each health endpoint in the detailed results tables (described below) to provide a measure of the uncertainty for the incidence and valuation results. These percentile bounds do not include uncertainties carried through from the air quality modeling analysis.

## Results

**Tables D-1** through **D-4** present point estimates of the annual health effects and valuation for the initial meta-scenario compared to the reference case in 2020. **Tables D-5** through **D-8** present analogous tables for the enhanced meta-scenario. Results are presented for Maryland; the Ozone Transport Region (OTR), an area along the eastern seaboard from northern Virginia to Maine, excluding Virginia and Maryland; areas outside of the OTR; and total effects in the modeled domain. We present both incidence and monetary valuation results for premature mortality, and various morbidity health endpoints assuming a 3 percent discount rate. Estimates using a discount rate of 7 percent for deferred health impacts decrease the estimated value; these estimates are presented in aggregate in the main report, but not in full detail in this report so as to avoid presenting extraneous data. Monetary results are presented in millions of dollars. Ranges of estimates reflect the results based on different studies included in the health impact assessment methodology.

Due to the valuation inputs and the health correlation between health effects and exposure, premature mortality accounts for the majority of health effects from the implementation of the policies. In addition, because the changes in modeled $PM_{2.5}$ concentrations result in more avoided premature deaths than the modeled ozone changes, the overwhelming majority of monetary values shown in the initial and enhanced meta-scenarios result from reductions in $PM_{2.5}$ concentrations.

For Maryland in 2020, this analysis suggests that the initial meta-scenario would result in 43 to 100 fewer premature deaths per year, while the enhanced meta-scenario would result in 84 to 192 fewer premature deaths per year (differences in the values presented here and those presented in the table are due to differences in rounding). Modeled avoided non-lethal (morbidity) effects in Maryland due to reduced ground level ozone concentrations would include (point estimates only for the initial and enhanced meta-scenarios):

- 5 (initial) to 6 (Enhanced) fewer hospital visits for respiratory symptoms;

- 2 (both initial and enhanced) fewer emergency room visits for respiratory symptoms;
- 4,900 (initial) to 5,800 (enhanced) fewer instances of acute respiratory symptoms; and
- 1,700 (initial) to 2,000 (enhanced) fewer school loss days.

For $PM_{2.5}$, the analysis indicated that fewer cases of non-lethal health endpoints would result for the initial and enhanced meta-scenarios compared to the reference case, as follows:

- Between 4 to 39 (initial) and 8 and 75 (enhanced) fewer non-fatal heart attacks;
- 13 (initial) to 25 (enhanced) fewer respiratory caused hospital admissions;
- 14 (initial) to 28 (enhanced) fewer cardiovascular caused hospital admissions;
- 30 (initial) to 59 (enhanced) fewer emergency room visits for asthma;
- 63 (initial) to 123 (enhanced) fewer cases of acute bronchitis;
- 810 (initial) to 1,600 (enhanced) fewer cases of lower respiratory symptoms (ages 7-14);
- 1,200 (initial) to 2,200 (enhanced) fewer cases of upper respiratory symptoms (ages 9-18);
- 3,200 (initial) to 15,000 (enhanced) fewer asthma exacerbations; and
- 6,000 (initial) to 12,000 (enhanced) fewer work loss days.

The monetary value of reduced incidence of mortality and morbidity health outcomes in Maryland for the initial meta-scenario was estimated to be between $420 million and $860 million (central point estimates, rounded to two significant figures) from the studies with the lowest estimates of outcomes to the studies with the highest estimates of outcomes, assuming a 3 percent discount rate for delayed mortality effects. Assuming a 7 percent discount rate for delayed mortality effects reduces the value of the avoided health impacts to between $330 million and $750 million.

For the enhanced meta-scenario, the monetary value of reduced incidence of mortality and morbidity health outcomes in Maryland was estimated to be between $820 million and $1,600 million (central point estimates, rounded to two significant figures), assuming a 3 percent discount rate for delayed mortality effects. Assuming a 7 percent discount rate for delayed mortality effects reduces the value of the avoided health impacts to between $630 million and $1.4 billion.

In aggregate, other states in the OTR would also benefit from reduced premature mortality in 2020 resulting from the analyzed GGRA policies. The range of point estimates for the prevented premature mortalities in 2020 within the OTR (excluding Maryland and Virginia) for the initial meta-scenario is from 230 to 510 incidences, and between 440 and 1,000 for the enhanced meta-scenario. For the initial meta-scenario, the total monetary benefit to all areas would be between $3.0 billion and $6.3 billion, assuming a 3 percent discount rate; or between $2.4 billion and $5.5 billion, assuming a 7 percent discount rate. Refer to the tables for modeled changes in morbidity incidence in Maryland, in the OTR, beyond the OTR, and in total.

Between 92 and 97 percent of the monetary value of the total air quality improvements can be attributed to prevented premature mortality effects due to reduced $PM_{2.5}$ exposure. It is important to note that effects were not distributed evenly among each state or within any state or county. In a few states, the model analysis indicated very slightly reduced air quality, resulting in slightly elevated risks for adverse health outcomes. More refined analysis would be required to address results in sensitive populations.

The range of values between the 5th and 95th percentile results is large, indicating the range of uncertainties associated with these outcomes. The results for the upper and lower percentile values are directionally uniform—i.e., nearly all results show some kind of benefit—even if the magnitude of the benefits of these upper and lower bounds differed greatly, from nearly an order of magnitude lower to three times higher than the point estimate. We also note that the negative estimates for certain endpoints are the result of the weak statistical power of the study used in BenMAP to calculate these health impacts and do not suggest that increases in air pollution exposure result in decreased health impacts.

While the modeled effects associated with implementing the GGRA policies within Maryland were significant, they were not restricted only to the State. According to this analysis, under both the initial meta-scenario and the enhanced meta-scenario, health benefits expected to accrue from reduced exposure to air pollutants in the OTR are several times the magnitude of the expected benefits within Maryland. Figure D-1 through Figure D-4 show the upper-end modeled distribution of changes mortality incidence for Maryland from the initial and enhanced meta-scenarios for ozone and $PM_{2.5}$. The incidence of other individual health effect estimates (e.g., for other estimates of premature mortality) is expected to scale similarly with population levels for each grid cell.

**Table D-1: 2020 Health Impact Incidence, Change from Reference Scenario to Initial Policy Scenario for Ozone (Central Point Estimate and Range of 95 Percent Confidence Intervals)[A]**

| | *Health effect* | *Maryland* | *OTR (excluding MD and VA)* | *Beyond OTR* | *Total* |
|---|---|---|---|---|---|
| Premature mortality | | | | | |
| | Bell et al. (2004) (all ages) | 0.67 (0.26—1.1) | 4.7 (1.8—7) | 3.8 (1.49—6.2) | 8.5 (3.3—14) |
| | Schwartz (2005) (all ages) | 1.0 (0.37—1.7) | 7 (2.6—11) | 6 (2.2—9.6) | 13 (4.7—21) |
| | Huang et al. (2005) (all ages) | 0.96 (0.41—1.5) | 6.4 (2.7—10) | 5.5 (2.3—8.6) | 12 (5.1—19) |
| Meta-analyses | Ito et al. (2005) (all ages) | 3.0 (1.9—4.1) | 21 (13—29) | 17.3 (10.9—24) | 38 (24—52) |
| Meta-analyses | Bell et al. (2005) (all ages) | 2.2 (1.1—3.2) | 15 (7.8—22) | 12.6 (6.5—18.6) | 28 (14—41) |
| Meta-analyses | Levy et al. (2005) (all ages) | 3.0 (2.2—3.9) | 21 (15—27) | 17.7 (12.6—23) | 39 (28—50) |
| Hospital admissions—respiratory causes (ages > 65) | | 2.9 (0.16—6.0) | 21 (-2.4—46) | 20 (0.94—38) | 41 (-1.4—84) |
| Hospital admissions—respiratory causes (ages < 2) | | 1.6 (0.79—2.5) | 6.1 (2.9—9) | 13.6 (6.5—20.6) | 20 (9.4—30) |
| Emergency room visits for asthma (all ages) | | 1.8 (-0.12—5.9) | 9 (-29—59) | 12.3 (-0.8—40) | 22 (-30—99) |
| Minor restricted-activity days (ages 18-65) | | 4,900 (2,300—7,500) | 25,000 (11,000—38,000) | 26,000 (12,000—40,000) | 51,000 (23,000—78,000) |
| School absence days | | 1,700 (670—2,400) | 8,400 (2,400—13,000) | 8,400 (3,400—12,300) | 17,000 (5,800—26,000) |

[A] Estimates rounded to two significant figures; values will not sum to total value.

**Table D-2: 2020 Health Impact Valuation (Millions 2010$), Change From Reference Scenario to Initial Policy Scenario for Ozone (Central Point Estimate and Range of 95 Percent Confidence Intervals)[A]**

| | *Health effect* | *Maryland* | *OTR (excluding MD and VA)* | *Beyond OTR* | *Total* |
|---|---|---|---|---|---|
| Premature mortality | | | | | |
| | Bell et al. (2004) (all ages) | $6.4 ($0.5—$19) | $45 (-$7.3—$140) | $37 ($3—$110) | $82 (-$4—$250) |
| | Schwartz (2005) (all ages) | $9.8 ($0.8—$29) | $68 (-$12—$220) | $57 ($5—$170) | $120 (-$7—$390) |
| | Huang et al. (2005) (all ages) | $9 ($1—$27) | $62 (-$18—$210) | $53 ($4—$160) | $110 (-$14—$360) |
| Meta-analyses | Ito et al. (2005) (all ages) | $29 ($3—$80) | $201 (-$27—$600) | $170 ($15—$460) | $370 (-$12—$1,100) |
| Meta-analyses | Bell et al. (2005) (all ages) | $21 ($2—$60) | $144 (-$22—$450) | $121 ($11—$350) | $260 (-$11—$790) |
| Meta-analyses | Levy et al. (2005) (all ages) | $29 ($3—$80) | $203 (-$27—$600) | $171 ($16—$460) | $370 (-$11—$1,100) |
| Hospital admissions—respiratory causes (ages > 65) | | $0.093 ($0.01—$0.18) | $0.68 (-$0.01—$1.4) | $0.6 ($0.1—$1.1) | $1.3 ($0.1—$2.5) |
| Hospital admissions—respiratory causes (ages < 2) | | $0.025 ($0.013—$0.037) | $0.093 (-$0.01—$0.2) | $0.21 ($0.11—$0.30) | $0.30 ($0.09—$0.50) |
| Emergency room visits for asthma (all ages) | | $0.001 ($0.000—$0.003) | $0.004 (-$0.012—$0.026) | $0.01 ($0.00—$0.02) | $0.009 (-$0.012—$0.040) |
| Minor restricted-activity days (ages 18-65) | | $0.33 ($0.13—$0.61) | $1.7 ($0.26—$3.5) | $1.8 ($0.7—$3.2) | $3.5 ($1.0—$6.7) |
| School absence days | | $0.16 ($0.07—$0.23) | $0.82 ($0.28—$1.3) | $0.8 ($0.4—$1.2) | $1.6 ($0.6—$2.4) |

[A] Estimates rounded to two significant figures; values will not sum to total value.

**Table D-3: 2020 Health Impact Incidence, Change from Reference Scenario to Ini Policy Scenario for Fine Particulate Matter ($PM_{2.5}$) (Central Point Estimate and Rai 95 Percent Confidence Intervals)[A]**

| *Health effect* | *Maryland* | *OTR (excluding MD and VA)* | *Beyond OTR* | |
|---|---|---|---|---|
| Avoided mortality | | | | |
| Krewski et al. (2009) (adult) | 43<br>(30—55) | 220<br>(150—280) | 86<br>(61—110) | (21 |
| Lepeule et al. (2012) (adult) | 97<br>(52—140) | 490<br>(270—720) | 200<br>(110—290) | (370 |
| Woodruff et al. (1997) (infant) | 0.11<br>(0.05—0.17) | 0.41<br>(0.18—0.64) | 0.23<br>(0.10—0.36) | (0. |
| Avoided Morbidity | | | | |
| Non-fatal heart attacks (age > 18) | | | | |
| Peters et al. (2001) | 39<br>(12—66) | 220<br>(68—370) | 89<br>(27—150) | (9 |
| Pooled estimate of 4 studies | 4.3<br>(1.9—10) | 24<br>(11—58) | 9.6<br>(4.4—23) | (1 |
| Hospital admissions—respiratory causes (all ages) | 13<br>(-4.0—25) | 69<br>(-23—132) | 27<br>(-8.4—51) | (-3 |
| Hospital admissions—cardiovascular (age > 18) | 14<br>(7.1—25) | 75<br>(36—130) | 31<br>(15—53) | (5 |
| Emergency room visits for asthma (age < 18) | 30<br>(-9.8—61) | 170<br>(-55—340) | 54<br>(-17—110) | (-7 |
| Acute bronchitis (age 8-12) | 63<br>(-8.4—130) | 300<br>(-40—650) | 130<br>(-18—280) | (-5 |
| Lower respiratory symptoms (age 7-14) | 810<br>(350—1,300) | 3,900<br>(1,700—6,100) | 1,700<br>(730—2,700) | (2,40 |
| Upper respiratory symptoms (asthmatics age 9-18) | 1,200<br>(290—2,000) | 5,500<br>(1,400—9,700) | 2,400<br>(600—4,200) | (2,00 |
| Asthma exacerbation (asthmatics 6-18) | 3,200<br>(180—6,700) | 16,000<br>(860—33,000) | 6,700<br>(370—14,000) | 2<br>(1,20 |
| Lost work days (ages 18-65) | 6,000<br>(5,200—6,900) | 29,000<br>(25,000—33,000) | 12,000<br>(11,000—14,000) | 4<br>(36,00 |
| Minor restricted-activity days (ages 18-65) | 36,000<br>(30,000—42,000) | 170,000<br>(140,000—200,000) | 74,000<br>(61,000—86,000) | 2<br>(21<br>29 |

[A] Estimates rounded to two significant figures; values will not sum to total value.

**Table D-4: 2020 Health Impact Valuation (Millions 2010$, 3 Percent Discount Rate), Change from Reference Scenario to Initial Policy Scenario for Fine Particulate Matter ($PM_{2.5}$) (Central Point Estimate and Range of 95 Percent Confidence Intervals)[A]**

| *Health effect* | *Maryland* | *OTR (excluding MD and VA)* | *Beyond OTR* | *Total* |
|---|---|---|---|---|
| Avoided mortality | | | | |
| Krewski et al. (2009) (adult) | $410 ($33—$990) | $2,000 ($170—$5,000) | $830 ($68—$2,000) | $2,900 ($240—$7,000) |
| Lepeule et al. (2012) (adult) | $820 ($72—$2,300) | $4,200 ($370—$12,000) | $1,700 ($150—$4,700) | $5,800 ($510—$17,000) |
| Woodruff et al. (1997) (infant) | $1.1 ($0.09—$3.1) | $4.0 ($0.33—$12) | $2.3 ($0.19—$6.6) | $6.2 ($0.52—$18) |
| Avoided Morbidity | | | | |
| Non-fatal heart attacks (age > 18) | | | | |
| Peters et al. (2001) | $4.9 ($0.85—$12) | $27 ($4.6—$67) | $11 ($1.9—$27) | $38 ($6.6—$95) |
| Pooled estimate of 4 studies | $1.1 ($0.52—$2.3) | $5.8 ($2.9—$13) | $2.4 ($1.2—$5.2) | $8.2 ($4.0—$18) |
| Hospital admissions—respiratory causes (all ages) | $0.31 (-$0.07—$0.58) | $1.7 (-$0.41—$3.1) | $0.67 (-$0.16—$1.2) | $2.3 (-$0.6—$4.3) |
| Hospital admissions—cardiovascular (age > 18) | $0.56 ($0.30—$0.94) | $2.9 ($1.5—$5.0) | $1.2 ($0.63—$2.0) | $4.1 ($2.1—$7.0) |
| Emergency room visits for asthma (age < 18) | $0.013 (-$0.002—$0.028) | $0.073 (-$0.014—$0.16) | $0.023 (-$0.004—$0.050) | $0.096 (-$0.019—$0.21) |
| Acute bronchitis (age 8-12) | $0.030 (-$0.001—$0.085) | $0.15 (-$0.01—$0.41) | $0.064 (-$0.003—$0.18) | $0.21 (-$0.01—$0.58) |
| Lower respiratory symptoms (age 7-14) | $0.017 ($0.006—$0.034) | $0.08 ($0.03—$0.16) | $0.036 ($0.012—$0.07) | $0.12 ($0.04—$0.24) |
| Upper respiratory symptoms (asthmatics age 9-18) | $0.039 ($0.008—$0.094) | $0.18 ($0.04—$0.45) | $0.081 ($0.018—$0.20) | $0.27 ($0.06—$0.65) |
| Asthma exacerbation (asthmatics 6-18) | $0.19 ($0.02—$0.50) | $0.90 ($0.08—$2.4) | $0.39 ($0.03—$1.0) | $1.3 ($0.1—$3.4) |
| Lost work days (ages 18-65) | $1.1 ($1.0—$1.3) | $5.0 ($4.4—$5.7) | $2.1 ($1.9—$2.4) | $7.2 ($6.2—$8.1) |
| Minor restricted-activity days (ages 18-65) | $2.5 ($1.3—$3.7) | $12 ($6.3—$18) | $5.0 ($2.7—$7.6) | $17 ($9.0—$26) |

[A] Estimates rounded to two significant figures; values will not sum to total value.

**Table D-5: 2020 Health Impact Incidence, Change from Reference Scenario to Enhanced Policy Scenario for Ozone (Central Point Estimate and Range of 95 Percent Confidence Intervals)[A]**

| | *Health effect* | *Maryland* | *OTR (excluding MD and VA)* | *Beyond OTR* | *Total* |
|---|---|---|---|---|---|
| Premature mortality | | | | | |
| | Bell et al. (2004) (all ages) | 0.81 (0.27—1.3) | -1.5 (-0.5—-3) | 4.1 (1.39—6.8) | 2.6 (0.9—4) |
| | Schwartz (2005) (all ages) | 1.2 (0.38—2.1) | -2 (-0.7—-4) | 6 (2—10.5) | 4 (1.2—6.3) |
| | Huang et al. (2005) (all ages) | 1.14 (0.43—1.8) | -3.4 (-1.2—-6) | 5.5 (2.1—8.7) | 2 (0.9—3) |
| Meta-analyses | Ito et al. (2005) (all ages) | 3.6 (2.2—4.9) | -7 (-4—-11) | 17.7 (10.9—24) | 10 (7—13) |
| Meta-analyses | Bell et al. (2005) (all ages) | 2.6 (1.2—3.9) | -5 (-2.3—-8) | 13.3 (6.4—19.7) | 8 (4—12) |
| Meta-analyses | Levy et al. (2005) (all ages) | 3.6 (2.5—4.7) | -7 (-5—-10) | 18.4 (12.8—24) | 11 (8—13) |
| Hospital admissions—respiratory causes (ages > 65) | | 4.4 (1.43—11.4) | -9 (-66.8—27) | 23 (-35.94—92) | 14 (-102.7—120) |
| Hospital admissions—respiratory causes (ages < 2) | | 1.5 (0.74—1.9) | -21.6 (-8.2—-38) | 9.8 (5.5—10.5) | -12 (-2.7—-28) |
| Emergency room visits for asthma (all ages) | | 1.6 (-4.93—6.1) | -22 (-135—94) | 8.5 (-66.8—67) | -14 (-202—161) |
| Minor restricted-activity days (ages 18-65) | | 5,800 (2,500—8,900) | -20,000 (-8,000—-34,000) | 27,000 (12,000—40,000) | 7,000 (4,000—6,000) |
| School absence days | | 2,000 (720—3,300) | -3,600 (-14,800—4,000) | 9,400 (-4,200—21,100) | 6,000 (-19,000—25,000) |

Notes: [A] Estimates rounded to two significant figures; values will not sum to total value.

**Table D-6: 2020 Health Impact Valuation (Millions 2010$), Change From Reference Scenario to Enhanced Policy Scenario for Ozone (Central Point Estimate and Range of 95 Percent Confidence Intervals)[A]**

| | *Health effect* | *Maryland* | *OTR (excluding MD and VA)* | *Beyond OTR* | *Total* |
|---|---|---|---|---|---|
| Premature mortality | | | | | |
| | Bell et al. (2004) (all ages) | $7.8 ($0.6—$23) | -$15 (-$103.7—$60) | $40 (-$50—$171) | $25 (-$153—$230) |
| | Schwartz (2005) (all ages) | $11.9 ($0.9—$36) | -$23 (-$162—$90) | $61 (-$77—$260) | $40 (-$239—$350) |
| | Huang et al. (2005) (all ages) | $11 ($1—$32) | -$33 (-$179—$80) | $53 (-$77—$230) | $20 (-$256—$310) |
| Meta-analyses | Ito et al. (2005) (all ages) | $34 ($3—$94) | -$72 (-$440—$230) | $170 (-$216—$700) | $100 (-$656—$900) |
| Meta-analyses | Bell et al. (2005) (all ages) | $25 ($2—$71) | -$49 (-$323—$170) | $128 (-$158—$530) | $80 (-$481—$710) |
| Meta-analyses | Levy et al. (2005) (all ages) | $35 ($3—$95) | -$72 (-$432—$230) | $177 (-$210—$710) | $100 (-$642—$900) |
| Hospital admissions—respiratory causes (ages > 65) | | $0.139 ($0.05—$0.37) | -$0.29 (-$2.12—$0.9) | $0.7 (-$1.1—$2.9) | $0.4 (-$3.3—$3.8) |
| Hospital admissions—respiratory causes (ages < 2) | | $0.023 ($0.011—$0.030) | -$0.329 (-$0.64—-$0.1) | $0.15 (-$0.10—$0.35) | -$0.18 (-$0.75—$0.29) |
| Emergency room visits for asthma (all ages) | | $0.001 (-$0.002—$0.003) | -$0.009 (-$0.055—$0.038) | $0.00 (-$0.03—$0.03) | -$0.006 (-$0.082—$0.070) |
| Minor restricted-activity days (ages 18-65) | | $0.39 ($0.15—$0.71) | -$1.4 (-$3.76—$0.6) | $1.8 (-$0.6—$4.5) | $0.5 (-$4.3—$5.2) |
| School absence days | | $0.19 ($0.07—$0.32) | -$0.35 (-$1.45—$0.4) | $0.9 (-$0.4—$2.1) | $0.6 (-$1.9—$2.5) |

Notes: [A] Estimates rounded to two significant figures; values will not sum to total value.

**Table D-7: 2020 Health Impact Incidence, Change from Reference Scenario to Enha Policy Scenario for Fine Particulate Matter ($PM_{2.5}$) (Central Point Estimate and Ra 95 Percent Confidence Intervals)[A]**

| *Health effect* | *Maryland* | *OTR (excluding MD and VA)* | *Beyond OTR* | |
|---|---|---|---|---|
| Avoided mortality | | | | |
| Krewski et al. (2009) (adult) | 83 (58—110) | 440 (310—570) | 120 (85—160) | ( |
| Lepeule et al. (2012) (adult) | 190 (100—270) | 1,000 (540—1,500) | 270 (150—400) | ( |
| Woodruff et al. (1997) (infant) | 0.21 (0.09—0.33) | 0.81 (0.35—1.30) | 0.34 (0.15—0.52) | ( |
| Avoided Morbidity | | | | |
| Non-fatal heart attacks (age > 18) | | | | |
| Peters et al. (2001) | 75 (23—130) | 420 (140—680) | 98 (35—137) | ( |
| Pooled estimate of 4 studies | 8.3 (3.8—20) | 49 (22—120) | 13 (-5.5—41) | |
| Hospital admissions—respiratory causes (all ages) | 25 (-7.8—48) | 140 (-47—260) | 37 (-40—99) | |
| Hospital admissions—cardiovascular (age > 18) | 28 (14—48) | 150 (73—260) | 43 (7—88) | |
| Emergency room visits for asthma (age < 18) | 59 (-19—120) | 330 (-110—650) | 76 (-91—210) | ( |
| Acute bronchitis (age 8-12) | 120 (-16—260) | 620 (-81—1,300) | 180 (-24—390) | (- |
| Lower respiratory symptoms (age 7-14) | 1,600 (680—2,400) | 7,400 (3,300—11,000) | 2,000 (960—2,900) | (4, |
| Upper respiratory symptoms (asthmatics age 9-18) | 2,200 (560—3,900) | 11,000 (2,800—20,000) | 3,300 (830—5,800) | (3, |
| Asthma exacerbation (asthmatics 6-18) | 15,000 (300—95,000) | 74,000 (1,400—510,000) | 22,000 (-65,000—200,000) | (-63 |
| Lost work days (ages 18-65) | 12,000 (10,000—13,000) | 58,000 (50,000—66,000) | 17,000 (15,000—19,000) | (65 |
| Minor restricted-activity days (ages 18-65) | 69,000 (58,000—81,000) | 340,000 (290,000—400,000) | 98,000 (82,000—110,000) | (370 |

[A] Estimates rounded to two significant figures; values will not sum to total value.

**Table D-8: 2020 Health Impact Valuation (Millions 2010$, 3 Percent Discount Rate), Change from Reference Scenario to Enhanced Policy Scenario for Fine Particulate Matter ($PM_{2.5}$) (Central Point Estimate and Range of 95 Percent Confidence Intervals)[A]**

| *Health effect* | *Maryland* | *OTR (excluding MD and VA)* | *Beyond OTR* | *Total* |
|---|---|---|---|---|
| Avoided mortality | | | | |
| Krewski et al. (2009) (adult) | $800 ($65—$1,920) | $4,100 ($350—$10,200) | $1,160 (-$949—$3,830) | $5,300 (-$600—$14,100) |
| Lepeule et al. (2012) (adult) | $1,594 ($140—$4,500) | $8,500 ($740—$24,000) | $2,300 (-$2,260—$9,000) | $10,800 (-$1,520—$33,000) |
| Woodruff et al. (1997) (infant) | $2.1 ($0.17—$6.1) | $7.7 ($0.65—$23) | $3.2 (-$3.14—$12.9) | $11.0 (-$2.50—$36) |
| Avoided Morbidity | | | | |
| Non-fatal heart attacks (age > 18) | | | | |
| Peters et al. (2001) | $9.3 ($1.64—$23) | $52 ($9.2—$123) | $12 (-$19.3—$48) | $64 (-$10.1—$171) |
| Pooled estimate of 4 studies | $2.1 ($1.00—$4.4) | $11.9 ($5.8—$26) | $3.2 (-$0.8—$9.2) | $15.1 ($5.0—$35) |
| Hospital admissions—respiratory causes (all ages) | $0.61 ($0.00—$0.00) | $3.4 ($0.00—$0.0) | $0.90 ($0.00—$0.0) | $4.3 ($0.0—$0.0) |
| Hospital admissions—cardiovascular (age > 18) | $1.09 ($0.00—$0.00) | $5.9 ($0.0—$0.0) | $1.7 ($0.00—$0.0) | $7.6 ($0.0—$0.0) |
| Emergency room visits for asthma (age < 18) | $0.025 ($0.000—$0.000) | $0.141 ($0.000—$0.00) | $0.032 ($0.000—$0.000) | $0.173 ($0.000—$0.00) |
| Acute bronchitis (age 8-12) | $0.059 (-$0.003—$0.164) | $0.30 (-$0.01—$0.82) | $0.088 (-$0.106—$0.35) | $0.38 (-$0.12—$1.17) |
| Lower respiratory symptoms (age 7-14) | $0.033 ($0.011—$0.066) | $0.16 ($0.05—$0.31) | $0.043 (-$0.031—$0.13) | $0.20 ($0.02—$0.43) |
| Upper respiratory symptoms (asthmatics age 9-18) | $0.075 ($0.016—$0.182) | $0.37 ($0.08—$0.91) | $0.110 (-$0.079—$0.37) | $0.48 ($0.00—$1.28) |
| Asthma exacerbation (asthmatics 6-18) | $0.86 ($0.03—$6.04) | $4.27 ($0.16—$32.6) | $1.24 (-$4.06—$12.6) | $5.5 (-$3.9—$45.2) |
| Lost work days (ages 18-65) | $2.2 ($1.9—$2.5) | $10.1 ($8.8—$11.3) | $3.0 ($2.3—$3.6) | $13.0 ($11.1—$15.0) |
| Minor restricted-activity days (ages 18-65) | $4.7 ($2.5—$7.2) | $23 ($12.4—$35) | $6.7 ($0.6—$13.0) | $30 ($13.0—$48) |

[A] Estimates rounded to two significant figures; values will not sum to total value.

**Figure D-1: Distribution of Upper End (Levy et al. 2005) Estimate of Premature Mortality in Maryland from Changes in Ozone Concentrations from Reference Case to Initial Meta-scenario**

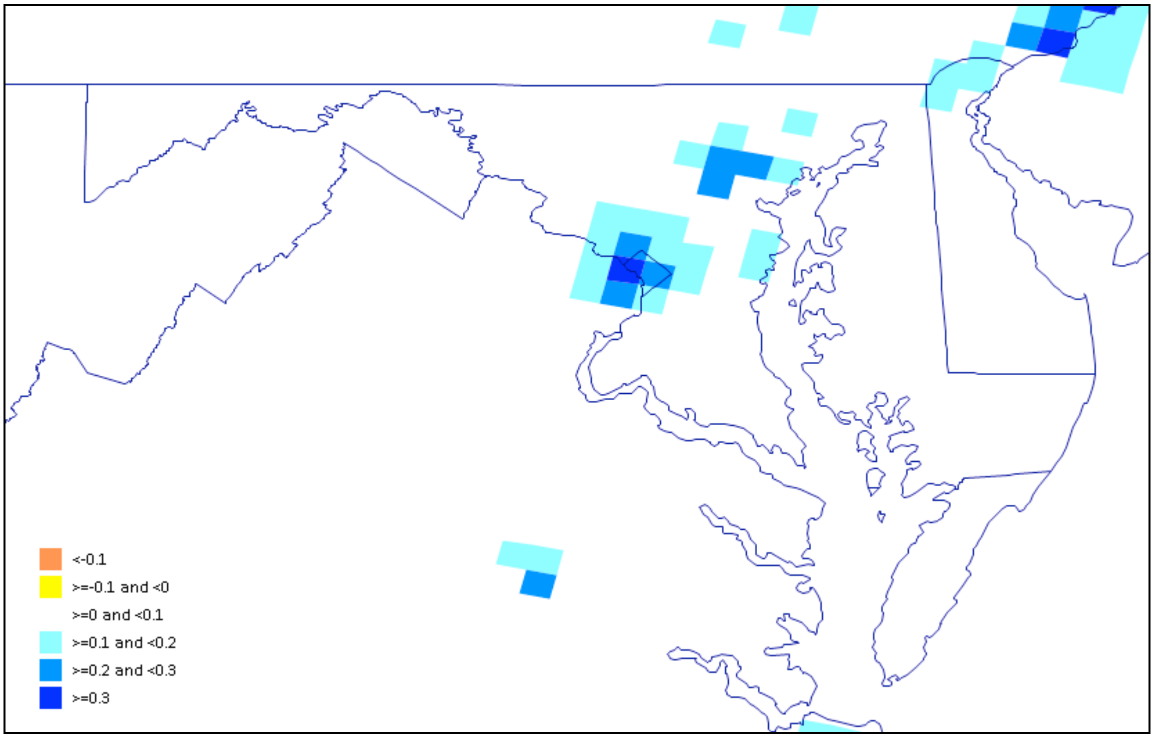


**Figure D-2: Distribution of Upper End (Lepeule et al. 2012) Estimate of Premature Mortality in Maryland from Changes in $PM_{2.5}$ Concentrations from Reference Case to Initial Meta-scenario**

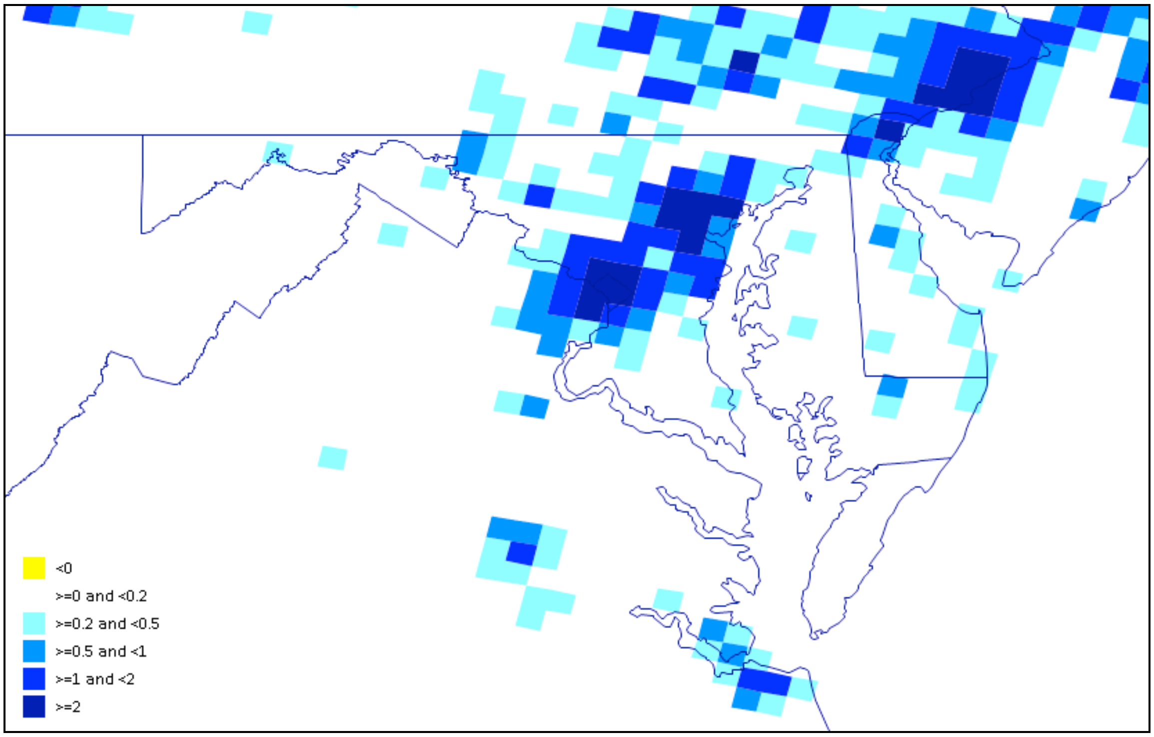


**Figure D-3: Distribution of Upper End (Levy et al. 2005) Estimate of Premature Mortality in Maryland from Changes in Ozone Concentrations from Reference Case to Enhanced Meta-scenario**

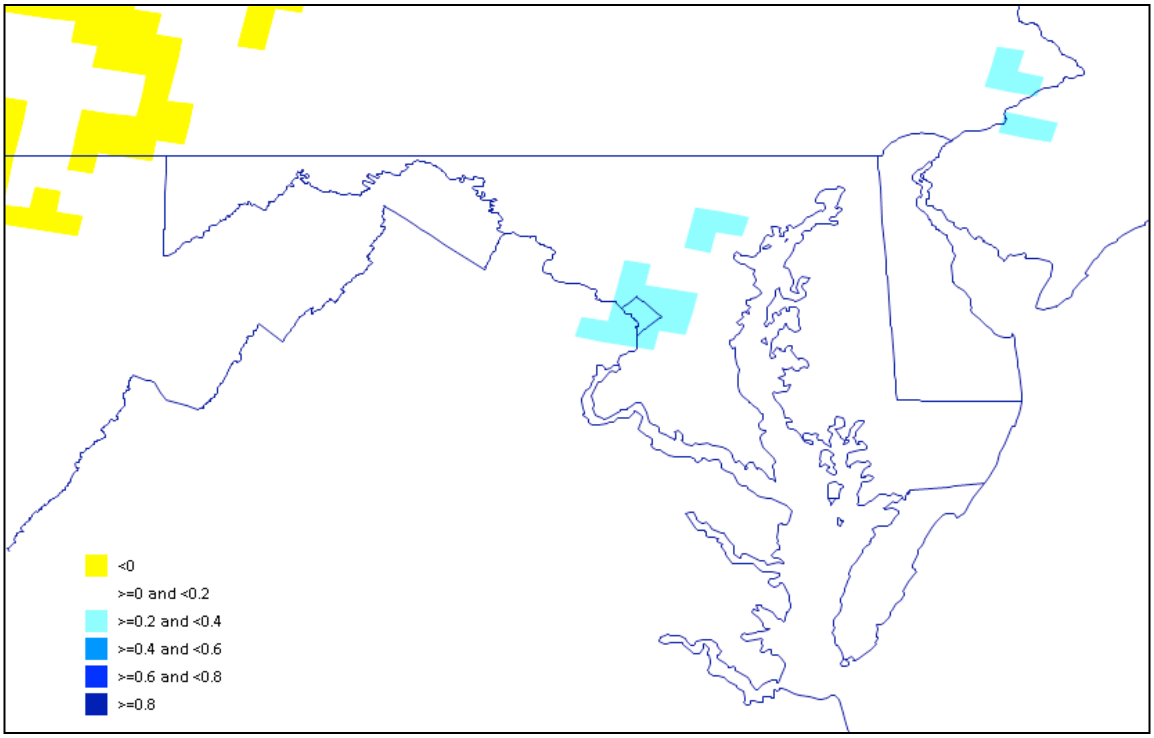
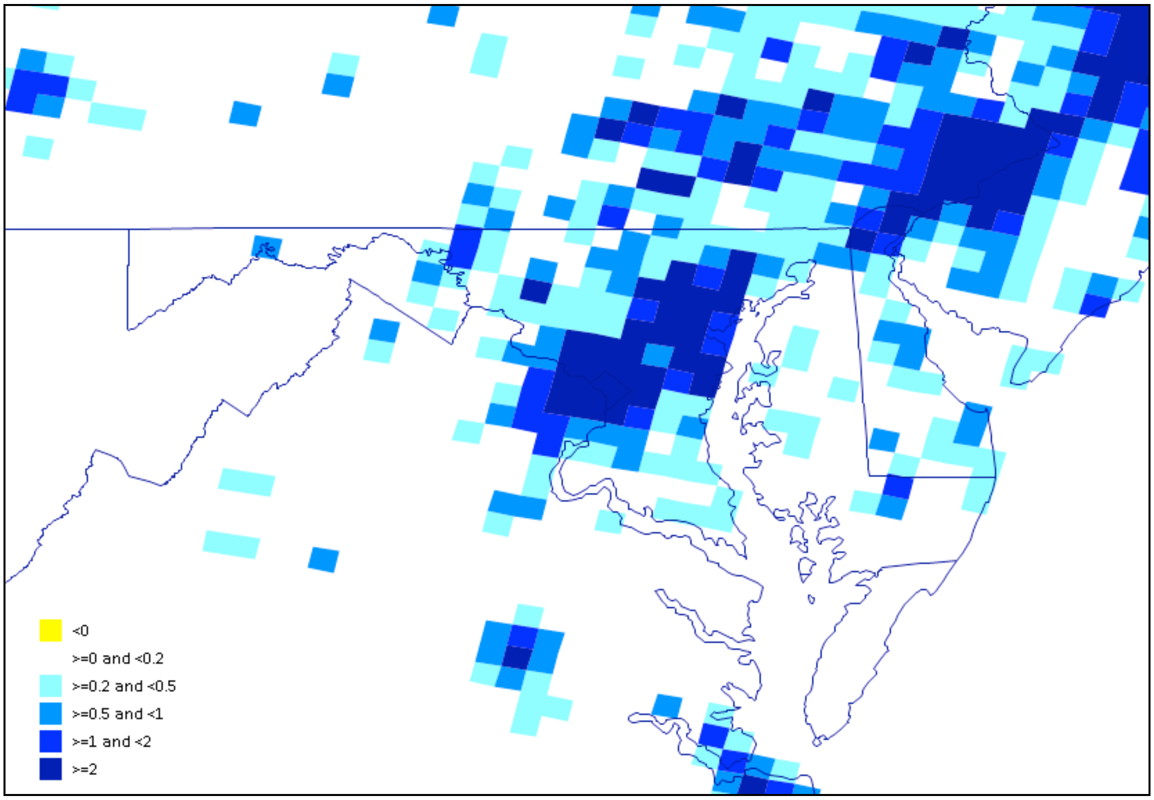


**Figure D-4: Distribution of Upper End (Lepeule et al. 2012) Estimate of Premature Mortality in Maryland from Changes in $PM_{2.5}$ Concentrations from Reference Case to Enhanced Meta-scenario**



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USEPA (U.S. Environmental Protection Agency). 2012. Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter. EPA-452/R-12-005. December 2012. Office of Air Quality Planning and Standards. Available at: http://www.epa.gov/ttnecas1/regdata/RIAs/finalria.pdf.

USEPA (U.S. Environmental Protection Agency). 2014. Environmental Benefits Mapping and Analysis Program (BenMAP) Community Edition, BenMAP-CE 4.0.52, US Version (June 2012). Available at: http://www.epa.gov/air/benmap/download.html.

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# Impact Analysis of the Greenhouse Gas Reduction Act of 2009 on the Manufacturing Industry in Maryland

*Prepared for*
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# 1.0 Executive Summary

## 1.1 Overview

The Maryland Department of the Environment (MDE) tasked the Regional Economic Studies Institute (RESI) to complete an impact analysis of the policies from the *Greenhouse Gas Emissions Reduction Act (GGRA) 2012 Plan* on Maryland's manufacturing industry. RESI employed the REMI PI+ model using agency level data collected for the GGRA report to determine the impact on Maryland's Manufacturing industry. In this report, RESI assumed that all GGRA initiatives were implemented and results are reported for the Manufacturing industry by the four-digit North American Industry Classification System (NAICS) codes.

In addition to an economic impact analysis, RESI solicited feedback from regional manufacturers to include in the report. Manufacturer interviews included in this report are case studies of greenhouse gas reduction measures taken by these firms to remain compliant with government environmental mandates. RESI and representatives from MDE visited these manufacturers to witness their methods and interview them one on one in regard to the challenges faced with reducing greenhouse gas emissions, if any.

## 1.2 Historical Trend Analysis

To provide background for the economic impact analysis, RESI analyzed the current historical trends of Manufacturing in Maryland. RESI found the following:

- The average weekly wages in the Manufacturing industry increased from $933 in 2002 to $1,324 in 2012.
- Preliminary estimates indicate that average weekly wages increased by $16 between 2012 and 2013—an increase from $1,324 in 2012 to $1,340 in 2013.[1]
- The industry accounted for 5.9 percent of Maryland's total output in 2012.

The industry remains a vital component of Maryland's economic base, despite declines since the recent recession. Industry data indicates that the workforce is shifting to demand employees with middle skills and more training. Partnerships with state-based groups such as the Regional Manufacturing Institute (RMI) and state agencies such as Maryland Public Service Commission (PSC) and Maryland Energy Administration have assisted manufacturers through funding opportunities to meet energy efficiency goals.

National partnerships are also key in building the needed workforce, such as those with Manufacturing Extension Partnership (MEP) and the National Institute of Standards and Technology. This partnership seeks to build and establish training to meet the higher skill needs of employers by the local workforce. As the industry shifts towards a higher skill-based workforce, partnerships such as those between industry leaders, state agencies, and federal

[1] "Quarterly Census of Employment and Wages," Bureau of Labor Statistics, accessed April 9, 2014, http://data.bls.gov/pdq/SurveyOutputServlet.

agencies will be vital to producing the workforce needed to implement the policies outlined in the GGRA.

### 1.3 Economic Impact Findings

RESI analyzed the GGRA initiatives outlined in the GGRA to determine the economic impacts on the manufacturing industry. Using agency-provided data along with external research, RESI found the following:

- The manufacturing industry will create 113 total jobs by 2020 related to implementation of the policies between 2010 and 2020.
- Directly, policy implementation between 2010 and 2020 will result in 104 direct jobs created to support the greenhouse gas reduction policies under the GGRA.
- The *Computer and electronic product manufacturing* sector will experience the greatest gains in employment between 2010 and 2020.
- The industry's wages will increase to $10.7 million by 2020.
- The industry's output will increase to $26.5 million by 2020.

RESI's economic impact analysis confirms historical and current trend analyses. To implement the strategies outlined in the GGRA, Maryland will create an additional 113 jobs in the Manufacturing industry by 2020. Of these 113 jobs, nearly 54 percent will be created within higher skilled sectors, such as *Computer and electronic product manufacturing* and *Electrical equipment and appliance manufacturing*. Some sectors, such as *Food Manufacturing* and *Textile mills; Textile product mills* will see minimal job declines between 2010 and 2020 as the industry shifts to a higher-skilled workforce demand to meet policy implementation associated with the GGRA. Despite all the change in Maryland's Manufacturing industry, there is no conclusive evidence that any closures or relocations outside Maryland are directly attributable to the GGRA or climate change planning. Based on the analysis provided within this report, RESI finds no discernible impacts on the manufacturing sector as a result of the GGRA programs. Furthermore, RESI recommends based on this analysis that Maryland not adopt any manufacturing specific GHG regulations in the future.

# 2.0 Introduction

The Maryland Department of the Environment (MDE) tasked the Regional Economic Studies Institute (RESI) to complete an impact analysis of the policies from the *Greenhouse Gas Emissions Reduction Act (GGRA) 2012 Plan* on Maryland's manufacturing industry. RESI employed the REMI PI+ model using agency-level data collected for the GGRA report to determine the impact on Maryland's Manufacturing industry. In this report, RESI assumed that all GGRA initiatives were implemented and results are reported for the Manufacturing industry by the four-digit North American Industry Classification System (NAICS) codes.

In addition to an economic impact analysis, RESI solicited feedback from regional manufacturers to include in the report. Manufacturer interviews included in this report are case studies of greenhouse gas reduction measures taken by these firms to remain compliant with government environmental mandates. RESI and representatives from MDE visited these manufacturers to witness their methods and interview them one on one in regard to the challenges faced with reducing greenhouse gas emissions, if any.

# 3.0 Literature Review

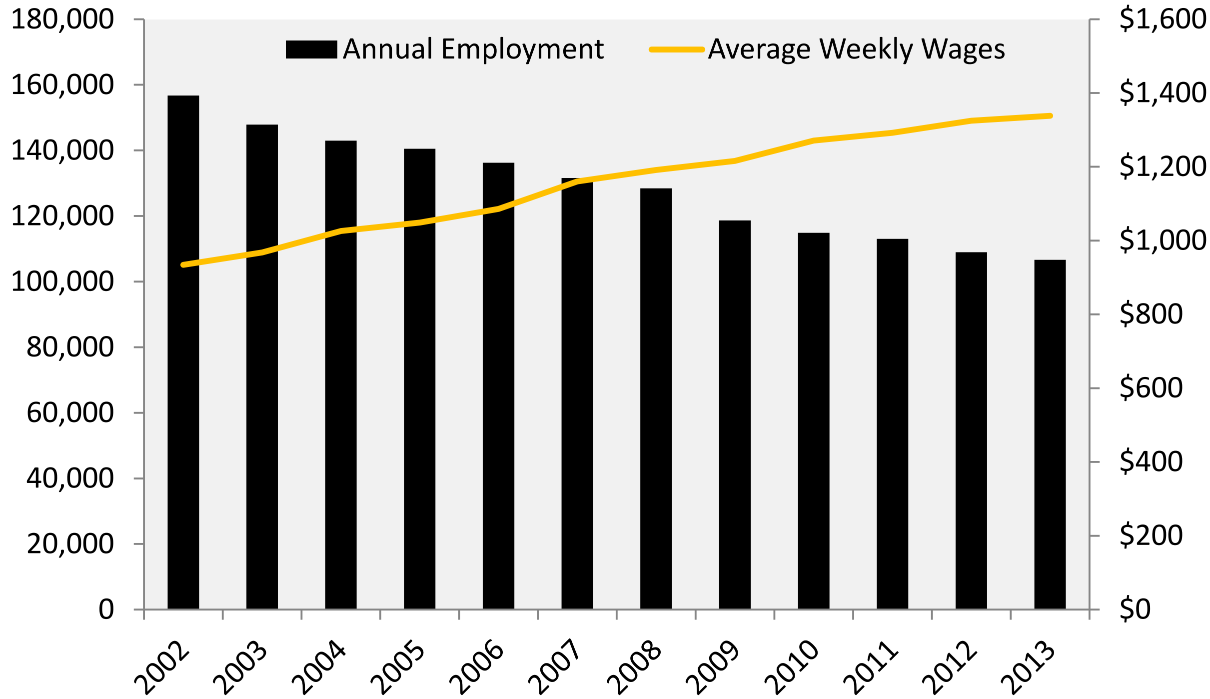
## 3.1 Trends in Manufacturing in Maryland

Since 2002 employment in Manufacturing in Maryland has steadily declined. In 2002 average annual employment in the manufacturing sector reached nearly 157,000 but dropped to approximately 109,000 in 2012.[2] Manufacturing as a percent of total Maryland employment has seen a less drastic change than employment within the manufacturing sector alone. In 2002 Manufacturing encompassed more than 6 percent of Maryland's total employment; by 2012 that share decreased slightly to 4 percent.[3] Despite employment declines, average weekly wages per worker have steadily increased. According to the Department of Labor, Licensing and Regulation (DLLR), average wages increased from $933 to $1,324 between 2002 and 2012. Average wages in Manufacturing have remained greater than average wages for Maryland industries overall.[4]

As seen in Figure 1, preliminary data for 2013 support the existing employment and wage trends. Employment in Manufacturing in Maryland decreased to fewer than 107,000 workers in 2013. [5] Preliminary figures for 2013 show that average weekly wages continue to increase; average weekly wages rose to approximately $1,340 in 2013, a $16 increase from 2012.[6]

[2] "Employment and Payrolls - Industry Series – Maryland," Department of Labor, Licensing and Regulation, September 30, 2013, accessed October 24, 2013, http://www.dllr.state.md.us/lmi/emppay/tab1md.shtml.
[3] Ibid.
[4] Ibid.
[5] "Quarterly Census of Employment and Wages," Bureau of Labor Statistics.
[6] Ibid.

**Figure 1: Manufacturing Employment and Wages for Maryland**[7]




Sources: BLS, QCEW

Regardless of employment declines, the manufacturing industry remains a vital enterprise for Maryland. In 2012 the manufacturing industry in Maryland

- Accounted for 5.9 percent of the total output in the state,
- Comprised 4.3 percent of the state's total employed workforce,
- Produced output of $18.7 billion, and
- Exported nearly $11 billion worth of goods.[8]

According to the 2014 report "Impact of the Manufacturing Renaissance from Energy Intensive Sources" prepared for the U.S. Conference of Mayors and the Council on Metro Economies and the New American City, the manufacturing industry has been a "keystone of economic growth" since the end of the recession—specifically, in the nation's metropolitan areas, such as the Baltimore-Columbia-Towson metropolitan statistical area (MSA), and in regard to industries that are energy intensive, such as Manufacturing.[9] Metropolitan areas encompass a vast

[7] QCEW wages and employment data reported here are seasonally adjusted.
[8] "Maryland Manufacturing Facts," National Association of Manufacturers, 1-2, 2012, accessed October 24, 2013, http://www.nam.org/~/media/40D1B093FBD64A17BCC68940B5A7F167/Maryland.pdf.
[9] "U.S. Metro Economies Report on Impact of Manufacturing Renaissance from Energy Intensive Sectors," Global Insight and iHS, 1, 2013, accessed April 10, 2014, http://www.usmayors.org/pressreleases/uploads/2014/0320-report-MetroEconomiesManufacturing.pdf.

amount of the nation's total employment. In 2012 metropolitan areas encompassed nearly 80 percent of the nation's total employment and more than 80 percent of "real sales" that resulted from energy-intensive manufacturing industry components.[10] The report forecasts that employment within energy-intensive manufacturing industry components will expand at the same rate as that expected on the national level through 2020. At 72 percent, the majority of projected expansion will occur in metropolitan areas.[11]

Maryland has multiple organizations that support and/or promote the manufacturing industry. Since 1990 the Regional Manufacturing Institute (RMI) of Maryland has acted as an advocate for Maryland manufacturers.[12] With the help of a recent $3 million grant, provided by the Maryland Public Service Commission and the Maryland Energy Administration, RMI aims to assist Maryland manufacturers in targeting energy efficiency opportunities.[13] Maryland is also home to one of the nation's centers of the Manufacturing Extension Partnership (MEP) and the Maryland World Class Manufacturing Consortium.

Through partnerships with other MEP centers nationwide, as well as the National Institute of Standards and Technology, the Maryland MEP facilitates the growth of manufacturers.[14] These partnerships allow the Maryland MEP to offer training in "Lean, Innovation Engineering, Advanced Manufacturing and Marketing." [15] Additional Manufacturing support comes from the Maryland World Class Manufacturing Consortium. The Consortium aids manufacturers in meeting international demand and standards.[16]

### 3.2 Maryland's Manufacturing Industry and Greenhouse Gas Reduction

Under the Greenhouse Gas Reduction Act (GGRA) of 2009, the State of Maryland is required to produce the 25 percent reduction from 2006 levels by 2020. The bill also states that Manufacturing can only be regulated at a federal level, and the industry is therefore excluded from the GGRA.[17] Greenhouse gas (GHG) emissions resulting from the state's Manufacturing

[10] "U.S. Metro Economies Report on Impact of Manufacturing Renaissance from Energy Intensive Sectors," Global Insight and iHS, 1.

[11] Ibid.

[12] "About RMI," Regional Manufacturing Institute of Maryland, accessed October 24, 2013, http://rmiofmaryland.com/about-rmi/.

[13] "Join the RMI's Next-Gen-M Energy Efficiency Program," Regional Manufacturing Institute of Maryland, October 14, 2013, accessed October 24, 2013, http://rmiofmaryland.com/join-the-rmis-next-gen-m-energy-efficiency-program/.

[14] "Maryland Direct Financial Incentives 2014," Area Development, 2014, accessed April 10, 2014, http://www.areadevelopment.com/stateResources/maryland/MD-Direct-Financial-Incentives-2014-124356.shtml.

[15] Ibid.

[16] Ibid.

[17] "Facts About The Greenhouse Gas Reduction Act of 2009," Maryland Department of the Environment, 1, accessed October 24, 2013, http://www.mde.state.md.us/assets/document/Air/ClimateChange/GGRA_factsheet.pdf.

industry make up a relatively small portion, only 4 percent, of the state's total GHG emissions—this percent is not expected to change significantly by 2020.[18]

**Regulation Impacts on Competitiveness**

Maryland manufacturers must contend with regional, national, and international competitors. Due to this competitiveness, the industry's GHG emissions are thought to be best regulated on a national level.[19] State regulations cannot require the manufacturing industry to reduce GHG emissions nor can such regulations place higher financial burden on Maryland manufacturers unless required at the federal level.[20] Doing so would place Maryland's Manufacturing sector at a competitive disadvantage.

While Manufacturing is currently excluded from GHG emissions reduction requirements, the GGRA encourages the manufacturing industry to reduce emissions voluntarily. In the future, it is possible that Manufacturing will be subject to reduction requirements; any GHG emissions reductions accomplished in Manufacturing in the short term will be applied to future reduction requirements. [21] With the GGRA of 2009, Maryland continues to advocate for a strong federal GHG reduction program. [22]

**Energy Efficiency Investments**

Across the U.S., companies have committed to at least a 25 percent reduction in energy intensity associated with manufacturing within 10 years—these companies are recognized by the Department of Energy's as Better Plants Program Partners.[23] Some of these companies have already reached the 25 percent reduction goal, while others have accepted the Better Buildings, Better Plants Challenge and strive to obtain "enhanced levels of transparency and innovation" and have "agreed to make a significant near-term investment in energy efficiency at a chosen facility." [24]

On a more local level, progress is evident throughout the state. For example, in 2012 seasoning company McCormick & Company announced that its distribution center based in Belcamp, Maryland, reached "net-zero" through energy conservation measures—in other words, the

[18] Facts About The Greenhouse Gas Reduction Act of 2009," Maryland Department of the Environment.
[19] "Chapter 172 (Senate Bill 278)," Maryland General Assembly, 2, 2009, accessed October 24, 2013, http://mgaleg.maryland.gov/2009rs/chapters_noln/Ch_172_sb0278E.pdf.
[20] Ibid, 7.
[21] "Facts About The Greenhouse Gas Reduction Act of 2009," Maryland Department of the Environment, 2.
[22] Ibid.
[23] Office of Energy Efficiency & Renewable Energy, "Better Plants Program Partners," U.S. Department of Energy, accessed January 7, 2015, http://www.energy.gov/eere/amo/better-plants-program-partners.
[24] Ibid.

distribution center uses less electricity that it produces.[25] To achieve net-zero status at its Belcamp location, McCormick installed "energy-efficient interior and exterior lighting, occupancy sensors, HVAC upgrades, and energy efficient pallet conveyors," with a solar array generating the surplus energy.[26]

The Regional Manufacturing Institute of Maryland (RMI), in partnership with the Maryland Energy Administration, is using a recently obtained $3 million grant "to help target energy efficiency opportunities with Maryland manufacturers in the BGE service territory." [27] Those firms that meet program criteria can receive business services, such as a comprehensive energy audit and energy efficiency training, at minimal out-of-pocket cost (services that could cost more than $30,000). [28] These services have the potential to reduce energy costs by 15 to 25 percent. [29] Current participants include the following:

- Chesapeake Specialty Chemical (Building Materials),
- Danko Arlington (pattern shop, foundry, and machine shop),
- Ellicott Dredge (Dredging Equipment Sector),
- Green Bay Packaging (Packaging Sector),
- GM Baltimore Operations (Automotive Sector),
- Maritime Applied Physics Corporation (Shipping Sector),
- Maryland Thermoform (Plastics Sector),
- Medifast (Dietary Meals/Snacks),
- Northrop Grumman Electronic Systems (Defense Electronics Sector),
- Sun Automation (Machinery Motors),
- U.S. Gypsum (Construction Materials), and
- Zentech Manufacturing (Electronics Sector).[30]

Firms that have seen production increases due to previous energy efficiency measures, such as Hunt Valley's Green Bay Packaging, have spoken out in favor of improved energy efficiency.[31] Other programs, such as BGE's Smart Energy Savers program, are aiding Maryland's journey toward energy efficiency. BGE's "success stories" include El Andariego, Mars Supermarkets, Pet

[25] "McCormick Distribution Center Achieves Net-Zero Energy Status," Environmental Leader, April 17, 2012, accessed January 7, 2015, http://www.environmentalleader.com/2012/04/17/mccormick-distribution-center-achieves-net-zero-energy-status/.
[26] Ibid.
[27] Energy Solutions Center, "About the RMI Energy Efficiency Program," Regional Manufacturing Institute of Maryland, accessed January 7, 2015, http://rmienergysolutions.com/about-us/.
[28] Ibid.
[29] Ibid.
[30] Ibid.
[31] Jamie Smith Hopkins, "A bid to lower manufacturers' energy bills," The Baltimore Sun, April 21, 2014, accessed January 7, 2015. http://articles.baltimoresun.com/2014-04-21/business/bs-bz-manufacturers-energy-efficiency-20140414_1_energy-efficiency-energy-bills-manufacturers.

Depot, Ski Haus, and Under Armour.[32] Under Armour operates two 300,000-plus-squarefoot distribution centers in Baltimore. Working with BGE, for a nearly 50 percent savings in retrofit costs, Under Armour recently installed nearly 900 new lighting fixtures between the two distribution centers. [33] These projects both aligned with the company's UA Green corporate mission, while producing a 28 percent reduction in kilowatt-hour (kWh) use per year and, therefore, generating ongoing energy savings in the future.[34]

Others, such as Gaithersburg's MedImmune have "been able to achieve savings in such an aggressive way due to its partnerships with DOE's Industrial Assessment Center program and the Maryland Energy Administration, as well as energy efficiency rebates available via its electric utility, Pepco."[35] MedImmune aims to reduce energy intensity by 25 percent by 2020, and as of 2013 MedImmune has achieved an energy intensity reduction of 19.2 percent.[36]

### 3.3 Greenhouse Gas Emissions Reduction Guidelines for Manufacturing

In the U.S., the greatest sources of GHG emissions include electricity production, transportation, industry, commercial and residential, agriculture, and land use and forestry.[37] Worldwide, electricity production followed by industry activity and forestry are the greatest sources of GHG emissions.[38] In 2006, the baseline year, industrial activity was responsible for approximately 7 percent of the total GHG emissions in Maryland.[39] In 2011 industrial activity was responsible for 20 percent of the total GHG emissions in the U.S. [40] To reduce GHG emissions, manufacturers and other industrial producers could increase energy efficiency, consider fuel switching, recycling, and institute training and awareness programs.[41] Many of these options have been successfully implemented both nationally and worldwide.

[32] "Success Stories," BGE, accessed January 7, 2015, http://www.bge.com/waystosave/business/bizlearnmore/bizsuccessstories/Pages/default.aspx.
[33] "Under Armour," BGE, accessed January 7, 2015, http://www.bge.com/waystosave/business/bizlearnmore/bizsuccessstories/Pages/Under-Armour.aspx.
[34] Ibid.
[35] MedImmune, "Maryland Manufacturer Pursues Energy Efficiency Improvements for Operational Savings," Maryland Energy Administration, accessed January 7, 2015, http://energy.maryland.gov/SEN/pdfs/MedImmune%20One%20Pager-042513.pdf.
[36] Ibid.
[37] "Sources of Greenhouse Gas Emissions Overview," United States Environmental Protection Agency, September 9, 2013, accessed October 24, 2013, http://www.epa.gov/climatechange/ghgemissions/sources.html.
[38] "Global Greenhouse Gas Emissions Data," United States Environmental Protection Agency, September 9, 2013, accessed April 18, 2014, http://www.epa.gov/climatechange/ghgemissions/global.html.
[39] "Maryland's Plan to Reduce Greenhouse Gas Emissions," Maryland Department of the Environment, 8, December 31, 2011, accessed October 28, 2013. http://www.mde.state.md.us/programs/Air/ClimateChange/Documents/2011%20Draft%20Plan/2011GGRADRAFTPlan.pdf.
[40] "Sources of Greenhouse Gas Emissions Overview," United States Environmental Protection Agency.
[41] "Sources of Greenhouse Gas Emissions Industry Sector Emissions," United States Environmental Protection Agency, October 30, 2013, accessed October 30, 2013, http://www.epa.gov/climatechange/ghgemissions/sources/industry.html.

**Alabama**

In Alabama, national policy affecting reduction of GHG emissions will impact a variety of industries, such as coal mining, energy, and manufacturing. These industries all have strong representation in the state.[42] To mitigate GHG emissions, the recommended policy options for the state include the following:

- Increased energy efficiency,
- Waste reduction and increased recycling,
- Increased use of methane/natural gas,
- Transportation changes, and
- Sequestration.[43]

**California**

Assembly Bill 32 passed in California in 2006. The bill included requirements that will help California meet GHG emissions reduction goals.[44] Specific requirements related to industrial activity include the adoption of required reporting regarding the level of greenhouse gas emissions as well as the adoption of set emissions limits.[45]

**Pennsylvania**

While climate change will impact Pennsylvania's energy industry, activities associated with renewable energy, such as manufacturing activities, will provide new jobs and revenue growth.[46] Coal, which has the highest carbon content when compared to other fossil fuels, will remain the major fuel source in the state, creating the challenge of managing GHG emissions associated with coal.[47] [48] In 2000, Pennsylvania's base year, coal production and use was responsible for 93 percent of the state's total energy-related emissions. [49] Due to the relatively controversial nature of coal and other fossil fuels, and Pennsylvania's abundance of such fuels, the state must seek viable uses of these natural resources.[50]

[42] Robert A. Griffin, William D. Gunther, and William J. Herz, "Policy Planning to Reduce Greenhouse Gas Emissions in Alabama Final Report," The University of Alabama, 16, December 1997, accessed October 28, 2013, http://www.epa.gov/statelocalclimate/documents/pdf/Alabama_action_plan.pdf.
[43] Ibid, 16-20.
[44] "Assembly Bill 32: Global Warming Solutions Act," California Environmental Protection Agency, accessed October 28, 2013, http://www.arb.ca.gov/cc/ab32/ab32.htm.
[45] Ibid.
[46] "Final Climate Change Action Plan," Pennsylvania Environmental Protection Agency, 2-3, December 18, 2009, accessed October 29, 2013, http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_001957.pdf.
[47] "Coal," Center for Climate and Energy Solutions, accessed April 18, 2014, http://www.c2es.org/energy/source/coal.
[48] "Final Climate Change Action Plan," Pennsylvania Environmental Protection Agency, 2-3.
[49] "Final Climate Change Action Plan," Pennsylvania Environmental Protection Agency, 4-3.
[50] Ibid, 2-3.

**Comparative International Findings**

Efforts to reduce GHG emissions are not limited to the U.S.; nations and organizations worldwide are working toward GHG emissions reductions. Canada, for instance, is committed to reducing GHG emissions—primarily through regulations pertaining to Canada's high emissions producing industries, like transportation and electricity.[51] Canada has seen a decrease in emissions of 5.1 percent from 2005 to 2012; this decrease did not hinder economic growth, which increased by 10.1 percent during the same period. [52] Other regulations implemented by Canada's climate change plan are performance standards for the major sources of emissions, with a focus on oil and gas, and other industrial emitters.[53]

A multitude of well-known global corporations, such as Unilever, Avon, SC Johnson, and Whirlpool, have all moved toward processes to reduce the GHG emissions created during the manufacturing process. Unilever aims to reduce emissions to or below 2008 levels by 2020 (a reduction of 40 percent per tonne of production), to increase its use of renewable energy to 40 percent of total energy with a long-term goal of using 100 percent renewable energy.[54] In 2012 Unilever's emission reductions were equivalent to that of reducing roadway congestion by approximately 200,000 cars.[55] As of 2012, all of Unilever's sites located in the U.S., Canada, and European Union utilized certified renewable electricity sources.[56]

Avon joined the Green Lights program, run by the U.S. Environmental Protection Agency, in 1994. At this time, Avon retrofitted many of its U.S.-based manufacturing and distribution locations with energy-efficient lighting.[57] Avon hoped to reduce GHG emissions created during operations by 20 percent compared to 2005 levels by 2020—a goal Avon exceeded in 2012 when reductions from the 2005 baseline reached 41 percent.[58] In the future, Avon hopes to switch to 100 percent clean energy, therefore eliminating emissions entirely.[59]

[51] "Canada's Action on Climate Change," Government of Canada, April 11, 2014, accessed April 18, 2014, http://www.climatechange.gc.ca/default.asp?lang=En&n=72F16A84-1.
[52] "Reducing Greenhouse Gases," Government of Canada, April 11, 2014, accessed April 18, 2014, http://www.climatechange.gc.ca/default.asp?lang=En&n=4FE85A4C-1.
[53] Ibid.
[54] "Reducing GHG from Manufacturing," Unilever, 2014, accessed April 10, 2014, http://www.unilever.com/sustainable-living/greenhousegases/reducingghgfrommanufacturing/.
[55] Ibid.
[56] Ibid.
[57] "Energy & Greenhouse Gas Emissions Reduction Efforts," Avon, the Company for Women, 2014, accessed April 10, 2014, http://www.avoncompany.com/corporatecitizenship/corporateresponsibility/sustainability/minimizingoperationalfootprint/energy-greenhouse-gas-reduction.html.
[58] "Energy & Greenhouse Gas Emissions Reduction Efforts," Avon.
[59] Ibid.

In 2000 SC Johnson established benchmarks for its largest plants, five in total at the international level, regarding GHG emissions.[60] In 2002 the corporation implemented additional reduction guidelines covering all operations in the U.S.; these goals were surpassed in 2005.[61] Over the past several years, SC Johnson has repeatedly set new reduction goals and continued to meet them. Most recently, SC Johnson began working toward an emissions reduction from global manufacturing of 48 percent compared to 2000 levels by 2016. [62] As of 2012, emissions from global sites compared at 40.2 percent of 2000 levels, with preliminary 2013 figures moving SC Johnson even closer to its 2016 goal. [63]

In 2003 Whirlpool stated its aim to accomplish a three percent emissions reduction from the 1998 base year by 2008.[64] Between 2003 and 2006, Whirlpool reduced GHG emissions by 4.1 million metric tons—the equivalent of planting nearly 1.4 million acres of trees.[65] In 2007 Whirlpool announced that it would further reduce GHG emissions by 6.6 percent by 2012; this announcement was made in support of Whirlpool's commitment to environmentally-sound business practices.[66] Whirlpool hopes to meet its overall reduction goals through the introduction of energy efficient models to its product line to reduce the impact of these products, as well as implementing improvements in both manufacturing and freight operations.[67]

Policies around the world are having vast impacts, and it is clear that successful policies regarding GHG emissions reduction have several key components in common. A 2003 Organization for Economic Co-Operation and Development report found three factors for success with greenhouse gas mitigation policies. Policies must be environmentally effective (i.e., reduce rather than reallocate), economically efficient (i.e., flexible options with minimal cost options), and have support.[68] These factors are also necessary if manufacturers worldwide are to remain competitive.

[60] "Reducing Greenhouse Gas Emissions," SC Johnson, A Family Company, 2013, accessed April 10, 2014, http://www.scjohnson.com/en/commitment/focus-on/conserving/reducing.aspx.
[61] Ibid.
[62] Ibid.
[63] Ibid.
[64] "Reducing Greenhouse Gas Emissions," Whirlpool Corporation, accessed April 10, 2014, http://www.whirlpoolcorp.com/responsibility/environment/performance/reducing_greenhouse_gas_emissions.aspx.
[65] Ibid.
[66] Ibid.
[67] Ibid.
[68] "Policies to Reduce Greenhouse as Emissions in Industry - Successful Approaches and Lessons Learned: Workshop Report," Organisation for Economic Co-operation and Development International Energy Agency, 10, 2003, accessed March 12, 2014, http://www.oecd.org/env/cc/2956442.pdf.

## 3.4 The Effect of Greenhouse Gas Emissions Reduction

**Energy Costs**

A 2014 Boston Consulting Group study finds that manufacturers in the U.S. are poised to benefit from the rising production of natural gas nationwide. [69] The lower electricity prices have already spurred investment in energy-intensive industries—even in industries that are less energy-intensive, low cost natural gas is estimated to shave "1 to 2 percent off of U.S. manufacturing costs as the benefits eventually flow downstream through the value chain."[70] BCG estimates that soon natural gas and electricity will account for just 2 percent and 1 percent, respectively, of average U.S. manufacturing costs—compared to the combined 7 to 13 percent energy costs seen in Japan and in the European Union. [71] Low energy costs will further narrow the cost gap between the manufacturers in the U.S. and in China. [72]

**Transportation**

Since 2010, following new greenhouse gas emissions standards implemented by the Obama administration, upfront vehicle prices have slightly increased (by approximately $1,000) yet lifetime fuel savings have surpassed that—coming in at $4,000 over the lifetime of the vehicle.[73] These estimates reflect a fuel efficiency of 35.5 miles per gallon required for standard cars and light trucks by model year 2016.[74] Since then, hybrid and electric vehicles have become increasingly popular—with the availability of electricity overweighing the availability of natural gas, vehicles of this type require less investment when compared to natural gas vehicles.[75] Alternatively, "the greatest opportunity to reduce greenhouse gas emissions…is through fuel substitution in fleets and heavy-duty vehicles." [76]

In some states, such as California, new transportation fuel policies benefit drivers and communities; however, trucking companies are not fairing as well—the EPA Regulations are putting some trucking companies out of business.[77] [78] The same regulations implemented by

[69] "Nearly Every Manufacturer in the U.S. Will Benefit from Low-Cost Natural Gas," The Boston Consulting Group, February 13, 2014, accessed January 7, 2015, http://www.bcg.com/media/PressReleaseDetails.aspx?id=tcm:12-154623.

[70] Ibid.

[71] Ibid.

[72] Ibid.

[73] Juliet Eilperin, "Emissions limits, greater fuel efficiency for cars, light trucks made official," The Washington Post, April 2, 2010, accessed January 7, 2015, http://www.washingtonpost.com/wp-dyn/content/article/2010/04/01/AR2010040101412.html.

[74] Ibid.

[75] "Leveraging Natural Gas to Reduce Greenhouse Gas Emissions," Center for Climate and Energy Solutions, June 2013, accessed January 7, 2015, http://www.c2es.org/publications/leveraging-natural-gas-reduce-greenhouse-gas-emissions.

[76] Ibid.

[77] Erica Morehouse, "Transportation fuel policies continue to benefit drivers and communities across California," Environmental Defense Fund, May 16, 2014, accessed January 7, 2015,

the California Air Resources Board (CARB) that will save drivers money will also put an "overwhelming burden for businesses, especially small businesses." [79] [80] As of January 1, 2015, "trucks weighing 14,000 pounds to 26,000 pounds will be forced to install PM retrofits;" retrofits cost are generally between $10,000 and $20,000.[81]

**Growth Opportunities**

Natural gas exploration has taken place in more than 30 states nationwide, creating local jobs in its wake.[82] Since the beginning of the Great Recession, states undergoing shale exploration have added nearly 1.4 million jobs; conversely states without shale exploration have lost more than 400,000 jobs.[83] According to 2014 study by the Perryman Group, natural gas exploration generates more than 9.3 million jobs and nearly $1.2 trillion in annual gross product.[84] Moreover, a PricewaterhouseCoopers study, done on the behalf of the National Association of Manufacturers, estimated that natural gas will generate an additional 1 million U.S. manufacturing jobs by 2025.[85]

## 3.5 Workforce Redevelopment

Manufacturing in Maryland and the U.S. as a whole has seen steady employment declines since 2002. The industry's average per capita weekly wage, however, has increased. This trend indicates a shift in the type of Manufacturing jobs available. According to the Manufacturing Institute, due in part to the increased "technological sophistication" of manufacturing, the industry now requires "more process-oriented, team-oriented workers."[86] As the industry evolves and the technical knowledge required of industry workers increases, the quality of available jobs is also increasing. Manufacturing jobs now require a higher level of training and education compared to traditional Manufacturing jobs. In 2000, 22 percent of the

http://blogs.edf.org/californiadream/2014/05/16/transportation-fuel-policies-continue-to-benefit-drivers-and-communities-across-california/.

[78] Wesley Coopersmith, "California EPA Regulation Puts Trucking Companies Out of Business," June 20, 2012, access January 7, 2015, http://www.freedomworks.org/content/california-epa-regulation-puts-trucking-companies-out-business.

[79] Morehouse, "Transportation fuel policies continue to benefit drivers and communities across California."

[80] Coopersmith, "California EPA Regulation Puts Trucking Companies Out of Business."

[81] Ibid.

[82] "Jobs," America's Natural Gas Alliance, accessed January 7, 2015, http://anga.us/why-natural-gas/jobs#.VKbsOyvF9yw.

[83] Tyler Durden, "Jobs: Shale States vs Non-Shale States," Zero Hedge, December 3, 2014, accessed January 7, 2015, http://www.zerohedge.com/news/2014-12-03/jobs-shale-states-vs-non-shale-states.

[84] Mella McEwen, "Study: Oil & Gas Industry Creates 9.3 Million Jobs in U.S.," Midland Reporter-Telegram, August 31, 2014, accessed January 7, 2015, http://www.cpapracticeadvisor.com/news/11674995/study-oil-gas-industry-creates-93-million-jobs-in-us.

[85] "Jobs," America's Natural Gas Alliance.

[86] "Percent of Manufacturing Workforce by Education Level," Manufacturing Institute, April 2014, accessed June 2, 2014, http://www.themanufacturinginstitute.org/Research/Facts-About-Manufacturing/Workforce-and-Compensation/Workforce-by-Education/Workforce-by-Education.aspx.

Manufacturing workforce in the U.S. held a Bachelor's degree or higher; this figure rose to approximately 29 percent in 2012.[87]

Having evolved to a new level of technological sophistication, Manufacturing now requires the use of "precision machinery, computer modeling and high-tech tooling."[88] According to the National Association of Manufacturers (NAM), the industry needs employee development, lifelong learning, and adult education, and many think it is necessary to develop these aspects well before beginning a career.[89] [90]

In recent years, many states have adopted a Common Core (CC) curriculum for K-12 grade levels. The CC curriculum focuses on higher universal standards in regard to literacy and mathematics, focuses which help prepare students "for these higher-skilled, internationally competitive jobs."[91] Beyond improvements made to the K-12 school system, many students who go on to earn a college degree often remain at a disadvantage. The industry lacks a standardized credentialing system, a limitation which creates an inadequate pool of desirable college graduates for employers in the industry.[92]

The aim of the newly launched Skills for America's Future program is to "provide 500,000 community college students with standardized manufacturing credentials that will promise secure jobs within the sector." [93] Through the program, students can "earn valuable credentials that are portable and demanded by vast amounts of firms." [94] Partners of the for-credit program of study include the Gates Foundation, the Lumina Foundation, and several members involved in education and training such as individuals from the American Welding Society, the National Institute of Metalworking Skills, the Society of Manufacturing Engineers, and the Manufacturing Skills Standards Council.[95]

[87] Ibid.
[88] Richard Haass and Klaus Kleinfeld, "Column: Lack of skilled employees hurting manufacturing," *USA Today News*, July 3, 2012, accessed June 2, 2014, http://usatoday30.usatoday.com/news/opinion/forum/story/2012-07-02/public-private-manufacuting/56005466/1.
[89] "Workforce Development and Training," National Association of Manufacturers, accessed June 2, 2014, http://www.nam.org/Issues/Employment-and-Labor/Manufacturing-Workforce-Development.aspx.
[90] "HRP-01 Education and the Workforce," National Association of Manufacturers, accessed June 2, 2014, http://www.nam.org/Issues/Official-Policy-Positions/Human-Resources-Policy/HRP-01-Education-and-the-Workforce.aspx#202.
[91] Haass and Kleinfeld, "Column: Lack of skilled employees hurting manufacturing."
[92] "President Obama and Skills for America's Future Partners Announce Initiatives Critical to Improving Manufacturing Workforce," Office of the Press Secretary, The White House, June 8, 2011, accessed June 2, 2014, http://www.whitehouse.gov/the-press-office/2011/06/08/president-obama-and-skills-americas-future-partners-announce-initiatives.
[93] Ibid.
[94] "President Obama and Skills for America's Future Partners Announce Initiatives Critical to Improving Manufacturing Workforce," Office of the Press Secretary.
[95] Ibid.

Skills for America's Future's partnerships also promote several other initiatives, such as the following:

- Helping manufacturers realize the need to implement credentials through "Boots on the Ground,"
- Building credentials into high school pathways,
- Providing new online tools for workers to earn and utilize these credentials,
- Improving awareness of such credentials through a Career Awareness Campaign,
- Increasing opportunities for at-risk youth to seek these careers and credentials, and
- Creating the next-generation engineering workforce.[96]

Locally, the Maryland Manufacturing Extension Partnership (MD MEP) has several programs designed to train the new manufacturing workforce. These programs include the Manufacturing Boot Camp and the Manufacturing Incumbent Workforce Training Partnership.[97] Both programs are made possible through the Employment Advancement Right Now (EARN) program. The Manufacturing Boot Camp, a six-week training program, aims to "increase the skills of potential workers and enhance their employability." [98] Following an assessment of trainee skills, individuals will undergo training for skills including but not limited to the following:

- Work ethic,
- Job readiness,
- Professionalism,
- Problem solving,
- Basic mathematics and English,
- Communication, and
- Basic manufacturing skills.[99]

An abbreviated version of this program was successfully piloted with Garrett Container Systems, Inc., a shipping and storage container manufacturer located in Western Maryland. Upon their completion of the program, ten of the program participants were hired by the company.[100]

[96] Ibid.
[97] Courtney Gaddi, "Maryland Manufacturing Extension Partnership Works to Grow Manufacturing in Maryland," *Columbia Patch*, February 20, 2014, accessed June 2, 2014, http://columbia.patch.com/groups/business-updates/p/maryland-manufacturing-extension-partnership-works-to-grow-manufacturing-in-maryland.
[98] "EARN Maryland 2014 Planning Grant Strategic Industry Partnerships," Maryland Department of Labor, Licensing and Regulation, 7, accessed June 2, 2014, http://www.dllr.maryland.gov/earn/earnsipsummaries.pdf.
[99] Gaddi, "Maryland Manufacturing Extension Partnership Proves Manufacturing Bootcamp Program Successful With Pilot Program."
[100] Gaddi, "Maryland Manufacturing Extension Partnership Proves Manufacturing Bootcamp Program Successful With Pilot Program."

In addition to the Manufacturing Boot Camp, the MD MEP proposed the Manufacturing Incumbent Workforce Training Partnership**.** This proposal seeks to "address skills gaps in advanced machining, master craftsmen and other areas," while alleviating the "burden on individual employers of incumbent worker training, such as tuition costs, wages and lost production time."[101]

# 4.0 Relevant Maryland Case Studies

While Manufacturing is excluded from current state regulations that require a 25 percent reduction in GHG emissions from 2006 levels by 2020, impacts associated with reduction efforts are occurring in the industry. RESI reached out to manufacturers in Maryland to discuss the impacts that reduction requirements have made. To date, Redland Brick and General Motors Baltimore Operations are the two completed case studies.

## 4.1 Redland Brick

On Thursday, December 12, 2013, team members from RESI and MDE visited and toured Redland Brick, Inc., in Williamsport, Maryland. Barry Miller (Manager of Safety, Environmental, and Quality) met with team members to discuss the impacts that legislation has had on Redland Brick and to provide a guided tour of the Williamsport facilities.

A subsidiary of Belden Holding & Acquisition Company, Inc., Redland Brick has six brick manufacturing plants, including two in Maryland (Cushwa and Rocky Ridge) and one each in Pennsylvania (Harmar), Connecticut (KF), and Virginia (Lawrenceville). Redland Brick produces a wide range of brick products, including handmade, moulded, and extruded styles.[102] Redland Brick's two moulded brick plants, located in Maryland, "have established themselves as the premier moulded brick producers in the United States."[103] In 2001 Redland Brick commissioned Harmar, located in suburban Pittsburgh, Pennsylvania. This plant offers "a variety of products including fireclay, red shale, and sand coated bricks" and is completely automated.[104] Located in South Windsor, Connecticut, is Redland's KF plant. According to the company's website, this plant "is a modern extruded plant that supplies quality brick products for New England and the Mid-Atlantic markets."[105] Redland also owns the two plants of Lawrenceville Brick in Lawrenceville, Virginia. Redland Brick has the unique ability to limit waste resulting from manufacturing. If at any time during the brick making process a brick is deemed flawed, it can be cycled back through to the beginning of the brickmaking process.

[101] "EARN Maryland 2014 Planning Grant Strategic Industry Partnerships," Maryland Department of Labor, Licensing and Regulation, 7.
[102] "Redland Brick Inc. – Brick Manufacturer," Redland Brick, 2011, accessed April 14, 2014, http://www.redlandbrick.com/aboutus.asp.
[103] Ibid.
[104] Ibid.
[105] "Redland Brick Inc. – Brick Manufacturer," Redland Brick.

To meet the Environmental Protection Agency's (EPA) Maximum Achievable Control Technology (MACT) requirements, in 2008 Redland Brick installed a new scrubber that cost approximately $1 million.[106] This particular scrubber uses high-quality, expensive limestone in the scrubbing process. In the interest of further reducing waste, Mr. Miller has worked with the Connecticut Agricultural Experiment Station to complete an analysis that shows that the limestone used by Redland Brick, and therefore the limestone waste resulting from the scrubbing process, provides a pH level comparable to the regular lime commonly used in farming when added to topsoil. After the expensive changes made by Redland Brick to meet the 2008 MACT requirements, the legislation was overturned. EPA is now finalizing a second MACT standard for the same emissions.

Depending upon the outcome, Redland Brick may need to replace that scrubber, continue to operate it, or have it determined that the scrubber was never necessary. The combination of regulatory requirements and the housing market crash has crippled the brick industry. Redland is not aware of technology available on the market today that can be used in a brick kiln to reduce greenhouse gas emissions. If forced to reduce greenhouse gas emissions, Redland would likely be forced to reduce production. Reducing production would lead to job losses and an additional sizable strain on Redland Brick's ability to operate.

### 4.2 General Motors Baltimore Operations

In June 2015, team members from RESI spoke with a representative from the General Motors (GM) Baltimore Operations. Michael Martinko, Senior Environmental Engineer, spoke with team members to discuss the impacts that legislation has had on GM's Baltimore Operations since the early 2000s.

GM is a dynamic motor vehicle manufacturer with operations worldwide.[107] GM's domestic brands include Buick, Cadillac, Chevrolet, and GMC. With nearly 400 facilities and more than 20,000 dealers, GM's wide spread activity encompasses 6 continents and 120 countries.[108] GM strives to create new vehicles and technology as well as engineer state-of-the-art plants.[109] Through innovative technology development, such as electric vehicles and fuel saving technology, GM is working to shape the automotive industry of the future.[110] The GM Baltimore Operations facility is located in White Marsh, Maryland.[111]

[106] While MACT is not a GHG reduction requirement, it is aimed at criteria pollutants.
[107] "Our Company," General Motors, accessed June 22, 2015, http://www.gm.com/company/aboutGM/our_company.html.
[108] Ibid.
[109] Ibid.
[110] "Our Company," General Motors.
[111] "Baltimore Operations," GM News, accessed June 22, 2015, http://media.gm.com/media/us/en/gm/company_info/facilities/powertrain/baltimore.html.

Opened in December 2000, GM Baltimore Operations encompasses more than 580,000 square feet.[112] This plant houses 1.81 megawatts of rooftop solar arrays and is landfill-free, meaning it recycles, reuses, or converts to energy all waste created from daily operations.[113] In April 2011, the facility took first place in the *Baltimore Business Journal*'s Annual Green Business Award Event; that same year, the facility earned Wildlife Habitat Council certification.[114] In June 2012, the facility was included among the winners of the Maryland Green Registry Leadership Awards, and in 2013 Baltimore County honored Baltimore Operations in the Baltimore County Chamber of Commerce Business Hall of Fame for the facility's environmental efforts.[115] More recently, in June 2014, the facility was recognized with a Project of Distinction Award from PV America for a smart microgrid charging technology, which uses a solar array and solar EV charging canopy to charge Chevrolet Volts or stores energy in a system to support the grid.[116]

GM committed to reduce its facilities' carbon intensity globally by 20 percent by 2020. While the solar array generates approximately 6 percent of GM Baltimore Operation's electricity, natural gas used in heat treating remains the facility's key contributor to GHG emissions. However, the plant maintains its commitment to operating landfill-free by recycling or reusing 90 percent of waste in 2013. In addition to the solar array on site at the facility, GM Baltimore Operations strives to reduce power usage during lunch hours by shutting down lights and running at a 20 percent level of production on weekends. GM Baltimore Operations recently met the Environmental Protection Agency's ENERGY STAR® Challenge for Industry by reducing the energy intensity of its operations by 15.5 percent in just three years. The site has continued other initiatives to reduce energy costs, such as moving from single speed compressors to variable speed compressors, a change that helps to reduce both energy and maintenance costs. Although the upfront cost is greater, Mr. Martinko noted that the long-term costs are diminished, which balances the short-term investment. GM Baltimore Operations attributes much of its success in leading the way as a manufacturer to collaborative environmental efforts with companies like Constellation Energy and TimberRock. These partnerships help GM Baltimore Operations continue to reduce its impact on climate change.

# 5.0 Economic Impacts from the GGRA on Manufacturing

Maryland's Manufacturing industry was one of the hardest hit industries in the state during the recession from 2007 through 2009. Upon passage of the GGRA, concerns arose about Manufacturing's ability to remain competitive if more costs were added after the recession. However, RESI's analysis shows that there are no net discernible impacts on Manufacturing from GGRA implementation.

[112] Ibid.
[113] Ibid.
[114] Ibid.
[115] Ibid.
[116] Ibid.

To determine the potential impacts associated with the GGRA, RESI used agency-specific data and external research to determine inputs for the analysis. These inputs included the following:

- Industry sales data,
- Energy consumption reduction estimates,
- Industry-level demand, and
- Tax credits.

Using these inputs, RESI ran the analysis using the REMI PI+ model, specifically calibrated to Maryland's economy, to determine impacts from 2010 through 2020. The following section discusses the impacts on employment, output, and wages.

## 5.1 Economic Impacts

To determine the level of impact on the Manufacturing industry, RESI ran all GGRA initiatives outlined in the GGRA from investment through operation. The following results are the impacts expected to occur in Maryland for the Manufacturing industry by 2020. Overall, RESI found no discernible impact on employment in the Manufacturing industry between 2010 and 2020. Figure 3 reports the findings for the 20 sectors that make up the industry at the four-digit NAICS level for employment in 2020.

**Figure 2: Manufacturing Employment Impacts from GGRA Initiatives, 2020**[117]

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 3.9 | -0.4 | 3.5 |
| Beverage and tobacco product manufacturing | 4.4 | -1.7 | 2.7 |
| Chemical manufacturing | 4.2 | -1.0 | 3.2 |
| Computer and electronic product manufacturing | 9.3 | 29.2 | 38.5 |
| Electrical equipment and appliance manufacturing | 23.0 | -0.4 | 22.6 |
| Fabricated metal product manufacturing | 16.3 | -0.5 | 15.8 |
| Food manufacturing | 5.3 | -13.7 | -8.4 |
| Furniture and related product manufacturing | -0.7 | 1.7 | 1 |
| Machinery manufacturing | -2.9 | 5.2 | 2.3 |
| Miscellaneous manufacturing | -1.1 | 3.4 | 2.3 |
| Motor vehicles, bodies and trailers, and parts manufacturing | 0.2 | 1.0 | 1.2 |
| Nonmetallic mineral product manufacturing | 14.3 | -2.7 | 11.6 |
| Other transportation equipment manufacturing | -1.5 | -0.8 | -2.3 |
| Paper manufacturing | 2.7 | -1.5 | 1.2 |
| Petroleum and coal products manufacturing | 0.7 | -0.3 | 0.4 |
| Plastics and rubber product manufacturing | 6.2 | -2.2 | 4 |
| Primary metal manufacturing | 0.6 | -1.0 | -0.4 |
| Printing and related support activities | 14.1 | -0.7 | 13.4 |
| Textile mills; Textile product mills | 0.0 | -0.6 | -0.6 |
| Wood product manufacturing | 4.9 | -3.8 | 1.1 |

Sources: REMI PI+, RESI

As reported in Figure 2, the two greatest gaining sectors in terms of employment by 2020 from GGRA initiatives are *Computer and electronic product manufacturing* and *Electrical equipment and appliance manufacturing*. The sectors that are likely to experience minimal to no loss are *Food manufacturing*, *Other transportation equipment manufacturing*, and *Textile mills; Textile product mills.* Overall, most sectors are expect to see some minor increases in employment during that period.

In addition to an increase in employment, output for the industry is expected to grow through 2020. Impacts associated with the changes in output are reported in Figure 3.

**Figure 3: Manufacturing Output Impacts from GGRA Initiatives, 2020**[118]

[117] The following impacts are those that are expected to occur in year 2020. Therefore, in year 2020, RESI expects that the *Apparel manufacturing; Leather and allied product manufacturing* sector will increase by 3.5 jobs.

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $213,645 | -$38,618 | $175,027 |
| Beverage and tobacco product manufacturing | $1,931,614 | -$423,644 | $1,507,970 |
| Chemical manufacturing | $6,739,902 | $1,829,887 | $8,569,789 |
| Computer and electronic product manufacturing | $1,836,413 | $2,108,593 | $3,945,006 |
| Electrical equipment and appliance manufacturing | $4,378,054 | -$128,919 | $4,249,135 |
| Fabricated metal product manufacturing | $2,347,909 | -$8,334 | $2,339,575 |
| Food manufacturing | $34,898,986 | -$35,919,825 | -$1,020,839 |
| Furniture and related product manufacturing | -$1,245,385 | $1,238,741 | -$6,644 |
| Machinery manufacturing | $1,222,865 | -$1,213,066 | $9,799 |
| Miscellaneous manufacturing | $1,214,402 | -$1,124,451 | $89,951 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $1,463,898 | -$1,647,134 | -$183,236 |
| Nonmetallic mineral product manufacturing | $1,766,294 | $410,368 | $2,176,662 |
| Other transportation equipment manufacturing | $1,775,479 | -$1,865,199 | -$89,720 |
| Paper manufacturing | $520,176 | $7,570 | $527,746 |
| Petroleum and coal products manufacturing | $2,934,225 | -$2,128,244 | $805,981 |
| Plastics and rubber product manufacturing | $3,420,268 | -$1,553,721 | $1,866,547 |
| Primary metal manufacturing | -$53,062 | $663,211 | $610,149 |
| Printing and related support activities | $1,597,468 | $178,777 | $1,776,245 |
| Textile mills; Textile product mills | $93,151 | -$75,113 | $18,038 |
| Wood product manufacturing | $1,238,096 | -$2,137,476 | -$899,380 |

Sources: REMI PI+, RESI

By 2020, the greatest increase in output will be associated with the *Computer and electronic production manufacturing* and the *Chemical Manufacturing* sectors. Smaller sectors such as *Other transportation equipment manufacturing* and *Textile mills; Textile product mills* are expected to see minimal gains during that period.

Finally, RESI found that wages are expected to rise through 2020 in the manufacturing industry if all GGRA initiatives are implemented. Figure 5 reports the wage impacts over the 20 sectors that comprise the Manufacturing industry.

[118] The following impacts are those that are expected to occur in year 2020. Therefore, in year 2020, RESI expects that the *Apparel manufacturing; Leather and allied product manufacturing* sector will increase by $175,027 in output.

**Figure 4: Manufacturing Wage Impacts from GGRA Initiatives, 2020**[119]

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---:|---:|---:|
| Apparel manufacturing; Leather and allied product manufacturing | $67,541 | -$7,935 | $59,606 |
| Beverage and tobacco product manufacturing | $130,895 | $25,425 | $156,320 |
| Chemical manufacturing | $443,825 | $139,011 | $582,836 |
| Computer and electronic product manufacturing | $1,685,521 | $3,862,656 | $5,548,177 |
| Electrical equipment and appliance manufacturing | $1,825,196 | -$59,269 | $1,765,927 |
| Fabricated metal product manufacturing | $1,057,189 | -$59,759 | $997,430 |
| Food manufacturing | $663,109 | -$1,018,840 | -$355,731 |
| Furniture and related product manufacturing | -$262,103 | $284,368 | $22,265 |
| Machinery manufacturing | $268,869 | -$178,872 | $89,997 |
| Miscellaneous manufacturing | -$188,135 | $220,202 | $32,067 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $83,647 | -$44,139 | $39,508 |
| Nonmetallic mineral product manufacturing | $604,918 | $72,718 | $677,636 |
| Other transportation equipment manufacturing | $277,546 | -$166,669 | $110,877 |
| Paper manufacturing | $508,840 | -$420,837 | $88,003 |
| Petroleum and coal products manufacturing | $101,596 | -$79,035 | $22,561 |
| Plastics and rubber product manufacturing | -$228,819 | $536,758 | $307,939 |
| Primary metal manufacturing | -$41,682 | $74,578 | $32,896 |
| Printing and related support activities | $284,661 | $212,314 | $496,975 |
| Textile mills; Textile product mills | -$116,148 | $124,413 | $8,265 |
| Wood product manufacturing | $277,286 | -$352,867 | -$75,581 |

Sources: REMI PI+, RESI

According to Figure 4, the sectors with the greatest gain in wages through 2020 are *Computer and electronic product manufacturing* and *Electrical equipment and appliance manufacturing.* Smaller gains are likely to be recorded in the *Textile mills; Textile product mills* sector and the *Petroleum and coal products manufacturing* sector.

## 5.2 Discussion

According to RESI's analysis, manufacturing will experience no discernible impact on employment between 2010 and 2020 if all policies are implemented. Manufacturing sectors

[119] The following impacts are those that are expected to occur in year 2020. Therefore, in year 2020, RESI expects that the *Apparel manufacturing; Leather and allied product manufacturing* sector will increase by $59.606 in wages.

associated with high and middle skilled labor, such as *Computer and electronic product manufacturing*, *Chemical manufacturing*, and *Electrical equipment and appliance manufacturing*, will experience the greatest impacts. Occupations within *Computer and electronic product manufacturing* include the following:

- Computer hardware engineers,
- Computer software engineers, applications,
- Computer software engineers, systems software,
- Electrical and electronic engineering technicians,
- Electrical and electronic equipment assemblers, and,
- Semiconductor processors.[120]

Some of the occupations within this sector, such as computer hardware engineers, require at least a Bachelor's degree.[121] This occupation pays a median salary of $100,920, which is well above the median income for a Bachelor's degree according to The National Center for Education Statistics.[122] [123] However, some occupations, such as electrical and electronic engineering technicians, require less additional education opening career pathways for non-college graduates. According to the BLS's Occupational Outlook Handbook, electrical and electronic engineering technician jobs require a minimum of an Associate's degree.[124]

Overall, RESI found that the GGRA's impact on Maryland may benefit Manufacturing for high- to middle-skilled labor. Although the workforce needed to meet this demand is likely to require additional education and training to meet specifics industry needs, Maryland is poised to provide this workforce to prospective employees. Continued partnerships, as discussed in Section 3.0, will provide the fundamental groundwork in meeting employer demand related to implementation and operation of GGRA initiatives. However, there is no conclusive evidence that any change in the Manufacturing industry operations has been directly attributable to the GGRA.

[120] "Industries at a Glance: Computer and Electronic Product Manufacturing: NAICS 334," Bureau of Labor Statistics, date extracted on April 29, 2014, accessed April 29, 2014, http://www.bls.gov/iag/tgs/iag334.htm.
[121] "Occupational Outlook Handbook: Computer Hardware Engineers," Bureau of Labor Statistics, last modified on January 8, 2014, accessed April 29, 2014, http://www.bls.gov/ooh/architecture-and-engineering/computer-hardware-engineers.htm.
[122] Ibid.
[123] "Fast Facts: Income of Young Adults," National Center for Education Statistics, updated 2013, accessed April 30, 2014. http://nces.ed.gov/fastfacts/display.asp?id=77
[124] "Occupational Outlook Handbook: Electrical and Electronics Engineering Technicians," Bureau of Labor Statistics, last modified on January 8, 2014, accessed April 29, 2014, http://www.bls.gov/ooh/architecture-and-engineering/electrical-and-electronics-engineering-technicians.htm.

# 6.0 Conclusion

The reduction of greenhouse gas emissions is not only a statewide issue but one that extends internationally. Internationally recognizable companies such as Avon, Whirlpool, SC Johnson, and General Motors have worked with the industry to achieve reductions in greenhouse gas emissions domestically and abroad. Nationally, partnerships between industry leaders, and state and federal agencies continue to pursue greenhouse gas emissions. Regional partnerships such as those between RMI and PSC have assisted manufacturers in effectively reducing energy consumption through funding opportunities.

RESI's research indicates that the Manufacturing industry will see no discernible impacts from the greenhouse gas reduction strategies as outlined in the GGRA. In addition to this finding, RESI expects the following:

- The manufacturing industry will create 113 jobs by 2020 to meet the demand for greenhouse gas reduction.
- Sectors within the industry such as *Computer and electronic product manufacturing* and *Electrical equipment and appliance manufacturing* will see the greatest growth during this time.
- Lower skilled sectors such as *Food manufacturing* and *Textile mills* will see minimal declines in employment between 2010 and 2020.
- Wages for the industry will increase by $10.7 million and output for the industry will grow by $26.5 million by 2020.

Some manufacturers have implemented energy-efficient strategies as a method for reducing production costs rather than a method for achieving greenhouse gas reduction. As stated by Mr. Miller from Redland Brick, the brick industry sector has transformed its energy use over time. From wood to coal and finally to natural gas, these reductions have been more focused on reducing costs than reducing emissions. The use of natural gas rather than coal reduces emissions but also allows the producer to reduce production costs and remain competitive.

The EIA expects these energy costs to increase over the next five years. During this time, manufacturers will need to seek new methods of cost reduction to retain competitiveness. The expansion of new technologies, energy efficiency methods, and partnerships to achieve these goals at the least cost will be key in the success of the GGRA as well as the Manufacturing industry through 2020. RESI's findings indicate that workforce training will be crucial in meeting industry demand as more GGRA initiatives are implemented and fully operational by 2020.

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# Appendix A—Annual Employment Impacts for the Manufacturing Industry

The following tables highlight the employment impacts associated with the GGRA to the Manufacturing industry in Maryland between 2010 and 2020.

**Figure 5: Manufacturing Employment Impacts from GGRA Initiatives, 2010**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 1.3 | 0.0 | 1.3 |
| Beverage and tobacco product manufacturing | 1.6 | 0.0 | 1.6 |
| Chemical manufacturing | 10.1 | 0.6 | 10.7 |
| Computer and electronic product manufacturing | 3.7 | 2.5 | 6.2 |
| Electrical equipment and appliance manufacturing | 5.0 | 0.0 | 5 |
| Fabricated metal product manufacturing | 18.0 | -0.3 | 17.7 |
| Food manufacturing | 2.5 | -0.1 | 2.4 |
| Furniture and related product manufacturing | 2.2 | 0.2 | 2.4 |
| Machinery manufacturing | 1.8 | 0.3 | 2.1 |
| Miscellaneous manufacturing | 1.6 | 0.1 | 1.7 |
| Motor vehicles, bodies and trailers, and parts manufacturing | 1.7 | 0.0 | 1.7 |
| Nonmetallic mineral product manufacturing | 14.1 | -0.4 | 13.7 |
| Other transportation equipment manufacturing | 0.5 | 0.1 | 0.6 |
| Paper manufacturing | 2.3 | -0.1 | 2.2 |
| Petroleum and coal products manufacturing | 0.8 | 0.0 | 0.8 |
| Plastics and rubber product manufacturing | 6.0 | -0.1 | 5.9 |
| Primary metal manufacturing | 0.6 | 0.2 | 0.8 |
| Printing and related support activities | 10.2 | -0.1 | 10.1 |
| Textile mills; Textile product mills | 0.2 | 0.0 | 0.2 |
| Wood product manufacturing | 6.2 | 1.2 | 7.4 |

Sources: REMI PI+, RESI

**Figure 6: Manufacturing Employment Impacts from GGRA Initiatives, 2011**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 3.0 | 0.0 | 3.0 |
| Beverage and tobacco product manufacturing | 3.0 | -0.1 | 2.9 |
| Chemical manufacturing | 15.7 | 1.2 | 16.9 |
| Computer and electronic product manufacturing | 21.7 | 22.0 | 43.7 |
| Electrical equipment and appliance manufacturing | 51.1 | -1.1 | 50.0 |
| Fabricated metal product manufacturing | 30.0 | 0.7 | 30.7 |
| Food manufacturing | 4.5 | -0.5 | 4.0 |
| Furniture and related product manufacturing | 2.1 | 1.6 | 3.7 |
| Machinery manufacturing | -1.8 | 5.5 | 3.7 |
| Miscellaneous manufacturing | 0.8 | 2.3 | 3.1 |
| Motor vehicles, bodies and trailers, and parts manufacturing | 1.6 | 1.0 | 2.6 |
| Nonmetallic mineral product manufacturing | 23.8 | -0.7 | 23.1 |
| Other transportation equipment manufacturing | 0.1 | 0.7 | 0.8 |
| Paper manufacturing | 3.2 | -0.2 | 3.0 |
| Petroleum and coal products manufacturing | 1.4 | 0.0 | 1.4 |
| Plastics and rubber product manufacturing | 9.8 | 0.0 | 9.8 |
| Primary metal manufacturing | 1.0 | 0.3 | 1.3 |
| Printing and related support activities | 14.2 | 0.1 | 14.3 |
| Textile mills; Textile product mills | 0.2 | 0.0 | 0.2 |
| Wood product manufacturing | 10.4 | 0.8 | 11.2 |

Sources: REMI PI+, RESI

**Figure 7: Manufacturing Employment Impacts from GGRA Initiatives, 2012**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 3.7 | -0.1 | 3.6 |
| Beverage and tobacco product manufacturing | 3.7 | -0.3 | 3.4 |
| Chemical manufacturing | 15.9 | 1.2 | 17.1 |
| Computer and electronic product manufacturing | 10.6 | 11.4 | 21.9 |
| Electrical equipment and appliance manufacturing | 19.8 | -0.2 | 19.6 |
| Fabricated metal product manufacturing | 32.6 | -0.2 | 32.4 |
| Food manufacturing | 5.4 | -1.1 | 4.3 |
| Furniture and related product manufacturing | 3.2 | 0.7 | 3.8 |
| Machinery manufacturing | 1.9 | 2.4 | 4.3 |
| Miscellaneous manufacturing | 2.5 | 1.0 | 3.5 |
| Motor vehicles, bodies and trailers, and parts manufacturing | 2.2 | 0.4 | 2.7 |
| Nonmetallic mineral product manufacturing | 26.0 | -0.9 | 25.1 |
| Other transportation equipment manufacturing | 0.6 | 0.1 | 0.8 |
| Paper manufacturing | 3.4 | -0.4 | 3.1 |
| Petroleum and coal products manufacturing | 1.3 | 0.0 | 1.2 |
| Plastics and rubber product manufacturing | 11.2 | -0.3 | 10.9 |
| Primary metal manufacturing | 1.0 | 0.4 | 1.3 |
| Printing and related support activities | 16.5 | -0.2 | 16.3 |
| Textile mills; Textile product mills | 0.3 | -0.1 | 0.1 |
| Wood product manufacturing | 11.8 | 0.8 | 12.6 |

Sources: REMI PI+, RESI

**Figure 8: Manufacturing Employment Impacts from GGRA Initiatives, 2013**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 3.5 | -0.1 | 3.4 |
| Beverage and tobacco product manufacturing | 3.6 | -0.4 | 3.2 |
| Chemical manufacturing | 12.9 | 1.5 | 14.4 |
| Computer and electronic product manufacturing | 17.9 | 22.4 | 40.3 |
| Electrical equipment and appliance manufacturing | 44.1 | -0.8 | 43.3 |
| Fabricated metal product manufacturing | 35.1 | 0.2 | 35.3 |
| Food manufacturing | 5.0 | -3.2 | 1.8 |
| Furniture and related product manufacturing | 2.1 | 1.4 | 3.5 |
| Machinery manufacturing | -1.0 | 5.2 | 4.2 |
| Miscellaneous manufacturing | 0.6 | 2.2 | 2.8 |
| Motor vehicles, bodies and trailers, and parts manufacturing | 1.6 | 0.9 | 2.5 |
| Nonmetallic mineral product manufacturing | 29.1 | -1.1 | 28.0 |
| Other transportation equipment manufacturing | 0.0 | 0.3 | 0.3 |
| Paper manufacturing | 3.5 | -0.5 | 3.0 |
| Petroleum and coal products manufacturing | 1.3 | -0.1 | 1.2 |
| Plastics and rubber product manufacturing | 11.3 | -0.4 | 10.9 |
| Primary metal manufacturing | 1.1 | 0.5 | 1.6 |
| Printing and related support activities | 15.6 | -0.1 | 15.5 |
| Textile mills; Textile product mills | 0.2 | -0.2 | 0.0 |
| Wood product manufacturing | 12.4 | -0.1 | 12.3 |

Sources: REMI PI+, RESI

**Figure 9: Manufacturing Employment Impacts from GGRA Initiatives, 2014**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 3.9 | -0.2 | 3.7 |
| Beverage and tobacco product manufacturing | 3.8 | -0.6 | 3.2 |
| Chemical manufacturing | 11.4 | 1.7 | 13.1 |
| Computer and electronic product manufacturing | 11.6 | 15.8 | 27.4 |
| Electrical equipment and appliance manufacturing | 24.7 | -0.3 | 24.5 |
| Fabricated metal product manufacturing | 27.0 | -0.2 | 26.8 |
| Food manufacturing | 4.9 | -4.9 | 0.0 |
| Furniture and related product manufacturing | 2.1 | 0.9 | 3.0 |
| Machinery manufacturing | 0.2 | 3.3 | 3.5 |
| Miscellaneous manufacturing | 1.2 | 1.3 | 2.6 |
| Motor vehicles, bodies and trailers, and parts manufacturing | 1.6 | 0.6 | 2.2 |
| Nonmetallic mineral product manufacturing | 22.4 | -1.1 | 21.3 |
| Other transportation equipment manufacturing | 0.1 | -0.1 | 0.0 |
| Paper manufacturing | 3.2 | -0.7 | 2.5 |
| Petroleum and coal products manufacturing | 1.1 | -0.1 | 1.0 |
| Plastics and rubber product manufacturing | 9.6 | -0.4 | 9.1 |
| Primary metal manufacturing | 0.9 | 0.4 | 1.3 |
| Printing and related support activities | 15.6 | -0.4 | 15.2 |
| Textile mills; Textile product mills | 0.2 | -0.2 | -0.1 |
| Wood product manufacturing | 9.6 | -0.9 | 8.6 |

Sources: REMI PI+, RESI

**Figure 10: Manufacturing Employment Impacts from GGRA Initiatives, 2015**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 4.6 | -0.2 | 4.4 |
| Beverage and tobacco product manufacturing | 4.7 | -0.7 | 3.9 |
| Chemical manufacturing | 13.9 | 1.8 | 15.7 |
| Computer and electronic product manufacturing | 24.7 | 30.5 | 55.2 |
| Electrical equipment and appliance manufacturing | 53.0 | -1.0 | 52.0 |
| Fabricated metal product manufacturing | 37.4 | 0.3 | 37.7 |
| Food manufacturing | 5.8 | -6.6 | -0.9 |
| Furniture and related product manufacturing | 1.7 | 2.0 | 3.7 |
| Machinery manufacturing | -3.0 | 6.9 | 3.8 |
| Miscellaneous manufacturing | -0.5 | 3.2 | 2.7 |
| Motor vehicles, bodies and trailers, and parts manufacturing | 1.3 | 1.2 | 2.4 |
| Nonmetallic mineral product manufacturing | 32.4 | -1.6 | 30.8 |
| Other transportation equipment manufacturing | -0.5 | 0.3 | -0.2 |
| Paper manufacturing | 3.9 | -0.9 | 3.1 |
| Petroleum and coal products manufacturing | 1.4 | -0.1 | 1.3 |
| Plastics and rubber product manufacturing | 12.6 | -0.6 | 12.0 |
| Primary metal manufacturing | 1.2 | 0.4 | 1.6 |
| Printing and related support activities | 19.8 | -0.3 | 19.5 |
| Textile mills; Textile product mills | 0.1 | -0.3 | -0.2 |
| Wood product manufacturing | 13.2 | -1.5 | 11.7 |

Sources: REMI PI+, RESI

**Figure 11: Manufacturing Employment Impacts from GGRA Initiatives, 2016**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 4.6 | -0.3 | 4.3 |
| Beverage and tobacco product manufacturing | 4.7 | -0.9 | 3.8 |
| Chemical manufacturing | 10.8 | 1.6 | 12.4 |
| Computer and electronic product manufacturing | 15.5 | 22.4 | 37.9 |
| Electrical equipment and appliance manufacturing | 29.1 | -0.4 | 28.7 |
| Fabricated metal product manufacturing | 27.7 | -0.3 | 27.4 |
| Food manufacturing | 5.5 | -8.3 | -2.8 |
| Furniture and related product manufacturing | 1.3 | 1.4 | 2.7 |
| Machinery manufacturing | -1.5 | 4.5 | 3.0 |
| Miscellaneous manufacturing | 0.3 | 2.1 | 2.4 |
| Motor vehicles, bodies and trailers, and parts manufacturing | 1.2 | 0.8 | 2.0 |
| Nonmetallic mineral product manufacturing | 23.7 | -1.6 | 22.1 |
| Other transportation equipment manufacturing | -0.5 | -0.2 | -0.7 |
| Paper manufacturing | 3.5 | -1.1 | 2.4 |
| Petroleum and coal products manufacturing | 1.2 | -0.1 | 1.1 |
| Plastics and rubber product manufacturing | 10.1 | -0.9 | 9.2 |
| Primary metal manufacturing | 0.9 | 0.2 | 1.1 |
| Printing and related support activities | 18.0 | -0.6 | 17.4 |
| Textile mills; Textile product mills | 0.1 | -0.4 | -0.3 |
| Wood product manufacturing | 9.6 | -2.5 | 7.1 |

Sources: REMI PI+, RESI

**Figure 12: Manufacturing Employment Impacts from GGRA Initiatives, 2017**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 5.1 | 0.0 | 5.0 |
| Beverage and tobacco product manufacturing | 5.8 | -1.1 | 4.7 |
| Chemical manufacturing | 16.2 | 1.7 | 17.9 |
| Computer and electronic product manufacturing | 83.8 | 104.6 | 188.4 |
| Electrical equipment and appliance manufacturing | 145.8 | -3.4 | 142.4 |
| Fabricated metal product manufacturing | 57.8 | 4.5 | 62.4 |
| Food manufacturing | 7.0 | -9.9 | -2.9 |
| Furniture and related product manufacturing | -4.4 | 8.4 | 4.0 |
| Machinery manufacturing | -21.2 | 23.2 | 2.0 |
| Miscellaneous manufacturing | -13.3 | 14.7 | 1.4 |
| Motor vehicles, bodies and trailers, and parts manufacturing | -2.7 | 4.1 | 1.4 |
| Nonmetallic mineral product manufacturing | 56.5 | -2.6 | 53.9 |
| Other transportation equipment manufacturing | -4.8 | 3.3 | -1.4 |
| Paper manufacturing | 5.3 | -1.0 | 4.3 |
| Petroleum and coal products manufacturing | 2.1 | -0.2 | 1.9 |
| Plastics and rubber product manufacturing | 17.1 | -0.6 | 16.5 |
| Primary metal manufacturing | 1.7 | 0.0 | 1.7 |
| Printing and related support activities | 21.6 | 2.0 | 23.5 |
| Textile mills; Textile product mills | -0.2 | -0.2 | -0.5 |
| Wood product manufacturing | 20.0 | -2.1 | 17.9 |

Sources: REMI PI+, RESI

**Figure 13: Manufacturing Employment Impacts from GGRA Initiatives, 2018**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 4.4 | 0.0 | 4.4 |
| Beverage and tobacco product manufacturing | 5.4 | -1.4 | 4.1 |
| Chemical manufacturing | 11.3 | 1.0 | 12.3 |
| Computer and electronic product manufacturing | 82.0 | 113.4 | 195.5 |
| Electrical equipment and appliance manufacturing | 157.7 | -3.9 | 153.8 |
| Fabricated metal product manufacturing | 45.0 | 5.2 | 50.2 |
| Food manufacturing | 6.4 | -11.6 | -5.2 |
| Furniture and related product manufacturing | -7.3 | 9.4 | 2.2 |
| Machinery manufacturing | -23.0 | 23.2 | 0.2 |
| Miscellaneous manufacturing | -16.5 | 17.1 | 0.6 |
| Motor vehicles, bodies and trailers, and parts manufacturing | -3.7 | 4.3 | 0.7 |
| Nonmetallic mineral product manufacturing | 46.4 | -2.7 | 43.7 |
| Other transportation equipment manufacturing | -5.9 | 3.7 | -2.3 |
| Paper manufacturing | 4.3 | -1.1 | 3.2 |
| Petroleum and coal products manufacturing | 1.6 | -0.2 | 1.4 |
| Plastics and rubber product manufacturing | 13.2 | -0.8 | 12.4 |
| Primary metal manufacturing | 1.3 | -0.4 | 0.9 |
| Printing and related support activities | 17.5 | 2.7 | 20.2 |
| Textile mills; Textile product mills | -0.3 | -0.3 | -0.6 |
| Wood product manufacturing | 15.5 | -2.5 | 13.0 |

Sources: REMI PI+, RESI

**Figure 14: Manufacturing Employment Impacts from GGRA Initiatives, 2019**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 4.0 | -0.3 | 3.7 |
| Beverage and tobacco product manufacturing | 4.7 | -1.6 | 3.0 |
| Chemical manufacturing | 5.7 | -0.5 | 5.1 |
| Computer and electronic product manufacturing | 22.1 | 45.0 | 67.1 |
| Electrical equipment and appliance manufacturing | 47.7 | -1.1 | 46.7 |
| Fabricated metal product manufacturing | 26.6 | 0.5 | 27.1 |
| Food manufacturing | 5.2 | -13.0 | -7.7 |
| Furniture and related product manufacturing | -1.5 | 3.1 | 1.6 |
| Machinery manufacturing | -6.0 | 8.6 | 2.6 |
| Miscellaneous manufacturing | -4.0 | 6.0 | 2.0 |
| Motor vehicles, bodies and trailers, and parts manufacturing | -0.4 | 1.6 | 1.2 |
| Nonmetallic mineral product manufacturing | 24.9 | -2.7 | 22.2 |
| Other transportation equipment manufacturing | -2.2 | 0.0 | -2.2 |
| Paper manufacturing | 2.9 | -1.4 | 1.5 |
| Petroleum and coal products manufacturing | 1.0 | -0.2 | 0.7 |
| Plastics and rubber product manufacturing | 8.3 | -1.9 | 6.4 |
| Primary metal manufacturing | 0.8 | -0.8 | 0.0 |
| Printing and related support activities | 13.5 | 0.1 | 13.6 |
| Textile mills; Textile product mills | -0.1 | -0.5 | -0.6 |
| Wood product manufacturing | 8.3 | -3.3 | 4.9 |

Sources: REMI PI+, RESI

**Figure 15: Manufacturing Employment Impacts from GGRA Initiatives, 2020**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | 3.9 | -0.4 | 3.5 |
| Beverage and tobacco product manufacturing | 4.4 | -1.7 | 2.7 |
| Chemical manufacturing | 4.2 | -1.0 | 3.2 |
| Computer and electronic product manufacturing | 9.3 | 29.2 | 38.5 |
| Electrical equipment and appliance manufacturing | 23.0 | -0.4 | 22.6 |
| Fabricated metal product manufacturing | 16.3 | -0.5 | 15.8 |
| Food manufacturing | 5.3 | -13.7 | -8.4 |
| Furniture and related product manufacturing | -0.7 | 1.7 | 1.0 |
| Machinery manufacturing | -2.9 | 5.2 | 2.4 |
| Miscellaneous manufacturing | -1.1 | 3.4 | 2.3 |
| Motor vehicles, bodies and trailers, and parts manufacturing | 0.2 | 1.0 | 1.2 |
| Nonmetallic mineral product manufacturing | 14.3 | -2.7 | 11.6 |
| Other transportation equipment manufacturing | -1.5 | -0.8 | -2.3 |
| Paper manufacturing | 2.7 | -1.5 | 1.2 |
| Petroleum and coal products manufacturing | 0.7 | -0.3 | 0.5 |
| Plastics and rubber product manufacturing | 6.2 | -2.2 | 4.0 |
| Primary metal manufacturing | 0.6 | -1.0 | -0.4 |
| Printing and related support activities | 14.1 | -0.7 | 13.4 |
| Textile mills; Textile product mills | 0.0 | -0.6 | -0.6 |
| Wood product manufacturing | 4.9 | -3.8 | 1.1 |

Sources: REMI PI+, RESI

## Appendix B—Annual Output Impacts for the Manufacturing Industry

The following tables highlight the output impacts associated with the GGRA to the Manufacturing industry in Maryland between 2010 and 2020.

**Figure 16: Manufacturing Output Impacts from GGRA Initiatives, 2010**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $94,903 | -$2,525 | $92,378 |
| Beverage and tobacco product manufacturing | $672,766 | -$3,862 | $668,904 |
| Chemical manufacturing | $5,167,544 | $494,917 | $5,662,461 |
| Computer and electronic product manufacturing | $1,265,981 | $706,372 | $1,972,353 |
| Electrical equipment and appliance manufacturing | $738,830 | $8,609 | $747,439 |
| Fabricated metal product manufacturing | $1,686,367 | -$50,148 | $1,636,219 |
| Food manufacturing | $894,864 | $4,124 | $898,988 |
| Furniture and related product manufacturing | $364,258 | -$96,868 | $267,390 |
| Machinery manufacturing | -$122,588 | $403,682 | $281,094 |
| Miscellaneous manufacturing | $261,958 | $39,613 | $301,571 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $4,183,581 | -$3,708,946 | $474,635 |
| Nonmetallic mineral product manufacturing | $1,200,929 | -$35,060 | $1,165,869 |
| Other transportation equipment manufacturing | $165,602 | $40,459 | $206,061 |
| Paper manufacturing | $425,175 | -$21,491 | $403,684 |
| Petroleum and coal products manufacturing | $1,182,126 | -$48,639 | $1,133,487 |
| Plastics and rubber product manufacturing | $1,070,274 | $4,552 | $1,074,826 |
| Primary metal manufacturing | $229,859 | $148,953 | $378,812 |
| Printing and related support activities | $1,495,866 | -$17,480 | $1,478,386 |
| Textile mills; Textile product mills | $27,195 | -$2,692 | $24,503 |
| Wood product manufacturing | $491,313 | $64,966 | $556,279 |

Sources: REMI PI+, RESI

**Figure 17: Manufacturing Output Impacts from GGRA Initiatives, 2011**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $172,720 | -$6,734 | $165,986 |
| Beverage and tobacco product manufacturing | $1,341,575 | -$72,780 | $1,268,795 |
| Chemical manufacturing | $9,321,764 | $797,065 | $10,118,829 |
| Computer and electronic product manufacturing | $5,023,113 | $6,430,400 | $11,453,513 |
| Electrical equipment and appliance manufacturing | $8,321,291 | -$158,889 | $8,162,402 |
| Fabricated metal product manufacturing | $3,482,996 | -$75,425 | $3,407,571 |
| Food manufacturing | $2,170,760 | -$470,388 | $1,700,372 |
| Furniture and related product manufacturing | $440,802 | $6,320 | $447,122 |
| Machinery manufacturing | $466,451 | $137,517 | $603,968 |
| Miscellaneous manufacturing | $519,019 | $16,835 | $535,854 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $845,439 | -$122,041 | $723,398 |
| Nonmetallic mineral product manufacturing | $2,512,994 | -$85,010 | $2,427,984 |
| Other transportation equipment manufacturing | $227,670 | $159,257 | $386,927 |
| Paper manufacturing | $629,966 | $16,143 | $646,109 |
| Petroleum and coal products manufacturing | $2,380,733 | -$54,375 | $2,326,358 |
| Plastics and rubber product manufacturing | $2,035,651 | $3,682 | $2,039,333 |
| Primary metal manufacturing | $510,022 | $310,610 | $820,632 |
| Printing and related support activities | $2,264,693 | -$66,287 | $2,198,406 |
| Textile mills; Textile product mills | $71,719 | -$25,393 | $46,326 |
| Wood product manufacturing | $1,032,239 | $66,287 | $1,098,526 |

Sources: REMI PI+, RESI

**Figure 18: Manufacturing Output Impacts from GGRA Initiatives, 2012**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $227,653 | -$11,805 | $215,848 |
| Beverage and tobacco product manufacturing | $1,878,507 | -$164,235 | $1,714,272 |
| Chemical manufacturing | $11,264,988 | $1,216,700 | $12,481,688 |
| Computer and electronic product manufacturing | $3,340,246 | $3,315,252 | $6,655,498 |
| Electrical equipment and appliance manufacturing | $3,350,295 | -$3,581 | $3,346,714 |
| Fabricated metal product manufacturing | $5,084,786 | -$149,915 | $4,934,871 |
| Food manufacturing | $3,843,341 | -$1,681,702 | $2,161,639 |
| Furniture and related product manufacturing | $626,299 | -$44,096 | $582,203 |
| Machinery manufacturing | $1,002,100 | -$214,257 | $787,843 |
| Miscellaneous manufacturing | $918,073 | -$282,951 | $635,122 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $1,073,565 | -$237,684 | $835,881 |
| Nonmetallic mineral product manufacturing | $4,084,305 | -$144,965 | $3,939,340 |
| Other transportation equipment manufacturing | -$1,261,570 | $1,746,332 | $484,762 |
| Paper manufacturing | $822,222 | -$36,180 | $786,042 |
| Petroleum and coal products manufacturing | $2,277,876 | -$36,635 | $2,241,241 |
| Plastics and rubber product manufacturing | $2,882,450 | -$11,457 | $2,870,993 |
| Primary metal manufacturing | $654,863 | $495,259 | $1,150,122 |
| Printing and related support activities | $2,734,350 | -$125,457 | $2,608,893 |
| Textile mills; Textile product mills | $100,785 | -$41,163 | $59,622 |
| Wood product manufacturing | $1,731,956 | $50,679 | $1,782,635 |

Sources: REMI PI+, RESI

**Figure 19: Manufacturing Output Impacts from GGRA Initiatives, 2013**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $251,512 | -$17,333 | $234,179 |
| Beverage and tobacco product manufacturing | $2,081,966 | -$295,504 | $1,786,462 |
| Chemical manufacturing | $12,530,887 | $828,774 | $13,359,661 |
| Computer and electronic product manufacturing | $4,957,832 | $6,140,568 | $11,098,400 |
| Electrical equipment and appliance manufacturing | $7,418,773 | -$100,402 | $7,318,371 |
| Fabricated metal product manufacturing | $5,125,728 | -$166,124 | $4,959,604 |
| Food manufacturing | $854,583 | $961,703 | $1,816,286 |
| Furniture and related product manufacturing | $605,173 | -$22,969 | $582,204 |
| Machinery manufacturing | $1,197,037 | -$409,985 | $787,052 |
| Miscellaneous manufacturing | $2,730,851 | -$2,106,407 | $624,444 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $991,605 | -$219,685 | $771,920 |
| Nonmetallic mineral product manufacturing | $4,137,489 | -$182,907 | $3,954,582 |
| Other transportation equipment manufacturing | $1,395,170 | -$962,520 | $432,650 |
| Paper manufacturing | $913,107 | -$101,149 | $811,958 |
| Petroleum and coal products manufacturing | $2,295,401 | -$96,267 | $2,199,134 |
| Plastics and rubber product manufacturing | $3,076,228 | -$26,078 | $3,050,150 |
| Primary metal manufacturing | $1,007,213 | $493,876 | $1,501,089 |
| Printing and related support activities | $2,807,574 | -$186,850 | $2,620,724 |
| Textile mills; Textile product mills | $278,954 | -$214,447 | $64,507 |
| Wood product manufacturing | $1,674,523 | -$281,708 | $1,392,815 |

Sources: REMI PI+, RESI

**Figure 20: Manufacturing Output Impacts from GGRA Initiatives, 2014**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $274,139 | -$22,913 | $251,226 |
| Beverage and tobacco product manufacturing | $2,451,365 | -$564,339 | $1,887,026 |
| Chemical manufacturing | $16,168,286 | -$1,837,320 | $14,330,966 |
| Computer and electronic product manufacturing | $2,689,489 | $5,463,488 | $8,152,977 |
| Electrical equipment and appliance manufacturing | $4,232,302 | $18,281 | $4,250,583 |
| Fabricated metal product manufacturing | $4,016,429 | -$206,809 | $3,809,620 |
| Food manufacturing | $2,702,260 | -$1,126,998 | $1,575,262 |
| Furniture and related product manufacturing | $718,091 | -$155,215 | $562,876 |
| Machinery manufacturing | $1,024,614 | -$405,242 | $619,372 |
| Miscellaneous manufacturing | $482,114 | $110,122 | $592,236 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $1,269,548 | -$578,387 | $691,161 |
| Nonmetallic mineral product manufacturing | $3,359,083 | -$203,029 | $3,156,054 |
| Other transportation equipment manufacturing | $128,712 | $266,106 | $394,818 |
| Paper manufacturing | $966,832 | -$215,261 | $751,571 |
| Petroleum and coal products manufacturing | $1,732,295 | -$105,705 | $1,626,590 |
| Plastics and rubber product manufacturing | $2,953,533 | $6,613 | $2,960,146 |
| Primary metal manufacturing | $1,083,521 | $606,923 | $1,690,444 |
| Printing and related support activities | $2,905,159 | -$389,393 | $2,515,766 |
| Textile mills; Textile product mills | $57,431 | $15,206 | $72,637 |
| Wood product manufacturing | $1,286,665 | -$522,494 | $764,171 |

Sources: REMI PI+, RESI

**Figure 21: Manufacturing Output Impacts from GGRA Initiatives, 2015**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $327,851 | -$29,535 | $298,316 |
| Beverage and tobacco product manufacturing | $2,336,665 | -$112,266 | $2,224,399 |
| Chemical manufacturing | $3,781,011 | $13,596,312 | $17,377,323 |
| Computer and electronic product manufacturing | $9,685,559 | $5,504,631 | $15,190,190 |
| Electrical equipment and appliance manufacturing | $9,128,097 | -$91,949 | $9,036,148 |
| Fabricated metal product manufacturing | $4,881,700 | -$283,430 | $4,598,270 |
| Food manufacturing | $2,965,177 | -$1,274,888 | $1,690,289 |
| Furniture and related product manufacturing | $980,659 | -$339,686 | $640,973 |
| Machinery manufacturing | $1,791,360 | -$1,106,106 | $685,254 |
| Miscellaneous manufacturing | $1,606,052 | -$961,202 | $644,850 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $2,151,327 | -$1,613,560 | $537,767 |
| Nonmetallic mineral product manufacturing | $4,149,767 | -$308,118 | $3,841,649 |
| Other transportation equipment manufacturing | -$163,474 | $560,612 | $397,138 |
| Paper manufacturing | $1,258,261 | -$400,506 | $857,755 |
| Petroleum and coal products manufacturing | $2,197,149 | -$231,220 | $1,965,929 |
| Plastics and rubber product manufacturing | $3,749,117 | -$83,596 | $3,665,521 |
| Primary metal manufacturing | $1,270,825 | $781,611 | $2,052,436 |
| Printing and related support activities | $2,900,178 | $213,412 | $3,113,590 |
| Textile mills; Textile product mills | $108,233 | -$23,820 | $84,413 |
| Wood product manufacturing | $1,564,820 | -$738,303 | $826,517 |

Sources: REMI PI+, RESI

**Figure 22: Manufacturing Output Impacts from GGRA Initiatives, 2016**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $271,255 | -$37,494 | $233,761 |
| Beverage and tobacco product manufacturing | $2,530,208 | -$698,599 | $1,831,609 |
| Chemical manufacturing | $9,954,553 | $2,585,322 | $12,539,875 |
| Computer and electronic product manufacturing | $3,816,454 | $5,520,227 | $9,336,681 |
| Electrical equipment and appliance manufacturing | $5,106,054 | -$55,186 | $5,050,868 |
| Fabricated metal product manufacturing | $4,078,895 | -$504,299 | $3,574,596 |
| Food manufacturing | $3,694,064 | -$2,976,505 | $717,559 |
| Furniture and related product manufacturing | $205,647 | $146,930 | $352,577 |
| Machinery manufacturing | $1,234,626 | -$748,723 | $485,903 |
| Miscellaneous manufacturing | $27,626 | $366,605 | $394,231 |
| Motor vehicles, bodies and trailers, and parts manufacturing | -$233,556 | $452,424 | $218,868 |
| Nonmetallic mineral product manufacturing | $3,521,037 | -$435,120 | $3,085,917 |
| Other transportation equipment manufacturing | $100,828 | $84,907 | $185,735 |
| Paper manufacturing | $1,383,137 | -$734,514 | $648,623 |
| Petroleum and coal products manufacturing | $1,853,499 | -$424,105 | $1,429,394 |
| Plastics and rubber product manufacturing | $1,880,853 | $876,775 | $2,757,628 |
| Primary metal manufacturing | $1,068,608 | $447,144 | $1,515,752 |
| Printing and related support activities | $1,594,898 | $683,873 | $2,278,771 |
| Textile mills; Textile product mills | $259,256 | -$200,131 | $59,125 |
| Wood product manufacturing | $1,133,600 | -$929,972 | $203,628 |

Sources: REMI PI+, RESI

**Figure 23: Manufacturing Output Impacts from GGRA Initiatives, 2017**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $261,522 | -$28,729 | $232,793 |
| Beverage and tobacco product manufacturing | $3,127,804 | -$1,273,199 | $1,854,605 |
| Chemical manufacturing | $10,116,640 | $1,525,363 | $11,642,003 |
| Computer and electronic product manufacturing | $18,668,643 | $22,807,428 | $41,476,071 |
| Electrical equipment and appliance manufacturing | $25,481,266 | -$607,122 | $24,874,144 |
| Fabricated metal product manufacturing | $4,110,311 | -$549,557 | $3,560,754 |
| Food manufacturing | $2,467,082 | -$2,208,642 | $258,440 |
| Furniture and related product manufacturing | $183,264 | -$194,912 | -$11,648 |
| Machinery manufacturing | $7,054,717 | -$7,470,977 | -$416,260 |
| Miscellaneous manufacturing | $12,324,903 | -$12,438,817 | -$113,914 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $7,346,827 | -$8,691,142 | -$1,344,315 |
| Nonmetallic mineral product manufacturing | $3,726,945 | -$737,582 | $2,989,363 |
| Other transportation equipment manufacturing | -$1,489,072 | $1,463,004 | -$26,068 |
| Paper manufacturing | $3,217,563 | -$2,536,655 | $680,908 |
| Petroleum and coal products manufacturing | $2,062,788 | -$708,029 | $1,354,759 |
| Plastics and rubber product manufacturing | $2,571,846 | $68,910 | $2,640,756 |
| Primary metal manufacturing | $2,390,261 | -$1,128,463 | $1,261,798 |
| Printing and related support activities | $2,056,315 | $502,472 | $2,558,787 |
| Textile mills; Textile product mills | -$71,767 | $85,215 | $13,448 |
| Wood product manufacturing | $996,381 | -$1,064,055 | -$67,674 |

Sources: REMI PI+, RESI

**Figure 24: Manufacturing Output Impacts from GGRA Initiatives, 2018**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $252,357 | -$32,177 | $220,180 |
| Beverage and tobacco product manufacturing | $2,922,896 | -$1,284,659 | $1,638,237 |
| Chemical manufacturing | $5,734,817 | $4,290,684 | $10,025,501 |
| Computer and electronic product manufacturing | $17,370,557 | $22,369,824 | $39,740,381 |
| Electrical equipment and appliance manufacturing | $28,036,356 | -$703,219 | $27,333,137 |
| Fabricated metal product manufacturing | $1,514,875 | $1,343,401 | $2,858,276 |
| Food manufacturing | $5,959,473 | -$6,153,599 | -$194,126 |
| Furniture and related product manufacturing | $5,271,158 | -$5,522,391 | -$251,233 |
| Machinery manufacturing | -$103,083,527 | $102,230,974 | -$852,553 |
| Miscellaneous manufacturing | -$186,036,880 | $185,575,972 | -$460,908 |
| Motor vehicles, bodies and trailers, and parts manufacturing | -$47,911,394 | $46,142,299 | -$1,769,095 |
| Nonmetallic mineral product manufacturing | $16,466,157 | -$13,932,561 | $2,533,596 |
| Other transportation equipment manufacturing | -$1,251,104 | $1,048,773 | -$202,331 |
| Paper manufacturing | -$934,274 | $1,541,811 | $607,537 |
| Petroleum and coal products manufacturing | $2,061,569 | -$1,047,719 | $1,013,850 |
| Plastics and rubber product manufacturing | $2,436,338 | -$235,389 | $2,200,949 |
| Primary metal manufacturing | -$421,842 | $1,361,164 | $939,322 |
| Printing and related support activities | $1,617,420 | $609,151 | $2,226,571 |
| Textile mills; Textile product mills | -$56,346 | $43,389 | -$12,957 |
| Wood product manufacturing | $593,083 | -$1,025,069 | -$431,986 |

Sources: REMI PI+, RESI

**Figure 25: Manufacturing Output Impacts from GGRA Initiatives, 2019**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $227,381 | -$38,499 | $188,882 |
| Beverage and tobacco product manufacturing | $1,861,513 | -$371,444 | $1,490,069 |
| Chemical manufacturing | $8,628,825 | -$545,061 | $8,083,764 |
| Computer and electronic product manufacturing | $4,271,675 | $6,064,376 | $10,336,051 |
| Electrical equipment and appliance manufacturing | $8,697,316 | -$245,073 | $8,452,243 |
| Fabricated metal product manufacturing | $346,863 | $1,838,945 | $2,185,808 |
| Food manufacturing | $9,154,797 | -$9,893,362 | -$738,565 |
| Furniture and related product manufacturing | $1,452,869 | -$1,496,097 | -$43,228 |
| Machinery manufacturing | $2,210,542 | -$2,359,087 | -$148,545 |
| Miscellaneous manufacturing | $1,872,284 | -$1,944,182 | -$71,898 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $2,755,307 | -$3,275,326 | -$520,019 |
| Nonmetallic mineral product manufacturing | $1,497,307 | $536,369 | $2,033,676 |
| Other transportation equipment manufacturing | $329,684 | -$462,086 | -$132,402 |
| Paper manufacturing | -$311,302 | $770,491 | $459,189 |
| Petroleum and coal products manufacturing | $3,137,543 | -$2,559,628 | $577,915 |
| Plastics and rubber product manufacturing | $2,781,636 | -$1,075,439 | $1,706,197 |
| Primary metal manufacturing | -$293,527 | $998,181 | $704,654 |
| Printing and related support activities | $1,315,287 | $177,773 | $1,493,060 |
| Textile mills; Textile product mills | $61,414 | -$48,362 | $13,052 |
| Wood product manufacturing | $503,621 | -$1,282,048 | -$778,427 |

Sources: REMI PI+, RESI

**Figure 26: Manufacturing Output Impacts from GGRA Initiatives, 2020**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $213,645 | -$38,618 | $175,027 |
| Beverage and tobacco product manufacturing | $1,931,614 | -$423,644 | $1,507,970 |
| Chemical manufacturing | $6,739,902 | $1,829,887 | $8,569,789 |
| Computer and electronic product manufacturing | $1,836,413 | $2,108,593 | $3,945,006 |
| Electrical equipment and appliance manufacturing | $4,378,054 | -$128,919 | $4,249,135 |
| Fabricated metal product manufacturing | $2,347,909 | -$8,334 | $2,339,575 |
| Food manufacturing | $34,898,986 | -$35,919,825 | -$1,020,839 |
| Furniture and related product manufacturing | -$1,245,385 | $1,238,741 | -$6,644 |
| Machinery manufacturing | $1,222,865 | -$1,213,066 | $9,799 |
| Miscellaneous manufacturing | $1,214,402 | -$1,124,451 | $89,951 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $1,463,898 | -$1,647,134 | -$183,236 |
| Nonmetallic mineral product manufacturing | $1,766,294 | $410,368 | $2,176,662 |
| Other transportation equipment manufacturing | $1,775,479 | -$1,865,199 | -$89,720 |
| Paper manufacturing | $520,176 | $7,570 | $527,746 |
| Petroleum and coal products manufacturing | $2,934,225 | -$2,128,244 | $805,981 |
| Plastics and rubber product manufacturing | $3,420,268 | -$1,553,721 | $1,866,547 |
| Primary metal manufacturing | -$53,062 | $663,211 | $610,149 |
| Printing and related support activities | $1,597,468 | $178,777 | $1,776,245 |
| Textile mills; Textile product mills | $93,151 | -$75,113 | $18,038 |
| Wood product manufacturing | $1,238,096 | -$2,137,476 | -$899,380 |

Sources: REMI PI+, RESI

## Appendix C—Annual Wage Impacts for the Manufacturing Industry

The following tables highlight the wage impacts associated with the GGRA to the Manufacturing industry in Maryland between 2010 and 2020.

**Figure 27: Manufacturing Wage Impacts from GGRA Initiatives, 2010**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $31,752 | -$795 | $30,957 |
| Beverage and tobacco product manufacturing | $83,802 | -$2,003 | $81,799 |
| Chemical manufacturing | $814,488 | $46,336 | $860,823 |
| Computer and electronic product manufacturing | $1,049,388 | $26,216 | $1,075,605 |
| Electrical equipment and appliance manufacturing | $259,106 | -$191 | $258,915 |
| Fabricated metal product manufacturing | $480,081 | -$13,961 | $466,120 |
| Food manufacturing | $238,633 | -$32,827 | $205,806 |
| Furniture and related product manufacturing | $89,403 | -$19,512 | $69,891 |
| Machinery manufacturing | $30,828 | $95,365 | $126,193 |
| Miscellaneous manufacturing | $87,557 | $7,880 | $95,437 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $349,847 | -$282,522 | $67,325 |
| Nonmetallic mineral product manufacturing | $288,208 | -$8,711 | $279,497 |
| Other transportation equipment manufacturing | $153,438 | -$40,440 | $112,998 |
| Paper manufacturing | $104,224 | -$5,350 | $98,874 |
| Petroleum and coal products manufacturing | $41,244 | -$1,708 | $39,536 |
| Plastics and rubber product manufacturing | $238,722 | -$3,532 | $235,190 |
| Primary metal manufacturing | $52,826 | $5,895 | $58,721 |
| Printing and related support activities | $458,069 | -$4,255 | $453,814 |
| Textile mills; Textile product mills | $17,083 | -$4,494 | $12,589 |
| Wood product manufacturing | $80,160 | $11,322 | $91,483 |

Sources: REMI PI+, RESI

**Figure 28: Manufacturing Wage Impacts from GGRA Initiatives, 2011**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $64,359 | -$2,295 | $62,064 |
| Beverage and tobacco product manufacturing | $199,135 | -$17,359 | $181,776 |
| Chemical manufacturing | $1,603,562 | $18,648 | $1,622,210 |
| Computer and electronic product manufacturing | $641,910 | $6,137,928 | $6,779,839 |
| Electrical equipment and appliance manufacturing | $2,935,886 | -$64,804 | $2,871,082 |
| Fabricated metal product manufacturing | $1,021,080 | -$21,033 | $1,000,047 |
| Food manufacturing | $839,280 | -$379,045 | $460,236 |
| Furniture and related product manufacturing | $140,174 | -$3,684 | $136,490 |
| Machinery manufacturing | $231,776 | $73,895 | $305,670 |
| Miscellaneous manufacturing | $174,238 | $18,682 | $192,919 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $129,324 | $360 | $129,683 |
| Nonmetallic mineral product manufacturing | $602,113 | -$21,510 | $580,603 |
| Other transportation equipment manufacturing | -$45,140 | $304,882 | $259,742 |
| Paper manufacturing | $187,954 | -$13,206 | $174,748 |
| Petroleum and coal products manufacturing | $83,397 | -$1,965 | $81,432 |
| Plastics and rubber product manufacturing | $507,421 | -$14,708 | $492,713 |
| Primary metal manufacturing | $195,630 | -$63,163 | $132,467 |
| Printing and related support activities | $761,471 | -$19,592 | $741,879 |
| Textile mills; Textile product mills | $99,382 | -$69,535 | $29,848 |
| Wood product manufacturing | $172,940 | $13,094 | $186,035 |

Sources: REMI PI+, RESI

**Figure 29: Manufacturing Wage Impacts from GGRA Initiatives, 2012**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $92,201 | -$4,413 | $87,787 |
| Beverage and tobacco product manufacturing | $311,118 | -$45,527 | $265,591 |
| Chemical manufacturing | $2,109,066 | -$60,226 | $2,048,840 |
| Computer and electronic product manufacturing | $1,722,385 | $2,302,458 | $4,024,843 |
| Electrical equipment and appliance manufacturing | $1,203,645 | -$15,924 | $1,187,720 |
| Fabricated metal product manufacturing | $1,520,733 | -$42,919 | $1,477,814 |
| Food manufacturing | $1,764,470 | -$1,098,482 | $665,988 |
| Furniture and related product manufacturing | $220,929 | -$21,802 | $199,127 |
| Machinery manufacturing | $449,929 | -$43,545 | $406,383 |
| Miscellaneous manufacturing | $358,362 | -$103,245 | $255,117 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $175,464 | -$6,091 | $169,373 |
| Nonmetallic mineral product manufacturing | $976,182 | -$36,222 | $939,960 |
| Other transportation equipment manufacturing | $422,206 | -$40,990 | $381,216 |
| Paper manufacturing | $257,729 | -$26,235 | $231,494 |
| Petroleum and coal products manufacturing | $92,157 | -$1,430 | $90,727 |
| Plastics and rubber product manufacturing | $765,000 | -$37,196 | $727,805 |
| Primary metal manufacturing | $293,844 | -$96,805 | $197,039 |
| Printing and related support activities | $970,864 | -$38,938 | $931,926 |
| Textile mills; Textile product mills | $88,722 | -$43,439 | $45,283 |
| Wood product manufacturing | $290,657 | $11,004 | $301,661 |

Sources: REMI PI+, RESI

**Figure 30: Manufacturing Wage Impacts from GGRA Initiatives, 2013**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $106,737 | -$6,850 | $99,887 |
| Beverage and tobacco product manufacturing | $387,835 | -$73,467 | $314,368 |
| Chemical manufacturing | $2,448,878 | -$387,237 | $2,061,641 |
| Computer and electronic product manufacturing | $2,857,241 | $4,366,951 | $7,224,192 |
| Electrical equipment and appliance manufacturing | $2,749,000 | -$66,157 | $2,682,843 |
| Fabricated metal product manufacturing | $1,608,243 | -$49,273 | $1,558,970 |
| Food manufacturing | -$383,121 | $1,091,305 | $708,184 |
| Furniture and related product manufacturing | $383,856 | -$179,546 | $204,310 |
| Machinery manufacturing | $527,382 | -$73,750 | $453,632 |
| Miscellaneous manufacturing | $1,490,033 | -$1,200,321 | $289,712 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $188,051 | -$16,418 | $171,633 |
| Nonmetallic mineral product manufacturing | $1,029,939 | -$48,020 | $981,919 |
| Other transportation equipment manufacturing | -$302,310 | $734,632 | $432,322 |
| Paper manufacturing | $316,737 | -$47,027 | $269,710 |
| Petroleum and coal products manufacturing | $100,578 | -$3,826 | $96,752 |
| Plastics and rubber product manufacturing | $825,178 | -$48,105 | $777,073 |
| Primary metal manufacturing | $112,662 | $125,801 | $238,463 |
| Printing and related support activities | $1,100,932 | -$54,790 | $1,046,142 |
| Textile mills; Textile product mills | $175,818 | -$125,176 | $50,642 |
| Wood product manufacturing | $297,513 | -$26,262 | $271,251 |

Sources: REMI PI+, RESI

**Figure 31: Manufacturing Wage Impacts from GGRA Initiatives, 2014**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $106,349 | -$9,232 | $97,118 |
| Beverage and tobacco product manufacturing | $505,962 | -$209,843 | $296,119 |
| Chemical manufacturing | $3,418,328 | -$1,397,168 | $2,021,161 |
| Computer and electronic product manufacturing | $1,019,198 | $4,274,849 | $5,294,047 |
| Electrical equipment and appliance manufacturing | $1,587,013 | -$4,494 | $1,582,520 |
| Fabricated metal product manufacturing | $1,342,349 | -$56,843 | $1,285,506 |
| Food manufacturing | $1,718,509 | -$1,225,305 | $493,204 |
| Furniture and related product manufacturing | $302,418 | -$106,144 | $196,274 |
| Machinery manufacturing | $594,195 | -$193,904 | $400,291 |
| Miscellaneous manufacturing | $19,434 | $211,600 | $231,034 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $173,974 | -$18,667 | $155,307 |
| Nonmetallic mineral product manufacturing | $1,068,040 | -$55,146 | $1,012,893 |
| Other transportation equipment manufacturing | -$33,623 | $451,464 | $417,841 |
| Paper manufacturing | $290,903 | -$62,464 | $228,439 |
| Petroleum and coal products manufacturing | $85,647 | -$4,268 | $81,379 |
| Plastics and rubber product manufacturing | $803,884 | -$78,018 | $725,866 |
| Primary metal manufacturing | $364,144 | -$130,554 | $233,589 |
| Printing and related support activities | $1,118,724 | -$92,237 | $1,026,486 |
| Textile mills; Textile product mills | -$170,856 | $218,552 | $47,696 |
| Wood product manufacturing | $305,658 | -$61,100 | $244,558 |

Sources: REMI PI+, RESI

**Figure 32: Manufacturing Wage Impacts from GGRA Initiatives, 2015**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $124,804 | -$11,574 | $113,230 |
| Beverage and tobacco product manufacturing | $30,042 | $305,639 | $335,680 |
| Chemical manufacturing | $332,876 | $2,113,835 | $2,446,711 |
| Computer and electronic product manufacturing | $7,477,982 | $2,738,498 | $10,216,481 |
| Electrical equipment and appliance manufacturing | $3,526,396 | -$87,249 | $3,439,147 |
| Fabricated metal product manufacturing | $1,614,689 | -$80,532 | $1,534,156 |
| Food manufacturing | -$3,118,075 | $3,624,845 | $506,770 |
| Furniture and related product manufacturing | $457,740 | -$238,171 | $219,570 |
| Machinery manufacturing | $1,449,639 | -$1,042,140 | $407,499 |
| Miscellaneous manufacturing | $229,597 | $37,771 | $267,368 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $212,601 | -$40,342 | $172,259 |
| Nonmetallic mineral product manufacturing | $1,266,581 | -$79,868 | $1,186,713 |
| Other transportation equipment manufacturing | -$101,389 | $588,141 | $486,752 |
| Paper manufacturing | $370,471 | -$97,694 | $272,777 |
| Petroleum and coal products manufacturing | $115,520 | -$9,440 | $106,080 |
| Plastics and rubber product manufacturing | $990,006 | -$146,413 | $843,593 |
| Primary metal manufacturing | $208,227 | $57,343 | $265,570 |
| Printing and related support activities | $1,273,313 | -$86,342 | $1,186,971 |
| Textile mills; Textile product mills | -$54,213 | $105,942 | $51,729 |
| Wood product manufacturing | $294,595 | -$92,612 | $201,982 |

Sources: REMI PI+, RESI

**Figure 33: Manufacturing Wage Impacts from GGRA Initiatives, 2016**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $124,331 | -$20,503 | $103,828 |
| Beverage and tobacco product manufacturing | $317,091 | -$8,093 | $308,998 |
| Chemical manufacturing | $1,192,499 | $306,794 | $1,499,293 |
| Computer and electronic product manufacturing | $2,385,912 | $4,483,764 | $6,869,676 |
| Electrical equipment and appliance manufacturing | $1,978,879 | -$15,403 | $1,963,476 |
| Fabricated metal product manufacturing | $1,396,050 | -$162,590 | $1,233,459 |
| Food manufacturing | -$1,038,027 | $1,384,149 | $346,122 |
| Furniture and related product manufacturing | -$972,187 | $1,122,941 | $150,754 |
| Machinery manufacturing | $355,852 | -$36,040 | $319,812 |
| Miscellaneous manufacturing | -$1,081,302 | $1,286,830 | $205,528 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $63,431 | $51,299 | $114,730 |
| Nonmetallic mineral product manufacturing | $919,502 | -$116,847 | $802,655 |
| Other transportation equipment manufacturing | $72,820 | $314,831 | $387,651 |
| Paper manufacturing | $364,107 | -$169,172 | $194,935 |
| Petroleum and coal products manufacturing | $91,412 | -$18,107 | $73,306 |
| Plastics and rubber product manufacturing | $580,696 | $175,869 | $756,565 |
| Primary metal manufacturing | $58,837 | $136,284 | $195,121 |
| Printing and related support activities | $757,136 | $229,042 | $986,178 |
| Textile mills; Textile product mills | -$864 | $43,809 | $42,945 |
| Wood product manufacturing | $289,822 | -$132,844 | $156,978 |

Sources: REMI PI+, RESI

**Figure 34: Manufacturing Wage Impacts from GGRA Initiatives, 2017**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $131,969 | -$30,523 | $101,445 |
| Beverage and tobacco product manufacturing | $376,986 | -$71,920 | $305,067 |
| Chemical manufacturing | -$1,343,875 | $2,772,524 | $1,428,649 |
| Computer and electronic product manufacturing | $15,191,860 | $19,468,494 | $34,660,353 |
| Electrical equipment and appliance manufacturing | $10,234,696 | -$262,523 | $9,972,173 |
| Fabricated metal product manufacturing | $1,408,095 | -$135,992 | $1,272,103 |
| Food manufacturing | -$225,199 | $394,257 | $169,058 |
| Furniture and related product manufacturing | $214,010 | -$123,043 | $90,967 |
| Machinery manufacturing | $1,759,791 | -$1,694,346 | $65,445 |
| Miscellaneous manufacturing | $1,809,360 | -$1,702,714 | $106,646 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $374,788 | -$342,461 | $32,328 |
| Nonmetallic mineral product manufacturing | $961,687 | -$170,015 | $791,672 |
| Other transportation equipment manufacturing | -$87,697 | $354,217 | $266,519 |
| Paper manufacturing | $563,713 | -$361,925 | $201,788 |
| Petroleum and coal products manufacturing | $96,682 | -$28,808 | $67,874 |
| Plastics and rubber product manufacturing | $877,685 | -$149,252 | $728,433 |
| Primary metal manufacturing | $274,622 | -$100,232 | $174,390 |
| Printing and related support activities | $943,180 | $149,102 | $1,092,282 |
| Textile mills; Textile product mills | -$10,725 | $40,876 | $30,152 |
| Wood product manufacturing | $218,977 | -$166,301 | $52,675 |

Sources: REMI PI+, RESI

**Figure 35: Manufacturing Wage Impacts from GGRA Initiatives, 2018**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $83,577 | $284 | $83,861 |
| Beverage and tobacco product manufacturing | $459,797 | -$203,421 | $256,375 |
| Chemical manufacturing | -$14,341 | $1,214,995 | $1,200,654 |
| Computer and electronic product manufacturing | $15,625,723 | $21,405,361 | $37,031,084 |
| Electrical equipment and appliance manufacturing | $11,619,208 | -$280,979 | $11,338,229 |
| Fabricated metal product manufacturing | $157,290 | $912,446 | $1,069,736 |
| Food manufacturing | $568,696 | -$557,249 | $11,447 |
| Furniture and related product manufacturing | $2,832,442 | -$2,808,608 | $23,834 |
| Machinery manufacturing | -$24,052,933 | $23,970,090 | -$82,843 |
| Miscellaneous manufacturing | -$26,803,351 | $26,815,836 | $12,485 |
| Motor vehicles, bodies and trailers, and parts manufacturing | -$1,836,745 | $1,844,798 | $8,053 |
| Nonmetallic mineral product manufacturing | $1,594,329 | -$922,408 | $671,921 |
| Other transportation equipment manufacturing | -$232,763 | $416,471 | $183,708 |
| Paper manufacturing | $58,451 | $116,360 | $174,811 |
| Petroleum and coal products manufacturing | $98,266 | -$44,091 | $54,175 |
| Plastics and rubber product manufacturing | $580,499 | $40,301 | $620,800 |
| Primary metal manufacturing | $11,762 | $131,162 | $142,924 |
| Printing and related support activities | $395,754 | $584,606 | $980,360 |
| Textile mills; Textile product mills | -$5,992 | $24,579 | $18,587 |
| Wood product manufacturing | $157,413 | -$142,374 | $15,039 |

Sources: REMI PI+, RESI

**Figure 36: Manufacturing Wage Impacts from GGRA Initiatives, 2019**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $75,067 | -$8,216 | $66,850 |
| Beverage and tobacco product manufacturing | $87,359 | $110,338 | $197,697 |
| Chemical manufacturing | $9,378,203 | -$8,610,795 | $767,409 |
| Computer and electronic product manufacturing | $4,089,844 | $7,439,774 | $11,529,618 |
| Electrical equipment and appliance manufacturing | $3,657,725 | -$115,540 | $3,542,185 |
| Fabricated metal product manufacturing | $807,662 | $262,704 | $1,070,366 |
| Food manufacturing | -$167,261 | -$45,717 | -$212,978 |
| Furniture and related product manufacturing | -$43,186 | $72,353 | $29,167 |
| Machinery manufacturing | $483,898 | -$416,258 | $67,640 |
| Miscellaneous manufacturing | $356,165 | -$300,913 | $55,252 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $142,040 | -$92,235 | $49,805 |
| Nonmetallic mineral product manufacturing | $594,689 | $116,894 | $711,583 |
| Other transportation equipment manufacturing | $151,113 | -$6,566 | $144,547 |
| Paper manufacturing | -$75,143 | $190,334 | $115,192 |
| Petroleum and coal products manufacturing | $178,536 | -$145,228 | $33,308 |
| Plastics and rubber product manufacturing | $1,208,731 | -$817,855 | $390,876 |
| Primary metal manufacturing | -$66,626 | $135,495 | $68,869 |
| Printing and related support activities | $474,823 | $137,616 | $612,439 |
| Textile mills; Textile product mills | $10,272 | $2,947 | $13,219 |
| Wood product manufacturing | $170,706 | -$202,718 | -$32,012 |

Sources: REMI PI+, RESI

**Figure 37: Manufacturing Wage Impacts from GGRA Initiatives, 2020**

| Manufacturing Sector | Direct | Indirect/Induced | Total |
|---|---|---|---|
| Apparel manufacturing; Leather and allied product manufacturing | $67,541 | -$7,935 | $59,606 |
| Beverage and tobacco product manufacturing | $130,895 | $25,425 | $156,321 |
| Chemical manufacturing | $443,825 | $139,011 | $582,837 |
| Computer and electronic product manufacturing | $1,685,521 | $3,862,656 | $5,548,178 |
| Electrical equipment and appliance manufacturing | $1,825,196 | -$59,269 | $1,765,927 |
| Fabricated metal product manufacturing | $1,057,189 | -$59,759 | $997,431 |
| Food manufacturing | $663,109 | -$1,018,840 | -$355,731 |
| Furniture and related product manufacturing | -$262,103 | $284,368 | $22,265 |
| Machinery manufacturing | $268,869 | -$178,872 | $89,997 |
| Miscellaneous manufacturing | -$188,135 | $220,202 | $32,067 |
| Motor vehicles, bodies and trailers, and parts manufacturing | $83,647 | -$44,139 | $39,508 |
| Nonmetallic mineral product manufacturing | $604,918 | $72,718 | $677,636 |
| Other transportation equipment manufacturing | $277,546 | -$166,669 | $110,877 |
| Paper manufacturing | $508,840 | -$420,837 | $88,003 |
| Petroleum and coal products manufacturing | $101,596 | -$79,035 | $22,561 |
| Plastics and rubber product manufacturing | -$228,819 | $536,758 | $307,939 |
| Primary metal manufacturing | -$41,682 | $74,578 | $32,896 |
| Printing and related support activities | $284,661 | $212,314 | $496,975 |
| Textile mills; Textile product mills | -$116,148 | $124,413 | $8,266 |
| Wood product manufacturing | $277,286 | -$352,867 | -$75,581 |

Sources: REMI PI+, RESI

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# MARYLAND GREENHOUSE GAS REDUCTION ACT PLAN

*Maryland Department of Transportation*

# 2015 Draft Emissions Update

August, 2015

# INTRODUCTION

This draft report documents the Maryland Department of Transportation's (MDOT) efforts to support: (1) the update of the 2013 Maryland Greenhouse Gas Reduction Act Plan (GGRP), which is due in October 2015, and (2) the efforts of the Maryland Commission on Climate Change (MCCC) to produce a report by November 2015.

The purpose of this report is to concisely document MDOT's approach to developing revised greenhouse gas (GHG) emissions estimates for the transportation sector. The revised updates include:

1. Emissions baseline (2006),
2. Business-as-usual (2020) emissions estimate, and
3. Emissions benefits resulting from the implementation of transportation policies, plans and programs (2020).

MDOT is preparing an update to the Maryland Department of Transportation Draft Implementation Plan (the Green Book), which will contain more details regarding background, transportation sector GHG emissions trends and progress, technical approach, and the transportation sector's contribution to Maryland's climate goals. That update will be made available to the Maryland Department of Environment (MDE) and the MCCC upon its completion (estimated September 2015).

## Coordination Activities

MDOT continues to work across its modal agencies and with the Washington Area Metropolitan Transit Authority (WMATA) to aggregate details on internal operations, programs, and any initiatives that are already generating GHG emission reductions and may lead to greater reductions over the long-term.

MDE and MDOT also continuously coordinate activities with Maryland's metropolitan planning organizations (MPOs) to support short and long-range transportation planning and the federal transportation conformity process. In addition, MDOT continues to chair the Electric Vehicle Infrastructure Council (EVIC), working with MDE and Maryland Energy Administration (MEA), as well as other public and private stakeholders to plan and develop policy regarding electric vehicles.

MDOT also works with external partners, including CSX Transportation and Norfolk Southern regarding the National Gateway and Crescent Corridor initiatives as well as studies, in cooperation with Amtrak and the Federal Railroad Administration, that over the long-term will greatly improve operations on the Northeast Corridor.

## Technical Approach

The 2015 technical approach utilizes the latest planning assumptions, approved by MDE, which reflect the current state of the practice for GHG emissions analysis in the transportation sector. Beyond the GGRA's 2015 legislative requirement, the motivating factors driving updates to MDOT's technical approach include:

1. Release of and updates to EPA MOVES2014 which includes enhanced data and assumptions reflecting updated mobile source emission characteristics, and refined information on final Federal fuel economy and GHG emissions standards, as well as the Tier 3 standards.

2. Continuation of Maryland's transportation planning, programming, and implementation process. Actions that have moved the process forward include finalization of the Maryland Transportation Plan in 2013 and passage of the Transportation Infrastructure Investment Act of 2013. In addition, recent major project completions (e.g. the Intercounty Connector and I-95 Express Toll Lanes), investment priority changes, a continued uncertain federal funding environment, and emergence of new programs have changed the structure of greenhouse gas beneficial projects in the 6-year Consolidated Transportation Program (CTP).

3. Vehicle miles traveled in Maryland has continued to remain steady, with minimal increase annually since 2010 - and total statewide VMT remains below the high-point in 2008.

4. A 2014 update to the EPA's State Inventory Tool (SIT) used to estimate off-road GHG emissions in the baseline and business as usual (BAU) scenarios.

## 2006 Baseline and 2020 Business as Usual (BAU) Emission Inventories

The updated 2006 baseline and 2020 BAU transportation sector GHG emissions forecast are summarized in Table 1. The on-road analyses were performed using MOVES2014 and include data, methods, and procedures approved by MDE. Off-road analyses utilized the SIT tool and the Projection Tool.

**Table 1: Maryland 2006 and 2020 Transportation Sector GHG Emissions**

| GHG Emissions (mmt $CO_2e$) | 2006 Baseline | 2020 BAU Forecast |
|---|---|---|
| *Light Duty Vehicles* | *23.34* | *30.77* |
| *Medium/Heavy Duty Trucks & Buses* | *7.38* | *9.36* |
| Total On-Road | 30.72 | 40.13 |
| Off-Road | 4.34 | 4.13 |
| **TOTAL GHG** | **35.06** | **44.26** |

Emissions

## Transportation Sector Contribution to Maryland's Climate Change Goals

The revised transportation sector GHG reduction estimates are based on updated planning assumptions and the new MOVES2014 modeling results. The transportation sector exceeds the 2013 GGRP initial reductions and achieves over 80 percent of the 2013 GGRP enhanced reductions that were representative of unfunded strategies. Table 2 compares the 2013 initial and enhanced emission reductions (using prior modeling tools and assumptions documented in the MDOT Green Book) to the funded 2015 reductions (using the tools and assumptions documented above).

### Table 2 2020 Transportation Sector Emission Reductions Summary

| GGRP Policy ID | GGRP Policy Name | 2013 (Initial) | 2013 (Enhanced) | 2015 (Funded) |
|---|---|---|---|---|
| **NA** | **Forecasted VMT Related Reduction (True-Up)** | **2.78** | **2.78** | **3.12** [1] |
| **E.1** | **Motor Vehicle Emissions & Fuel Standards** | **7.72** | **7.72** | **5.57** |
| E.1.A | Maryland Clean Car | 4.33 [2] | 4.33 | 5.06 [4] |
| E.1.B | CAFE 2008-2011 | 2.27 | 2.27 | NA |
| E.1.C | National Medium and Heavy Duty Standards | 0.88 [3] | 0.88 | 0.28 [5] |
| E.1.D | Federal Renewable Fuel Standards | 0.24 | 0.24 | 0.23 |
| **E.2** | **On-Road, Airport, Port and Freight/Freight Rail** | **0.38** | **0.62** | **1.06** |
| E.2.A | On Road Technology | Included in E.2.A | Included in E.2.A | 1.00 |
| E.2.B | Airport Initiatives | Included in E.2.A | Included in E.2.A | 0.04 |
| E.2.C | Port Initiatives | Included in E.2.A | Included in E.2.A | 0.03 |
| E.2.D | Freight & Freight Rail Programs | Included in E.2.A | Included in E.2.A | Included in E.2.A |
| **E.3** | **Electric & Low Emitting Vehicle Initiatives** | **0.00** | **0.27** | **0.25** |
| **F.1*** | **Public Transportation Initiatives** | **2.00** | **2.89** | **1.61** |
| **F.2** | **Intercity Transportation Initiatives** | **Included in F.1** | **Included in F.1** | **0.16** |
| **G** | **Pricing Initiatives** | **0.43** | **2.30** | **1.99** |
| **H.2** | **Bike & Pedestrian Initiatives** | **Included in F.1** | **Included in F.1** | **0.07** |
| | **TOTAL** | **13.29** | **16.58** | **13.83** |

1. The "True-Up" represents a reforecasting of the 2020 BAU based on actual VMT through 2014.
2. The Maryland Clean Car Program includes the Maryland Clean Car and National Fuel Economy (2012-2025) Program.
3. 2014-2018 National Medium and Heavy Duty Vehicle Standards.
4. The Maryland Clean Car Program includes the Maryland Clean Car, Tier 3 (fuels only), and 2007-2025 National Fuel Economy Programs.
5. 2014-2018 and proposed 2019-2025 National Medium and Heavy Duty Vehicle Standards.

Table 3 represents committed funding through 2020, documented in MDOTs Final FY 2015 – FY 2020 CTP for projects with GHG benefits.

**Table 3 2015 – 2020 Consolidated Transportation Program Summary -**

***GHG Beneficial Project Costs (1000's)***

| GGRP Policy Name | GGRP Policy ID | Planning & Engineering Costs | Right-of-Way Costs | Construction Costs | Total Costs |
|---|---|---|---|---|---|
| On Road Technology | E.2.A | $252,821 | $328,928 | $751,707 | $1,333,456 |
| Airport Initiatives | E.2.B | $1,395 | $- | $10,682 | $12,077 |
| Port Initiatives | E.2.C | $- | $- | $38,605 | $38,605 |
| Freight & Freight Rail Programs | E.2.D | $28,721 | $44,128 | $338,412 | $411,261 |
| Electric & Low Emitting Vehicle Initiatives | E.3 | $- | $- | $500 | $500 |
| Public Transportation Initiatives | F.1* | $125,073 | $278,488 | $3,208,775 | $3,612,336 |
| Intercity Transportation Initiatives | F.2 | $92,328 | $1,100 | $298,480 | $391,908 |
| Pricing Initiatives | G | $2,922 | $1,994 | $282,131 | $287,047 |
| Bike & Pedestrian Initiatives | H.2 | $7,400 | $- | $152,731 | $160,131 |
| TOTAL | | $510,660 | $654,638 | $5,082,023 | $6,247,321 |

Source: Maryland Department of Transportation, FY 2015 – FY 2020 Consolidated Transportation Program.

*Note: Excludes all previously spent and planned spending on the Red Line. Maintains Purple Line cost documented in the CTP.

# Refined Economic Impact Analysis for the Greenhouse Gas Emissions Reduction Act 2012 Plan

*Prepared for*
Maryland Department of the Environment

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## Acronyms and Abbreviations

| | |
|---|---|
| BGE | Baltimore Gas and Electric |
| BWI | Baltimore/Washington International Thurgood Marshall Airport |
| CAP | Climate Action Plan |
| CAFE | Corporate Average Fuel Economy |
| DBED | Department of Business and Economic Development |
| DGS | Department of General Services |
| DHCD | Department of Housing and Community Development |
| DHMH | Department of Health and Mental Hygiene |
| DNR | Department of Natural Resources |
| EPA | U.S. Environmental Protection Agency |
| GGRA | Greenhouse Gas Emissions Reduction Act |
| GHG | Greenhouse Gas |
| IMPLAN | Impact Analysis for Planning |
| MACT | Maximum Achievable Control Technology |
| MARC | Maryland Area Regional Commuter |
| MDA | Maryland Department of Agriculture |
| MDOT | Maryland Department of Transportation |
| MDP | Maryland Department of Planning |
| MEA | Maryland Energy Administration |
| MIA | Maryland Insurance Administration |
| MDE | Maryland Department of the Environment |
| NAICS | North American Industrial Classification System |
| PAYD | Pay-As-You-Drive® |
| PEPCO | Potomac Electric Power Company |
| RECs | Renewable Energy Credits |
| RESI | Regional Economic Studies Institute of Towson University |
| REMI | Regional Economic Models, Inc. |
| RGGI | Regional Greenhouse Gas Initiative |
| SAM | Social Accounting Matrix |
| SMECO | Southern Maryland Electric Cooperative |

# 1.0 Executive Summary

## 1.1 Introduction

Climate change and mitigation strategies are important factors for many elements of the economy and society in general: the rising costs of energy and transportation, threats to the environment, and the health of the greater population (and, by extension, the labor pool). Energy, transportation, agriculture and forestry, recycling, buildings, land use, and many other areas are affected by climate change. As such, mitigating climate change is a vital concern.

Maryland State government agencies are doing their part to mitigate the negative effects of climate change by creating and implementing climate change mitigation strategies designed to reduce GHG emissions in The State. The GGRA strategies under various state government agencies have been organized into eight subject areas: energy, transportation, agriculture and forestry, recycling, multi-sector, buildings, land use, and innovative initiatives.

This report is a refinement of RESI's 2014 results, taking into account the short-term job creation, economic activity, and wage effects from these GGRA strategies and potential enhancements of some programs. The 2014 report was a preliminary analysis of the potential economic impacts of mitigation strategies for the 2012 GGRA report. During this refinement, RESI used a dynamic model known as the REMI model PI+ to assist in determining cumulative benefits and annual impacts to the region. This model allowed RESI to review the interactions among agencies within the region from the strategies and changes that would result from the interaction of those agencies. The results of this report are considered to be a more accurate representation of the possible outcomes from these reduction strategies and provide a potential estimation of economic activity through 2020.

This report includes refined data from agencies that outlined spending on programs, and allocation of funds to different industries. Additionally, areas such as *Transportation* were refined with agency coordination to determine the impact from these programs directly associated with greenhouse gas reduction, and the categories of spending such as architecture, planning, land acquisition, and construction. This report highlights how the GGRA will benefit Maryland in job creation across all economic groups, as well as retain Maryland's currently highly educated workforce through programs associated with the green economy.

## 1.2 Summary of Findings

RESI analyzed data collected in collaboration with state agencies and MDE in order to estimate the economic impacts of climate action strategies and their subprograms. Using data contained in strategy write-ups provided by MDE as well as external research from a variety of sources, including the implementing agencies, RESI estimated the impacts of each strategy and subprogram.

RESI coordinated with state agencies to develop a methodology. The agencies assisted in the development and finalization of all assumptions used in the economic modeling for RESI's analysis. Through this coordinated effort, RESI built upon their original design in 2011 creating an investment and operation phase. A detailed explanation of the investment and operation phases and what they entail can be found in Appendix B.1 of Appendix E of the GGRA plan.

To quantify the economic and fiscal impacts of climate action strategies and their subprograms, RESI utilized the REMI PI+ input/output model. For more information regarding REMI PI+, please refer to Appendix B.2 of Appendix E, which presents *The Economic Impact Analysis Revision for the Greenhouse Gas Emissions Reduction Act 2012 Plan* hereafter referred to as the full report in this Chapter.

A summary of RESI's findings, including the total economic impacts (employment, output, and total net benefits) of all strategies within a subject area can be found in Figure 1. Figure 2 presents the total fiscal impacts (state and local tax revenues) resulting from the investment and operation phases of the strategies. The total wage impacts can be found in Figures 3 and 4. Total net benefits can be found in Figures 5 and 6.

RESI reviewed findings for both status quo program spending and enhancement spending. Although the enhancements are not guaranteed funding, the potential to reduce more greenhouse gases and increase jobs within the state was analyzed. Enhanced programs ranged from energy, transportation, land use, and innovative initiatives. The agencies provided the potential costs to achieve these new GHG targets under the enhanced scenarios of specific strategies, and RESI used this data to create a secondary analysis.

This update provides updated costs and benefits associated with GGRA policies as analyzed in the 2014 report. In addition to updated annual data, RESI received detailed data regarding funding of programs, spending, and how programs would be implemented if enhanced GGRA reductions were approved.

For more detailed impacts and further explanation, please refer to Section 3.0 and Appendix A of the full report. Information regarding the modeling assumptions and procedures used to derive impacts for each strategy within the subject areas can be found in Appendix C of the full report. Appendix D provides a discussion of the general occupations most likely to be associated with each subject area.

**Figure 1: Total Annual Economic Impacts by Strategy Subject Area—Investment and Operation Phases, 2010–2020[1][2]**

| Subject Area | Jobs[3] | Output | Total Cost | Total Net Benefit |
|---|---|---|---|---|
| **Energy** | | | | |
| Status Quo | 12,156.0 | $14,039,556,803 | $14,983,805,248 | -$944,248,445 |
| Enhancement | 14,058.1 | $15,448,356,592 | $16,729,297,904 | -$1,280,941,312 |
| **Transportation** | | | | |
| Status Quo | 3,099.7 | $3,491,312,335 | $2,206,654,201 | $1,284,658,134 |
| Enhancement | 6,267.7 | $8,383,504,300 | $4,244,515,129 | $4,138,989,171 |
| **Agriculture** | | | | |
| Status Quo | -298.2 | $2,099,151,612 | $632,038,070 | $1,467,113,542 |
| Enhancement | -297.7 | $2,104,949,646 | $760,708,403 | $1,344,241,243 |
| **Recycling** | | | | |
| Status Quo | 325.5 | $303,588,867 | $9,257,145 | $294,331,722 |
| Enhancement | 558.0 | $419,730,048 | $15,869,391 | $403,860,657 |
| **Buildings** | | | | |
| Status Quo | 726.8 | $357,208,252 | $7,873,194 | $349,335,058 |
| Enhancement | N/A | N/A | N/A | N/A |
| **Land Use** | | | | |
| Status Quo | 6,748.1 | $15,258,536,194 | $15,564,480,642 | -$305,944,448 |
| Enhancement | 8,522.9 | $21,967,353,014 | $23,832,525,089 | -$1,865,172,075 |
| **Innovative Initiatives** | | | | |
| Status Quo | 3,564.2 | $602,800,640 | $213,878,700 | $388,921,940 |
| Enhancement | 3,572.4 | $616,880,934 | $228,332,229 | $388,548,705 |
| **Outreach** | | | | |
| Status Quo | 0.1 | $152,588 | $22,500 | $130,088 |
| Enhancement | N/A | N/A | N/A | N/A |
| **Total** | | | | |
| Status Quo | 26,322.2 | $36,152,307,291 | $33,618,009,700 | $2,534,297,591 |
| Enhancement | 33,442.8 | $49,298,135,374 | $45,819,143,839 | $3,478,991,535 |

Source: REMI PI+, RESI

[1] The *Transportation* and *Innovative Initiatives* subject areas exhibit impacts from 2020 to 2025. However, those impacts were excluded in Figure 1 and Figure 2. For the specific distribution of impacts over time, refer to Section 3.0 of the full report. In addition, summed impacts throughout the report may not add up exactly to totals due to rounding.

[2] All dollar values are reported in 2015 dollars.

[3] Jobs figures reflect net job impacts in the year 2020.

As shown in the figure above, during the investment and operation phases of these strategies, the total economic benefits would include approximately 26,322 jobs maintained in 2020 and $36.2 billion in output between 2010 and 2020 for the status quo. The total cost of all strategies in all subject areas is approximately $33.6 billion, for the status quo. The expected net benefits under the enhanced scenarios would be $3.5 billion in net benefit with 33.4 thousand jobs maintained in 2020. The net benefit includes public and private costs. It is important to note that employment impacts are not cumulative, and therefore annual impacts are jobs created above the baseline forecast. For more information on interpreting the results, please review the REMI PI+ model overview in Appendix B.2. All employment impacts in this report represent the number of jobs created or maintained in a given year as compared to the baseline.

A summary of the wage impacts is represented in Figure 2 and 3. The investment phase generates more jobs than the operation phase because the public and private sectors must hire workers to implement the strategies. However, once policies are in place, growth stabilizes, and maintenance and monitoring are the primary employment needs of a program.

**Figure 2: Wage Impact by Strategy Subject Area—Investment Phase, 2010–2020[4]**

| Subject Area | Jobs[5] | Wages |
|---|---|---|
| **Energy** | | |
| Status Quo | 9,019.5 | $4,651,750,397 |
| Enhancement | 10,041.5 | $7,761,206,051 |
| **Transportation** | | |
| Status Quo | 2,490.0 | $1,439,102,172 |
| Enhancement | 5,018.7 | $2,980,082,579 |
| **Agriculture** | | |
| Status Quo | 498.4 | $59,032,440 |
| Enhancement | 498.9 | $61,617,397 |
| **Recycling** | | |
| Status Quo | 773.1 | $292,888,641 |
| Enhancement | 1,325.3 | $414,719,170 |
| **Buildings** | | |
| Status Quo | 18.6 | $10,284,424 |
| Enhancement | N/A | N/A |
| **Land Use** | | |
| Status Quo | 4,920.9 | $4,744,735,057 |
| Enhancement | 5,652.4 | $8,053,793,823 |
| **Innovative Initiatives** | | |
| Status Quo | 361.1 | $228,725,433 |
| Enhancement | 368.3 | $236,843,110 |
| **Outreach** | | |
| Status Quo | 0.0 | $0 |
| Enhancement | N/A | N/A |
| **Total** | | |
| Status Quo | 18,081.6 | $11,426,518,564 |
| Enhancement | 22,923.6 | $19,518,546,554 |

Source: REMI PI+, RESI

[4] All dollar values are reported in 2015 dollars.
[5] Job figures reflect net job impacts in the year 2020.

**Figure 3: Wage Impact by Strategy Subject Area—Operation Phase, 2010–2020[6]**

| Subject Area | Jobs[7] | Wages |
|---|---|---|
| **Energy** | | |
| Status Quo | 3,136.4 | $1,273,496,043 |
| Enhancement | 4,051.2 | $1,932,556,944 |
| **Transportation** | | |
| Status Quo | 609.8 | $131,679,378 |
| Enhancement | 1,249.0 | $247,501,555 |
| **Agriculture** | | |
| Status Quo | -796.6 | $698,379,517 |
| Enhancement | -796.6 | $698,379,517 |
| **Recycling** | | |
| Status Quo | -447.6 | -$169,242,859 |
| Enhancement | -767.3 | -$238,978,248 |
| **Buildings** | | |
| Status Quo | 708.2 | $54,687,500 |
| Enhancement | N/A | N/A |
| **Land Use** | | |
| Status Quo | 1,827.2 | $1,601,903,602 |
| Enhancement | 2,870.5 | $2,488,973,900 |
| **Innovative Initiatives** | | |
| Status Quo | 3,203.1 | $181,956,159 |
| Enhancement | 3,204.0 | $182,612,688 |
| **Outreach** | | |
| Status Quo | 0.1 | $61,035 |
| Enhancement | N/A | N/A |
| **Total** | | |
| Status Quo | 8,240.7 | $3,772,920,375 |
| Enhancement | 10,519.2 | $5,365,794,892 |

Source: REMI PI+, RESI

As shown in the figures above, these strategies result in a wage impact that ranges from of $11.4 to $19.5 billion in the investment phase for status quo and enhancement, respectively. In the operation phase, wage impacts range from $3.8 to $5.4 billion for status quo and enhancements, respectively. The strategies generate approximately 18.1 to 22.9 thousand jobs in the investment phase and 8.2 to 10.5 thousand jobs in the operation phase for status quo and enhancements, respectively.

[6] All dollar values are reported in 2015 dollars.
[7] Jobs figures reflect net job impacts in the year 2020.

RESI also calculated the total net benefits from these strategies. A summary of these findings can be found in Figures 4 and 5. Although some of these policies may generate negative net impacts, the programs are still generating other benefits that are not accounted for in the market. These benefits include environmental improvements to ecosystems and improvements to human health from reduced pollution and greenhouse gases. Additionally, the program as a whole has net economic benefits.

**Figure 4: Total Net Benefit by Strategy Subject Area—Investment Phase, 2010–2020**[8]

| Subject Area | Output | Total Cost | Total Net Benefit |
|---|---:|---:|---:|
| **Energy** | | | |
| Status Quo | $11,154,722,778 | $13,097,859,286 | -$2,197,436,981 |
| Enhancement | $12,316,690,319 | $13,881,581,739 | -$1,783,499,402 |
| **Transportation** | | | |
| Status Quo | $3,270,160,599 | $2,206,654,201 | $1,056,522,384 |
| Enhancement | $7,990,266,382 | $4,244,515,129 | $313,182,368 |
| **Agriculture** | | | |
| Status Quo | $65,643,311 | $214,057,002 | -$148,867,164 |
| Enhancement | $71,441,345 | $222,727,335 | -$151,285,990 |
| **Recycling** | | | |
| Status Quo | $719,085,693 | $9,257,145 | $709,828,548 |
| Enhancement | $990,256,168 | $15,869,391 | $974,386,777 |
| **Buildings** | | | |
| Status Quo | $17,364,502 | $7,688,994 | $9,675,508 |
| Enhancement | N/A | N/A | N/A |
| **Land Use** | | | |
| Status Quo | $9,780,953,979 | $15,230,800,642 | -$1,133,515,000 |
| Enhancement | $15,158,674,064 | $22,837,241,668 | -$974,355,000 |
| **Innovative Initiatives** | | | |
| Status Quo | $301,666,260 | $213,878,700 | $176,430,870 |
| Enhancement | $393,191,252 | $228,332,229 | $175,316,299 |
| **Outreach** | | | |
| Status Quo | $0 | $0 | $0 |
| Enhancement | N/A | N/A | N/A |
| **Total** | | | |
| Status Quo | $25,309,597,123 | $30,980,195,969 | -$5,670,598,846 |
| Enhancement | $36,937,884,032 | $41,437,956,486 | -$4,500,072,454 |

Source: REMI PI+, RESI

[8] All dollar values are reported in 2015 dollars.

**Figure 5: Total Net Benefit by Strategy Subject Area—Operation Phase, 2010–2020**[9]

| Subject Area | Output | Total Cost | Total Net Benefit |
|---|---:|---:|---:|
| **Energy** | | | |
| Status Quo | $2,884,834,025 | $1,885,945,962 | $963,202,841 |
| Enhancement | $3,131,666,273 | $2,847,716,165 | $226,564,081 |
| **Transportation** | | | |
| Status Quo | $221,151,736 | $0 | $106,127,930 |
| Enhancement | $393,237,918 | $0 | $202,999,028 |
| **Agriculture** | | | |
| Status Quo | $2,033,508,301 | $417,981,068 | $1,514,239,386 |
| Enhancement | $2,033,508,301 | $537,981,068 | $854,071,331 |
| **Recycling** | | | |
| Status Quo | -$415,496,826 | $0 | -$415,496,826 |
| Enhancement | -$570,526,120 | $0 | -$570,526,120 |
| **Buildings** | | | |
| Status Quo | $339,843,750 | $184,200 | $339,659,550 |
| Enhancement | N/A | N/A | N/A |
| **Land Use** | | | |
| Status Quo | $5,477,582,215 | $333,680,000 | $1,165,863,599 |
| Enhancement | $6,808,678,950 | $995,283,421 | $820,949,641 |
| **Innovative Initiatives** | | | |
| Status Quo | $301,134,380 | $0 | $223,458,425 |
| Enhancement | $223,689,682 | $0 | $223,277,695 |
| **Outreach** | | | |
| Status Quo | $152,588 | $22,500 | $130,088 |
| Enhancement | N/A | N/A | N/A |
| **Total** | | | |
| Status Quo | $10,842,710,169 | $2,637,813,730 | $8,204,896,439 |
| Enhancement | $12,360,251,342 | $4,381,187,354 | $7,979,063,988 |

Source: REMI PI+, RESI

As shown in Figures 4 and 5, total net benefit during the investment phase totals a negative $5.7 billion and a positive $7.9 billion during the operation phase for the status quo. For enhancements, as shown in Figures 4 and 5 the total net benefit during the investment phase totals a negative $4.5 billion and a positive $8.0 billion during the operation phase. Total net benefit is the difference between output impact and total cost. Total net benefit is analogous to "profit" in the business sense. Positive total net benefit values recognize desirable policy

[9] All dollar values are reported in 2015 dollars.

outcomes for Marylanders. The total net benefit from both the investment and operation phases totals $2.3 billion for status quo, a desirable outcome. An additional net benefit of $3.5 billion can be claimed in enhancement programs are considered into Maryland's GGRA initiatives.

# 2.0 Introduction

## 2.1 Overview

Climate change and mitigation strategies are important factors for many elements of the economy and society in general: the rising costs of energy and transportation, threats to the environment, and the health of the greater population (and, by extension, the labor pool). Energy, transportation, agriculture and forestry, recycling, buildings, land use, and many other areas are affected by climate change. As such, mitigating climate change is a vital concern.

Maryland state government agencies are doing their part to mitigate the negative effects of climate change by creating and implementing climate change mitigation strategies designed to reduce GHG emissions in the State. The strategies under various state government agencies have been organized into seven subject areas: energy, transportation, agriculture and forestry, recycling buildings, land use, and innovative initiatives.

RESI conducted an analysis of the potential economic impacts of mitigation strategies for the 2014 GGRA report. This report estimated the job creation, economic activity, and wage effects of these strategies and their subprograms in development or already enacted. The findings within the 2014 report were a revised analysis of these strategies from the 2013 report, providing an estimate of the economic impact these strategies would have in Maryland.

This report is a refinement of RESI's 2014 results, with more complete data about historical, current, and projected budget expenditures associated with programs. Additionally, RESI created a preliminary analysis of a selection of strategies designated for potential enhancement. Enhanced programs are those currently in the GGRA, but could be expanded to further decrease GHG output within Maryland. During this refinement, RESI used a dynamic model known as the REMI model PI+ to assist in determining net benefits and annual impacts to the region. This model allowed RESI to review the interactions among agencies within the region from the strategies. The results of this report are considered to be a more accurate representation (than the 2014 RESI report) of the possible outcomes from these reduction strategies and provide a potential estimation of economic activity through 2020 for an enhanced GGRA.

## 2.2 Methodology

RESI analyzed data collected by state agencies and their contractors in order to quantify the economic impacts of climate action strategies and their subprograms. Each program was assessed at the status quo and enhanced levels. Under the status quo, the programs were assessed using the historical, current, and projected budgeting data provided in cooperation with the agencies. Enhanced programs were then identified, and agencies were asked to provide further data regarding the expenditures and potential changes for those programs highlighted for enhancements. RESI in some cases used external data to determine potential outcomes from status quo and enhanced programs during investment and operational phases when agency level data was not readily available.

The impacts were modeled for two phases: an investment phase and an operation phase. The investment phase refers to the entire period during which a strategy and its subprograms are being developed, invested in, and implemented. The operation phase refers to the period during which a strategy and its subprograms have already been implemented and the “end user” cost savings are being realized. A detailed explanation of the investment and operation phases and what they entail can be found in Appendix B.1.

To quantify the economic and fiscal impacts of climate action strategies under both status quo and enhanced scenarios, RESI used the REMI PI+ input/output model. This model enumerates the economic and fiscal impacts of each dollar earned and spent by the following: employees associated with the strategies, other supporting vendors (business services, retail, etc.), each dollar spent by these vendors on other firms, and each dollar spent by the households associated with the strategies’ employees, other vendors’ employees, and other businesses’ employees. For more information regarding REMI PI+ and how to interpret the results, please refer to Appendix B.2.

The strategies have been organized into seven subject areas: energy, transportation, agriculture and forestry, recycling, buildings, land use, and innovative initiatives. RESI’s report is similarly organized, with each subject area separated into a different section. The economic impacts are broken down by year from 2010 through 2020.  Figure 6 outlines the strategies under each sector that were analyzed for potential enhancements.

**Figure 6: Listing of Enhanced Programs for 2015 Report**

| Subject Area | Program Name |
|---|---|
| **Energy** | Regional Greenhouse Gas Initiative<br>EmPOWER: Energy Efficiency in the Residential Sector<br>EmPOWER: Energy Efficiency in the Commercial and Industrial Sector<br>EmPOWER: Energy Efficiency in the Power Sector—General<br>Maryland Renewable Energy Portfolio Standard<br>BeSMART (Mainstreet Initiatives)<br>Weatherization and Energy Efficiency for Low-Income Homes |
| **Transportation** | Transportation Technologies<br>Public Transportation Initiatives<br>Intercity Transportation Initiatives<br>Pricing Initiatives<br>Bike and Pedestrian Initiatives |
| **Agriculture** | Nutrient Trading for GHG Benefits |
| **Zero Waste** | Zero Waste |
| **Land Use** | Reducing Emissions through Smart Growth and Land Use/Location Efficiency (Include Land Use Planning and Growth Boundary GHG Benefits)<br>Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) |
| **Innovative Initiatives** | Lead-by-Example: State of Maryland Initiatives and Carbon Footprint |

Source: MDE, RESI

# 3.0 Findings

RESI's findings show that all strategies and subprograms will have net positive significant economic impact. The direct, spinoff, and average annual economic impacts (jobs, output, and wages) for each strategy and subprogram for the investment phase and the operation phase were calculated. It is important to note that job impacts associated for any subject area or strategy do not indicate cumulative job creation. The job impacts are differences based on the current baseline for Maryland based on BEA historical data. Each year reflects new jobs or job loss difference from the baseline. This applies throughout the report for jobs. In regard to wages and output, each year's results indicate the modeled difference between the relevant policy scenario and the baseline scenario for that year. For more information on how to interpret the results please review Appendix B.2.

For more detailed economic impacts of all the programs, please refer to Appendix A. Information regarding the modeling assumptions and procedures used to derive impacts for each strategy within the subject areas can be found in Appendix C. A discussion of the general occupations most likely to be associated with each subject area is in Appendix D.

## 3.1 Energy

### 3.1.1 Regional Greenhouse Gas Initiative (RGGI)

Maryland is one of nine Northeast and Mid-Atlantic States that participate in the Regional Greenhouse Gas Initiative (RGGI) – a regional market-based cap-and-trade program to reduce $CO_2$ emissions from fossil-fuel fired power plants in the region.[10] RGGI reduces emissions through an emissions cap applied to the nine-state geographic region. Under the initiative, the participating states issue "allowances" equal to the number of tons of $CO_2$ emissions allowed under the regional cap. A single allowance permits a source to emit one ton of carbon dioxide.

**Investment Phase – Status Quo**

The average annual economic impacts of the investment phase of the *Regional Greenhouse Gas Initiative* strategy can be found in Figure 7.

[10] Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont currently participate in RGGI.

**Figure 7: Regional Greenhouse Gas Initiative—Investment Phase**[11]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 8.0 | $640,869 | $320,435 |
| 2011 | 8.6 | $671,387 | $320,435 |
| 2012 | 8.7 | $671,387 | $350,952 |
| 2013 | 8.3 | $640,869 | $366,211 |
| 2014 | 8.4 | $701,904 | $366,211 |
| 2015 | 7.8 | $610,352 | $396,729 |
| 2016 | 7.8 | $671,387 | $411,987 |
| 2017 | 8.6 | $671,387 | $457,764 |
| 2018 | 8.9 | $732,422 | $503,540 |
| 2019 | 7.7 | $732,422 | $442,505 |
| 2020 | 8.0 | $732,422 | $473,022 |
| ***Average*** | ***8.3*** | ***$679,710*** | ***$400,890*** |

Source: REMI PI+, RESI

As shown in the figure above, during the investment phase of this strategy's implementation will maintain approximately 8 jobs by 2020, and generate $679,710 in output and $400,890 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *State government*, primarily due to the expectation that government sources would be used to maintain records and manage the RGGI markets. This could include additional administration to manage dissemination of funds, oversight, and budgeting.

**Investment Phase – Enhanced**

The average annual economic impacts of the investment phase of the *Regional Greenhouse Gas Initiative* strategy can be found in Figure 8.

[11] Values are adjusted for inflation. Summed impacts throughout the report may not add up exactly to totals due to rounding.

**Figure 8: Regional Greenhouse Gas Initiative—Investment Phase**[12]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 8.0 | $640,869 | $320,435 |
| 2011 | 8.6 | $671,387 | $320,435 |
| 2012 | 8.7 | $671,387 | $350,952 |
| 2013 | 8.3 | $640,869 | $366,211 |
| 2014 | 8.4 | $701,904 | $366,211 |
| 2015 | 7.8 | $610,352 | $396,729 |
| 2016 | 7.8 | $671,387 | $411,987 |
| 2017 | 8.6 | $671,387 | $457,764 |
| 2018 | 8.9 | $732,422 | $503,540 |
| 2019 | 7.7 | $732,422 | $442,505 |
| 2020 | 8.0 | $732,422 | $473,022 |
| ***Average*** | ***8.3*** | ***$679,710*** | ***$400,890*** |

Source: REMI PI+, RESI

As shown in the figure above, during the investment phase of this strategy's enhanced implementation will remain unchanged. Under the enhanced scenario for RGGI, allowance prices will increase and therefore the more impacts would be associated with the operational side of RGGI. During the enhancement phase, this strategy will maintain approximately 8 jobs by 2020, and generate $679,710 in output and $400,890 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *State government*, primarily due to the expectation that government sources would be used to maintain records and manage the RGGI markets. This could include additional administration to manage dissemination of funds, oversight, and budgeting.

**Operation Phase – Status Quo**

The average annual economic impacts of the operation phase of the Regional Greenhouse Gas Initiative strategy for status quo can be found in Figure 9.

[12] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding.

**Figure 9: Regional Greenhouse Gas Initiative—Operation Phase**[13]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 298.4 | $20,874,023 | $11,260,986 |
| 2011 | 266.1 | $17,211,914 | $11,245,728 |
| 2012 | 230.4 | $13,671,875 | $11,016,846 |
| 2013 | 196.7 | $10,437,012 | $10,604,858 |
| 2014 | 167.8 | $7,965,088 | $10,330,200 |
| 2015 | 143.0 | $5,798,340 | $10,101,318 |
| 2016 | 123.1 | $4,150,391 | $9,811,401 |
| 2017 | 108.3 | $2,929,688 | $9,719,849 |
| 2018 | 96.7 | $1,953,125 | $9,658,813 |
| 2019 | 90.1 | $1,403,809 | $9,689,331 |
| 2020 | 87.7 | $1,098,633 | $9,872,437 |
| ***Average*** | ***164.4*** | ***$7,953,991*** | ***$10,301,070*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 88 jobs by 2020, and generate $8.0 million in output and $10.3 million in wages on average each year once in operation. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Administrative and waste management services.*

**Operation Phase – Enhanced**

The average annual economic impacts of the operation phase of the Regional Greenhouse Gas Initiative strategy for enhanced scenario can be found in Figure 10.

[13] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding.

**Figure 10: Regional Greenhouse Gas Initiative—Operation Phase**[14]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 298.4 | $20,874,023 | $11,260,986 |
| 2011 | 266.1 | $17,211,914 | $11,245,728 |
| 2012 | 230.4 | $13,671,875 | $11,016,846 |
| 2013 | 196.7 | $10,437,012 | $10,604,858 |
| 2014 | 1,583.0 | $75,118,832 | $97,424,232 |
| 2015 | 1,390.6 | $56,369,964 | $98,202,411 |
| 2016 | 1,234.0 | $41,595,422 | $98,330,355 |
| 2017 | 1,137.1 | $30,745,488 | $102,004,563 |
| 2018 | 1,044.1 | $21,087,148 | $104,282,539 |
| 2019 | 1,004.7 | $15,656,495 | $108,063,850 |
| 2020 | 1,006.8 | $12,617,314 | $113,380,590 |
| ***Average*** | ***853.8*** | ***$28,671,408*** | ***$69,619,723*** |

Source: REMI PI+, RESI

As shown in Figure 10, the strategy will maintain approximately 1,007 jobs by 2020, and generate $28.7 million in output and $69.7 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Professional, scientific, and technical services.*

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $173,947 for the investment phase and $9,185,320 for the operation phase under the status quo.

If the program were enhanced, total state and local tax revenues would increase by approximately $626,208 for the investment phase and $33,067,152 for the operation phase.

### 3.1.2 GHG Reductions from Imported Power

Through the 2008 Climate Action Plan, a generation performance standard was set for load-serving entities, including electricity providers. The promotion of energy and capacity from low-carbon or renewable sources through the policy aim to reduce the amount of energy imported annually, specifically for those states in which electricity generators primarily produce electricity using a higher concentration of coal in their fuel mixtures. The policy's goal is to enact a standard of no more than 1,125 pounds of GHGs per megawatt-hour by 2013.

[14] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding.

**Investment Phase**

The total economic impacts of the investment phase of the *GHG Reductions from Imported Power* strategy can be found in Figure 11.

**Figure 11: GHG Reductions from Imported Power—Investment Phase**[15]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | -$15,259 |
| 2012 | 0.1 | $0 | $0 |
| 2013 | -0.5 | -$30,518 | $0 |
| 2014 | 0.1 | $61,035 | $15,259 |
| 2015 | -0.3 | $0 | $15,259 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $30,518 |
| 2018 | -0.1 | -$61,035 | $0 |
| 2019 | -0.5 | $0 | $0 |
| 2020 | -1.0 | -$61,035 | -$15,259 |
| ***Average*** | ***-0.2*** | ***-$8,323*** | ***$2,774*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will result in one forgone job by 2020, approximately $8,323 in forgone output and generate $2,774 in wages on average each year. It should be noted that the investment phase for this strategy does not have much cost associated with the policy and any loss would result in the private sector for implementation procedures. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Protective service occupations*, primarily due to the expectation that the demand for low-carbon and renewable energy technologies would increase. Therefore, companies may wish to hire additional security personnel to ensure safety during expansion periods. Companies involved in the development of such technologies are a part of this industry.

**Operation Phase**

The average annual economic impacts of the operation phase of the *GHG Reductions from Imported Power* strategy can be found in Figure 12.

[15] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 12: GHG Reductions from Imported Power—Operation Phase**[16]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 3.8 | $457,764 | $106,812 |
| 2011 | 6.9 | $732,422 | $183,105 |
| 2012 | 9.1 | $946,045 | $274,658 |
| 2013 | 11.3 | $1,159,668 | $350,952 |
| 2014 | 12.3 | $1,373,291 | $396,729 |
| 2015 | 12.2 | $1,342,773 | $427,246 |
| 2016 | 13.5 | $1,464,844 | $488,281 |
| 2017 | 15.0 | $1,647,949 | $549,316 |
| 2018 | 15.6 | $1,647,949 | $610,352 |
| 2019 | 15.3 | $1,770,020 | $625,610 |
| 2020 | 13.7 | $1,647,949 | $595,093 |
| ***Average*** | ***11.7*** | ***$1,290,061*** | ***$418,923*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 14 jobs by 2020, and generate $1.3 million in output and $0.4 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction, extraction occupations* primarily due to the expectation that utilities switching from fossil fuel-based imported electricity to renewable energy sources would experience a net fuel cost savings after they recoup the upfront cost of fuel switching.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $155 for the investment phase and $261,882 for the operation phase.

### 3.1.3 Federal New Source Performance Standard

The U.S. Environmental Protection Agency (EPA) is using the New Source Performance Standard authority under the federal Clean Air Act to promulgate new regulations to reduce GHG emissions from fossil fuel-fired power plants. The performance standards, which are expected to become final in early 2013, will apply to new electricity generating units and will be based on existing technologies. EPA is coordinating this action on GHGs with a number of other required regulatory actions for other pollutants, thereby enabling electricity generating units to develop multi-pollutant strategies to reduce pollutants in a more efficient and cost-effective way than would be possible by addressing multiple pollutants separately.

[16] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase**

The average annual economic impacts of the investment phase of the *Federal New Source Performance Standard* strategy can be found in Figure 13.

**Figure 13: Federal New Source Performance Standard—Investment Phase**[17]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 18.2 | $1,403,809 | $701,904 |
| 2014 | 17.9 | $1,434,326 | $732,422 |
| 2015 | 17.2 | $1,403,809 | $808,716 |
| 2016 | 16.8 | $1,342,773 | $854,492 |
| 2017 | 16.4 | $1,342,773 | $885,010 |
| 2018 | 15.9 | $1,342,773 | $930,786 |
| 2019 | 15.6 | $1,342,773 | $961,304 |
| 2020 | 14.4 | $1,281,738 | $900,269 |
| ***Average*** | ***12.0*** | ***$990,434*** | ***$615,900*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 14 jobs by 2020, and generate $1.0 million in output and $0.6 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Sales, office, administrative occupations*, primarily due to the expectation that sources subject to the standard will seek out cost-effective measures to reduce air pollutants. Business entities providing such services are within this industry.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Federal New Source Performance Standard* strategy can be found in Figure 14.

[17] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 14: Federal New Source Performance Standard—Operation Phase**[18]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 7.4 | $823,975 | $183,105 |
| 2012 | 11.9 | $1,312,256 | $350,952 |
| 2013 | 16.2 | $1,739,502 | $488,281 |
| 2014 | 18.8 | $2,075,195 | $579,834 |
| 2015 | 20.6 | $2,258,301 | $686,646 |
| 2016 | 23.4 | $2,563,477 | $793,457 |
| 2017 | 24.7 | $2,746,582 | $915,527 |
| 2018 | 26.3 | $2,868,652 | $1,007,080 |
| 2019 | 26.3 | $2,929,688 | $1,022,339 |
| 2020 | 25.9 | $2,929,688 | $1,037,598 |
| ***Average*** | ***18.3*** | ***$2,022,483*** | ***$642,256*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 26 jobs by 2020, and generate $2.0 million in output and $0.6 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction, extraction occupations*, primarily due to the expectation that sources subject to the standard will switch from fossil fuel use in order to reduce air pollution and will experience cost savings from cost-effective, cleaner fuels and technologies in the long run as a result.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $245,308 for the investment phase and $6,296,959 for the operation phase.

### 3.1.4 MACT

EPA has adopted new air emissions requirements for industrial, commercial, and institutional boilers under two separate rulemakings.[19] The first, which took effect January 31, 2013, establishes national emission standards for Hazardous Air Pollutants (HAPs) for major sources.[20]

[18] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

[19] Boilers burn fuel, including natural gas, fuel oil, coal, biomass (e.g., wood), or other gas to produce steam or hot water. The steam is used to produce electricity, drive an industrial process, or provide heat. Emissions from burning the fuel can include toxic air pollutants like mercury, lead and particle pollution.

[20] "National Emission Standards for Hazardous Air Pollutants for Major sources: Industrial, Commercial, and Institutional Boilers and Process Heaters", 78 Fed. Reg. 7138 (January 31, 2103).

The rule affects thousands of boilers and process heaters at facilities nationwide which are considered as major sources of HAPs. These facilities also emit GHGs.

The Boiler MACT rule applies to any stationary source with a boiler or group of stationary sources with boilers that emit 10 tons per year of any single HAP or 25 tons per year of any combination of HAPs. The rule requires each boiler to meet pollution emission limits on an annual and continuous basis.

EPA also issued a Boiler MACT rule for smaller “area sources”, which took effect February 1, 2013.[21]

Among other things, the Boiler MACT rules require operators to conduct a boiler tune-up to improve efficiency, minimize fuel consumption and reduce emissions. EPA estimates there will be a one percent fuel savings due to the tune-ups, which equates to an equivalent one percent reduction in GHG emissions.

**Investment Phase**

The average annual economic impacts of the investment phase of the *MACT* strategy can be found in Figure 15.

**Figure 15: MACT—Investment Phase[22]**

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 1.5 | $33,086 | $61,035 |
| 2013 | 1.3 | $24,815 | $45,776 |
| 2014 | 1.0 | $33,086 | $45,776 |
| 2015 | 1.0 | $16,543 | $45,776 |
| 2016 | 1.5 | $33,086 | $76,294 |
| 2017 | 1.0 | $33,086 | $61,035 |
| 2018 | 1.5 | $16,543 | $61,035 |
| 2019 | 0.6 | $33,086 | $61,035 |
| 2020 | 0.5 | $16,543 | $45,776 |
| ***Average*** | ***0.9*** | ***$80,455*** | ***$45,776*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy’s implementation will maintain approximately less than one job by 2020, and generate $80,455 in output and $45,776

[21] “National Emission Standards for Hazardous Air Pollutants for Area Sources: Industrial, commercial, and Institutional Boilers”. 78 Fed. Reg. 7488 (February 1, 2013).

[22] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations*, primarily due to the expectation that professionals such as environmental consultants in this field would be contracted to develop and implement the technologies associated with MACT.

**Operation Phase**

The total economic impacts of the operation phase of the *MACT* strategy can be found in Figure 16.

**Figure 16: MACT—Operation Phase**[23]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 256.7 | $18,157,959 | $10,208,130 |
| 2013 | 227.0 | $14,801,025 | $10,177,612 |
| 2014 | 196.7 | $11,962,891 | $10,040,283 |
| 2015 | 168.1 | $9,338,379 | $9,826,660 |
| 2016 | 143.3 | $7,080,078 | $9,536,743 |
| 2017 | 123.4 | $5,432,129 | $9,307,861 |
| 2018 | 106.3 | $3,906,250 | $9,094,238 |
| 2019 | 94.6 | $2,929,688 | $8,941,650 |
| 2020 | 88.6 | $2,258,301 | $8,941,650 |
| ***Average*** | ***127.7*** | ***$6,896,973*** | ***$7,824,984*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 89 jobs by 2020, and generate $6.9 million in output and $7.8 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Protective services occupation.* Utilities and energy producing entities within the industry which house boilers subject to the strategy will reduce boiler fuel consumption in order to decrease pollutants. This will result in cost savings. This cost savings could result in additional expansion or investment which may require additional security personnel during these periods.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $17,022 for the investment phase and $2,087,507 for the operation phase.

[23] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

### 3.1.5 Energy Efficiency in the Residential Sector

The State's residential energy efficiency initiatives are part of the EmPOWER Maryland suite of energy efficiency programs administered primarily by MEA using SEIF revenues. Together with programs implemented by the utilities, 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. Programs funded and administered through other State agencies, including the DHCD, contribute to the EmPOWER goal, as do federally-funded energy efficiency programs.

**Investment Phase–Status Quo**

The average annual economic impacts of the investment phase of the *Energy Efficiency in the Residential Sector* strategy under status quo can be found in Figure 17.

**Figure 17: Energy Efficiency in the Residential Sector Status Quo—Investment Phase[24]**

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 6,518.9 | $419,799,805 | $151,763,916 |
| 2011 | 3,512.2 | $221,282,959 | $90,087,891 |
| 2012 | 3,987.3 | $246,856,689 | $103,271,484 |
| 2013 | 3,641.8 | $220,733,643 | $98,907,471 |
| 2014 | 3,466.9 | $207,427,979 | $99,273,682 |
| 2015 | 3,007.0 | $175,659,180 | $91,278,076 |
| 2016 | 363.5 | $4,150,391 | $20,736,694 |
| 2017 | 60.0 | -$16,052,246 | $7,400,513 |
| 2018 | -75.2 | -$24,841,309 | -$808,716 |
| 2019 | -100.7 | -$25,939,941 | -$4,898,071 |
| 2020 | -71.7 | -$23,315,430 | -$6,210,327 |
| ***Average*** | ***2,210.0*** | ***$127,796,520*** | ***$59,163,874*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will result in approximately 72 forgone jobs by 2020, and generate $127.8 million in output and $59.2 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations*. Newly created programs to promote energy efficiency within the residential sector include incentives for households to replace current appliances for Energy Star equivalents. These consumer purchases being offset by some of the energy efficiency programs, help to drive employment within the retail sales industry.

[24] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase–Enhanced**

The average annual economic impacts of the investment phase of the *Energy Efficiency in the Residential Sector* strategy under enhanced scenario can be found in Figure 18.

**Figure 18: Energy Efficiency in the Residential Sector Enhanced—Investment Phase**[25]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 6,518.9 | $419,799,805 | $151,763,916 |
| 2011 | 3,512.2 | $221,282,959 | $90,087,891 |
| 2012 | 3,987.3 | $246,856,689 | $103,271,484 |
| 2013 | 3,641.8 | $220,733,643 | $98,907,471 |
| 2014 | 3,466.9 | $207,427,979 | $99,273,682 |
| 2015 | 3,010.6 | $175,868,279 | $91,386,731 |
| 2016 | 363.9 | $4,155,331 | $20,761,379 |
| 2017 | 60.1 | -$16,071,354 | $7,409,322 |
| 2018 | -75.3 | -$24,870,879 | -$809,678 |
| 2019 | -100.8 | -$25,970,819 | -$4,903,902 |
| 2020 | -71.8 | -$23,343,184 | -$6,217,720 |
| ***Average*** | ***2,210.3*** | ***$127,806,223*** | ***$59,175,507*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's enhanced implementation will result in approximately 72 forgone jobs by 2020, and generate $127.8 million in output and $59.2 million in wages on average each year. Although the difference is minimal, the change would help to reduce current greenhouse gas emissions between FY 2014 and FY 2020. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations*. The program does not change the current structure but rather increase the incentives available to individuals to offset their current energy consumption within Maryland.

**Operation Phase—Status Quo**

The total economic impacts of the operation phase of the *Energy Efficiency in the Residential Sector* strategy under the status quo can be found in Figure 19.

[25] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 19: Energy Efficiency in the Residential Sector—Operation Phase**[26]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 134.2 | -$2,471,924 | $1,235,962 |
| 2011 | 113.7 | -$3,631,592 | $961,304 |
| 2012 | 98.9 | -$4,455,566 | $747,681 |
| 2013 | 88.1 | -$5,035,400 | $564,575 |
| 2014 | 83.1 | -$5,249,023 | $457,764 |
| 2015 | 79.8 | -$5,371,094 | $442,505 |
| 2016 | 77.5 | -$5,432,129 | $381,470 |
| 2017 | 77.2 | -$5,432,129 | $442,505 |
| 2018 | 75.7 | -$5,493,164 | $396,729 |
| 2019 | 74.1 | -$5,432,129 | $411,987 |
| 2020 | 76.6 | -$5,310,059 | $534,058 |
| ***Average*** | ***89.0*** | ***-$4,846,746*** | ***$597,867*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 77 jobs by 2020, approximately $4.8 million in forgone output and generate $0.6 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations*, which is driven by indirect and induced job creation in reallocation of consumer spending away from utility costs.

**Operation Phase—Enhanced**

The total economic impacts of the operation phase of the *Energy Efficiency in the Residential Sector* strategy under the enhanced scenario can be found in Figure 20.

[26] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 20: Energy Efficiency in the Residential Sector—Operation Phase**[27]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 134.2 | -$2,471,924 | $1,235,962 |
| 2011 | 113.7 | -$3,631,592 | $961,304 |
| 2012 | 98.9 | -$4,455,566 | $747,681 |
| 2013 | 88.1 | -$5,035,400 | $564,575 |
| 2014 | 83.1 | -$5,249,023 | $457,764 |
| 2015 | 79.8 | -$5,377,487 | $443,032 |
| 2016 | 77.6 | -$5,438,595 | $381,924 |
| 2017 | 77.2 | -$5,438,595 | $443,032 |
| 2018 | 75.8 | -$5,499,703 | $397,201 |
| 2019 | 74.2 | -$5,438,595 | $412,478 |
| 2020 | 76.7 | -$5,316,380 | $534,693 |
| ***Average*** | ***89.0*** | ***-$4,850,260*** | ***$598,149*** |

Source: REMI PI+, RESI

As shown in the Figure 20, the strategy maintain approximately 77 jobs by 2020, approximately $4.8 million in forgone output and generate $0.6 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations*, which is driven by indirect and induced job creation as a result of increased household disposable income from reduced energy costs.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $54,053,314 for the investment phase and $6,436,360 for the operation phase.

If the program were enhanced, the total state and local tax revenues would increase by approximately $54,061,382 for the investment phase and $6,437,321.

### 3.1.6 Energy Efficiency in the Commercial and Industrial Sectors

MEA's commercial and industrial energy efficiency programs support or compliment the EmPOWER Maryland suite of energy efficiency programs. MEA administers four programs that target energy efficiency improvements in the commercial and industrial sectors, which represent approximately 58 percent of electricity consumption in Maryland. These programs offer incentives for energy audits and funding for upgrades. The four programs are: 1) DOE Save Energy Now; 2) the Lawton Loan Program; 3) C/I Deep Retrofits; and 4) the State Agencies Loan Program.

[27] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

Energy Efficiency in the Commercial and Industrial Sectors is a key program under "EmPOWER Maryland" and when enhanced in tandem with RGGI will provide additional benefits to Maryland.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *Energy Efficiency in the Commercial and Industrial Sectors* strategy for status quo can be found in Figure 21.

**Figure 21: Energy Efficiency in the Commercial and Industrial Sectors—Investment Phase[28]**

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 3,255.3 | $250,244,141 | $115,112,305 |
| 2011 | 2,318.3 | $175,872,803 | $86,654,663 |
| 2012 | 2,916.2 | $221,466,064 | $111,816,406 |
| 2013 | 2,929.6 | $220,489,502 | $115,234,375 |
| 2014 | 3,127.8 | $236,877,441 | $127,502,441 |
| 2015 | 3,173.4 | $240,844,727 | $133,666,992 |
| 2016 | 5,666.1 | $442,443,848 | $244,918,823 |
| 2017 | 5,755.8 | $448,913,574 | $259,140,015 |
| 2018 | 5,789.3 | $453,735,352 | $271,255,493 |
| 2019 | 5,788.6 | $453,735,352 | $278,015,137 |
| 2020 | 5,807.6 | $455,505,371 | $284,301,758 |
| ***Average*** | ***4,229.8*** | ***$327,284,379*** | ***$184,328,946*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 5,808 jobs by 2020, and generate $327.3 million in output and $184.3 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations.* Energy efficiency technologies and improvements create additional savings for the commercial industry allowing for potential expansion and investments from increased energy saving incentives.

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase of the *Energy Efficiency in the Commercial and Industrial Sectors* strategy for the enhanced scenario can be found in Figure 22.

[28] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 22: Energy Efficiency in the Commercial and Industrial Sectors—Investment Phase**[29]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 3,255.3 | $250,244,141 | $115,112,305 |
| 2011 | 2,318.3 | $175,872,803 | $86,654,663 |
| 2012 | 2,916.2 | $221,466,064 | $111,816,406 |
| 2013 | 2,929.6 | $220,489,502 | $115,234,375 |
| 2014 | 3,127.8 | $236,877,441 | $127,502,441 |
| 2015 | 3,210.1 | $243,631,055 | $135,213,383 |
| 2016 | 5,731.7 | $447,562,472 | $247,752,285 |
| 2017 | 5,822.4 | $454,107,047 | $262,138,001 |
| 2018 | 5,856.3 | $458,984,607 | $274,393,643 |
| 2019 | 5,855.5 | $458,984,607 | $281,231,489 |
| 2020 | 5,874.8 | $460,775,104 | $287,590,840 |
| ***Average*** | ***4,263.5*** | ***$329,908,622*** | ***$185,876,348*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's enhanced implementation will maintain approximately 5,875 jobs by 2020, and generate $329.9 million in output and $185.9 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations.* Energy efficiency technologies and improvements create additional savings for the commercial industry allowing for potential expansion and investments from increased energy saving incentives.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Energy Efficiency in the Commercial and Industrial Sectors* strategy under status quo can be found in Figure 23.

[29] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 23: Energy Efficiency in the Commercial and Industrial Sectors—Operation Phase**[30]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 311.1 | $24,017,334 | $5,981,445 |
| 2011 | 755.8 | $60,852,051 | $15,258,789 |
| 2012 | 1,330.7 | $111,175,537 | $28,121,948 |
| 2013 | 2,043.9 | $177,398,682 | $44,662,476 |
| 2014 | 2,918.9 | $264,007,568 | $67,230,225 |
| 2015 | 3,894.8 | $365,783,691 | $94,390,869 |
| 2016 | 4,398.8 | $436,523,438 | $112,808,228 |
| 2017 | 4,730.0 | $494,140,625 | $127,365,112 |
| 2018 | 4,907.5 | $542,053,223 | $138,671,875 |
| 2019 | 4,933.5 | $575,622,559 | $143,676,758 |
| 2020 | 4,880.0 | $601,684,570 | $145,629,883 |
| ***Average*** | ***3,191.4*** | ***$332,114,480*** | ***$83,981,601*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy under status quo will maintain approximately 4,880 jobs by 2020, and generate $332.1 million in output and $84.0 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations*. It is expected that businesses in the commercial and industrial sectors will benefit from energy efficiency after implementation in the form of operation cost savings, among other benefits.

**Operation Phase—Enhanced**

The average annual economic impacts of the operation phase of the *Energy Efficiency in the Commercial and Industrial Sectors* strategy under enhanced scenario can be found in Figure 24.

[30] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 24: Energy Efficiency in the Commercial and Industrial Sectors—Operation Phase**[31]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 311.1 | $24,017,334 | $5,981,445 |
| 2011 | 755.8 | $60,852,051 | $15,258,789 |
| 2012 | 1,330.7 | $111,175,537 | $28,121,948 |
| 2013 | 2,043.9 | $177,398,682 | $44,662,476 |
| 2014 | 2,918.9 | $264,007,568 | $67,230,225 |
| 2015 | 3,939.9 | $370,015,436 | $95,482,875 |
| 2016 | 4,449.7 | $441,573,569 | $114,113,304 |
| 2017 | 4,784.8 | $499,857,329 | $128,838,597 |
| 2018 | 4,964.3 | $548,324,226 | $140,276,167 |
| 2019 | 4,990.6 | $582,281,925 | $145,338,952 |
| 2020 | 4,936.4 | $608,645,448 | $147,314,672 |
| ***Average*** | ***3,220.6*** | ***$335,286,282*** | ***$84,783,586*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy under the enhanced scenario will maintain approximately 4,936 jobs by 2020, and generate $335.3 million in output and $84.8 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations*. It is expected that businesses in the commercial and industrial sectors will benefit from energy efficiency after implementation in the form of operation cost savings, among other benefits.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $3,191,579,250 for the investment phase and $67,256,829 for the operation phase.

If this strategy were enhanced, the total state and local tax revenues would increase by approximately $3,217,007,455 for the investment phase and $67,792,683 for the operation phase.

### 3.1.7 Energy Efficiency—Appliances and Other Products

MEA administers several appliance and equipment rebate programs for homeowners. It also administers low-interest loans for residential and commercial energy efficiency improvements, which may include appliances, equipment and lighting.

[31] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase**
The average annual economic impacts of the investment phase of the *Energy Efficiency – Appliances and Other Products* strategy can be found in Figure 25.

**Figure 25: Energy Efficiency – Appliances and Other Products—Investment Phase**[32]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | -25.4 | -$1,647,949 | -$595,093 |
| 2012 | -60.9 | -$3,875,732 | -$1,464,844 |
| 2013 | -94.6 | -$5,950,928 | -$2,380,371 |
| 2014 | -124.9 | -$7,812,500 | -$3,372,192 |
| 2015 | -158.3 | -$9,887,695 | -$4,486,084 |
| 2016 | -185.5 | -$11,535,645 | -$5,584,717 |
| 2017 | -183.4 | -$11,230,469 | -$5,874,634 |
| 2018 | -165.7 | -$10,070,801 | -$5,706,787 |
| 2019 | -140.2 | -$8,361,816 | -$5,096,436 |
| 2020 | -114.3 | -$6,713,867 | -$4,348,755 |
| ***Average*** | ***-113.9*** | ***-$7,007,946*** | ***-$3,537,265*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will result in approximately 114 forgone jobs by 2020, approximately $7.0 million in forgone output and $3.5 million in forgone wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Transportation and Warehousing*. The increased demand for appliances related to energy efficiency may increase consumable good shipments within the region. Although this is a small economic benefit, this is still a positive benefit.

**Operation Phase**
The average annual economic impacts of the operation phase of the *Energy Efficiency – Appliances and Other Products* strategy can be found in Figure 26.

[32] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 26: Energy Efficiency – Appliances and Other Products—Operation Phase**[33]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 52.1 | -$946,045 | $488,281 |
| 2011 | 45.0 | -$1,373,291 | $396,729 |
| 2012 | 38.7 | -$1,739,502 | $305,176 |
| 2013 | 35.0 | -$1,922,607 | $244,141 |
| 2014 | 32.1 | -$2,075,195 | $167,847 |
| 2015 | 29.8 | -$2,197,266 | $137,329 |
| 2016 | 29.7 | -$2,136,230 | $167,847 |
| 2017 | 29.5 | -$2,136,230 | $198,364 |
| 2018 | 29.3 | -$2,136,230 | $198,364 |
| 2019 | 29.5 | -$2,014,160 | $213,623 |
| 2020 | 29.4 | -$2,075,195 | $244,141 |
| ***Average*** | ***34.6*** | ***-$1,886,541*** | ***$251,076*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 29 jobs by 2020, approximately $1.9 million in forgone output and generate $0.3 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy are those (such as *Sales, office, and administrative occupations)* providing the goods and services that will be in demand as households have more disposable income from the energy savings.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would decrease by approximately $1,609,349 for the investment phase and increase by $5,810,761 for the operation phase.

### 3.1.8 Energy Efficiency in the Power Sector – General

EmPOWER Maryland mandated that the PSC require each utility to propose cost-effective energy efficiency, conservation, and demand response programs designed to achieve targeted per capita energy reductions of at least five percent by the end of 2011 and at least 10 percent by the end of 2015, in addition to a 15 percent per capita peak demand reduction.

The five participating utilities are Potomac Edison (formerly known as Allegheny Power); Baltimore Gas and Electric (BGE); Delmarva Power and Light; Potomac Electric Power Company (Pepco); and Southern Maryland Electric Cooperative (SMECO). These utilities are responsible for two thirds of the EmPOWER 15 percent energy consumption reduction goal and all of the

[33] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

peak demand reduction goal. Energy savings targets are spread amongst all customer classes, including low-to-moderate income customers.

Energy Efficiency in the Power Sector—General is a key program under "EmPOWER Maryland" and when enhanced in tandem with RGGI will provide additional benefits to Maryland.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *Energy Efficiency in the Power Sector – General* strategy under the status quo can be found in Figure 27.

**Figure 27: Energy Efficiency in the Power Sector – General—Investment Phase**[34]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | -1,119.4 | -$129,150,391 | -$30,853,271 |
| 2011 | -1,448.5 | -$159,973,145 | -$40,802,002 |
| 2012 | -2,032.4 | -$221,435,547 | -$58,685,303 |
| 2013 | -2,504.6 | -$269,531,250 | -$74,111,938 |
| 2014 | -3,116.7 | -$338,714,600 | -$96,710,205 |
| 2015 | -3,385.5 | -$366,760,254 | -$109,954,834 |
| 2016 | -3,562.0 | -$386,657,715 | -$121,063,232 |
| 2017 | -3,690.0 | -$402,465,820 | -$130,783,081 |
| 2018 | -3,763.7 | -$414,916,992 | -$139,404,297 |
| 2019 | -3,765.3 | -$420,776,367 | -$143,554,688 |
| 2020 | -3,747.1 | -$424,865,723 | -$146,286,011 |
| ***Average*** | ***-2,921.4*** | ***-$321,386,164*** | ***-$99,291,715*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will result in approximately 3,747 forgone jobs by 2020, approximately $321.4 million in forgone output and $99.3 million in forgone wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Computer, math, architect, engineer occupations*, primarily due to the expectation that the power sector will contract with professional consultants to implement energy efficiency improvements.

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase of the *Energy Efficiency in the Power Sector – General* strategy under the enhanced scenario can be found in Figure 28.

[34] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 28: Energy Efficiency in the Power Sector – General—Investment Phase**[35]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | -1,119.4 | -$129,150,391 | -$30,853,271 |
| 2011 | -1,448.5 | -$159,973,145 | -$40,802,002 |
| 2012 | -2,032.4 | -$221,435,547 | -$58,685,303 |
| 2013 | -2,504.6 | -$269,531,250 | -$74,111,938 |
| 2014 | -3,116.7 | -$338,714,600 | -$96,710,205 |
| 2015 | -3,394.3 | -$367,710,997 | -$110,239,867 |
| 2016 | -3,571.2 | -$387,660,037 | -$121,377,061 |
| 2017 | -3,699.5 | -$403,509,122 | -$131,122,107 |
| 2018 | -3,773.5 | -$415,992,571 | -$139,765,671 |
| 2019 | -3,775.1 | -$421,867,135 | -$143,926,821 |
| 2020 | -3,756.8 | -$425,967,091 | -$146,665,224 |
| ***Average*** | ***-2,926.5*** | ***-$321,955,626*** | ***-$99,478,134*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase under the enhanced scenario of this strategy's implementation will result in approximately 3,757 forgone jobs by 2020, approximately $322.0 million in forgone output and $99.5 million in forgone wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Professional, scientific, and technical services*, primarily due to the expectation that the power sector will contract with professional consultants to implement energy efficiency improvements.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Energy Efficiency in the Power Sector – General* strategy under the status quo scenario can be found in Figure 29.

[35] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 29: Energy Efficiency in the Power Sector – General—Operation Phase**[36]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 80.3 | $9,246,826 | $2,197,266 |
| 2011 | 142.3 | $15,899,658 | $3,967,285 |
| 2012 | 218.8 | $23,925,781 | $6,301,880 |
| 2013 | 340.2 | $37,200,928 | $10,040,283 |
| 2014 | 510.8 | $56,365,967 | $15,762,329 |
| 2015 | 723.2 | $80,139,160 | $23,376,465 |
| 2016 | 711.8 | $77,026,367 | $24,124,146 |
| 2017 | 723.4 | $78,552,246 | $25,741,577 |
| 2018 | 720.9 | $79,223,633 | $26,947,021 |
| 2019 | 705.7 | $78,979,492 | $27,221,680 |
| 2020 | 690.5 | $78,491,211 | $27,328,491 |
| ***Average*** | ***506.2*** | ***$55,913,752*** | ***$17,546,220*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy under the status quo will maintain approximately 691 jobs by 2020, and generate $55.9 million in output and $17.5 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction, extraction occupations.* Energy efficiency improvements implemented during the investment phase will result in cost savings for power generating entities within the industry, which may then expand employment or operations. Other top gaining industries reflect the increased household spending resulting from new households established due to direct and indirect job creation and wage generation in the *Construction, extraction occupations* industry.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *Energy Efficiency in the Power Sector – General* strategy under the enhanced scenario can be found in Figure 30.

[36] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 30: Energy Efficiency in the Power Sector – General—Operation Phase**[37]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 80.3 | $9,246,826 | $2,197,266 |
| 2011 | 142.3 | $15,899,658 | $3,967,285 |
| 2012 | 218.8 | $23,925,781 | $6,301,880 |
| 2013 | 340.2 | $37,200,928 | $10,040,283 |
| 2014 | 510.8 | $56,365,967 | $15,762,329 |
| 2015 | 725.1 | $80,346,903 | $23,437,063 |
| 2016 | 713.6 | $77,226,041 | $24,186,682 |
| 2017 | 725.2 | $78,755,875 | $25,808,306 |
| 2018 | 722.7 | $79,429,002 | $27,016,876 |
| 2019 | 707.5 | $79,184,229 | $27,292,246 |
| 2020 | 692.3 | $78,694,682 | $27,399,334 |
| ***Average*** | ***507.2*** | ***$56,025,081*** | ***$17,582,686*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy under the enhanced scenario will maintain approximately 692 jobs by 2020, and generate $56.0 million in output and $17.6 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is the *Construction* sector. Energy efficiency improvements implemented during the investment phase will result in cost savings for power generating entities within the industry, which may then expand employment or operations. Other top gaining industries reflect the increased household spending resulting from new households established due to direct and indirect job creation and wage generation in the *Construction, extraction occupations* industry.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $4,494,845 for the investment phase and $18,514,443 for the operation phase.

If the strategy was enhanced, the total state and local tax revenues would increase by approximately $4,502,692 for the investment phase and $18,546,764 for the operation phase.

### 3.1.9 Maryland Renewable Energy Portfolio Standard Subprogram

The RPS is implemented through the creation, sale and transfer of RECs. Each REC represents one megawatt of renewably generated electricity. Electricity suppliers are required to purchase RECs to demonstrate they have obtained specified percentages of their energy supply from renewable resources. Sources are classified as Tier 1 and Tier 2. Tier 1 sources consist of:

[37] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

solar; wind; qualifying biomass; qualifying methane; geothermal; ocean; qualifying fuel cell, qualifying hydroelectric power, poultry litter-to-energy; waste-to-energy; and refuse-derived fuel. Non-solar Tier 1 requirements gradually increase to 18 percent in 2020, and then peak in 2022 at 20 percent and are subsequently maintained at that level. Tier 1 includes a solar set-aside requirement which gradually increases until it peaks at two percent in 2020. Maryland's Tier 2 source (eligible hydroelectric power) 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 development of new Tier 1 renewable sources in the State.

The RPS is designed to create a stable and predictable market for renewable energy and to foster additional development and growth in the renewable energy industry.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *Maryland Renewable Energy Portfolio Standard Subprogram* strategy for status quo can be found in Figure 31.

**Figure 31: Maryland Renewable Energy Portfolio Standard Subprogram—Investment Phase**[38]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 487.1 | $28,045,654 | $10,894,775 |
| 2011 | 7,249.2 | $417,968,750 | $167,144,775 |
| 2012 | 2,698.3 | $154,144,287 | $73,776,245 |
| 2013 | 6,441.0 | $365,722,656 | $166,763,306 |
| 2014 | 3,769.0 | $210,906,982 | $111,907,959 |
| 2015 | 10,887.4 | $616,149,902 | $305,389,404 |
| 2016 | 7,282.8 | $406,311,035 | $229,507,446 |
| 2017 | 40,462.6 | $2,299,865,723 | $1,203,445,435 |
| 2018 | 39,924.7 | $2,203,369,141 | $1,289,352,417 |
| 2019 | 17,769.5 | $998,352,051 | $682,495,117 |
| 2020 | 6,427.2 | $324,462,891 | $315,597,534 |
| ***Average*** | ***13,036.3*** | ***$729,572,643*** | ***$414,206,765*** |

Source: REMI PI+, RESI

As shown in the previous figure, the investment phase of this strategy's implementation under status quo will maintain approximately 6,427 jobs by 2020, and generate $729.6 million in output and $414.2 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Professional, scientific, and technical services,* primarily due to the expectation that those

[38] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

entities implementing renewable energy would seek outside contractors and purchasers to assist in acquiring the investment materials.

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase of the *Maryland Renewable Energy Portfolio Standard Subprogram* strategy for status quo can be found in Figure 32.

**Figure 32: Maryland Renewable Energy Portfolio Standard Subprogram—Investment Phase**[39]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 487.1 | $28,045,654 | $10,894,775 |
| 2011 | 7,249.2 | $417,968,750 | $167,144,775 |
| 2012 | 2,698.3 | $154,144,287 | $73,776,245 |
| 2013 | 6,441.0 | $365,722,656 | $166,763,306 |
| 2014 | 3,769.0 | $210,906,982 | $111,907,959 |
| 2015 | 11,197.9 | $633,720,958 | $314,098,347 |
| 2016 | 7,490.5 | $417,898,010 | $236,052,425 |
| 2017 | 41,616.5 | $2,365,452,146 | $1,237,764,691 |
| 2018 | 41,063.2 | $2,266,203,722 | $1,326,121,526 |
| 2019 | 18,276.2 | $1,026,822,556 | $701,958,172 |
| 2020 | 6,610.5 | $333,715,761 | $324,597,587 |
| ***Average*** | ***13,354.5*** | ***$747,327,408*** | ***$424,643,619*** |

Source: REMI PI+, RESI

As shown in the previous figure, the investment phase of this strategy's implementation under enhancement will maintain approximately 6,611 jobs by 2020, and generate $747.3 million in output and $424.6 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Professional, scientific, and technical services*, primarily due to the expectation that those entities implementing renewable energy would seek outside contractors and purchasers to assist in acquiring the investment materials.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Maryland Renewable Energy Portfolio Standard Subprogram* strategy under status quo can be found in Figure 33.

[39] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 33: Maryland Renewable Energy Portfolio Standard Subprogram—Operation Phase**[40]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | -346.5 | -$37,506,104 | -$4,730,225 |
| 2011 | -625.6 | -$64,453,125 | -$12,374,878 |
| 2012 | -845.9 | -$85,723,877 | -$18,737,793 |
| 2013 | -1,025.7 | -$103,485,107 | -$24,505,615 |
| 2014 | -1,134.5 | -$116,333,008 | -$29,296,875 |
| 2015 | -1,193.0 | -$126,831,055 | -$27,175,903 |
| 2016 | -1,275.8 | -$137,268,066 | -$31,311,035 |
| 2017 | -1,819.9 | -$192,749,023 | -$50,506,592 |
| 2018 | -2,451.1 | -$257,324,219 | -$74,386,597 |
| 2019 | -2,877.8 | -$303,710,938 | -$92,620,850 |
| 2020 | -3,154.6 | -$337,524,414 | -$106,216,431 |
| ***Average*** | ***-1,522.8*** | ***-$160,264,449*** | ***-$42,896,618*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy under status quo will result in approximately 3,155 forgone jobs by 2020, approximately $160.3 million in forgone output and $42.9 million in forgone wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy are those (such as *Farm, fishing, and forestry occupations)* which provide goods and services that households demand. New households are likely to be created due to the development of a renewable energy industry in Maryland as a result of job creation and wage generation in industries—such as *Farm, fishing, and forestry occupations*—associated with RPS.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *Maryland Renewable Energy Portfolio Standard Subprogram* strategy under enhancements can be found in Figure 34.

[40] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 34: Maryland Renewable Energy Portfolio Standard Subprogram—Operation Phase**[41]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | -346.5 | -$37,506,104 | -$4,730,225 |
| 2011 | -625.6 | -$64,453,125 | -$12,374,878 |
| 2012 | -845.9 | -$85,723,877 | -$18,737,793 |
| 2013 | -1,025.7 | -$103,485,107 | -$24,505,615 |
| 2014 | -1,134.5 | -$116,333,008 | -$29,296,875 |
| 2015 | -1,227.0 | -$130,447,959 | -$27,950,892 |
| 2016 | -1,312.2 | -$141,182,609 | -$32,203,948 |
| 2017 | -1,871.8 | -$198,245,744 | -$51,946,914 |
| 2018 | -2,521.0 | -$264,662,462 | -$76,507,917 |
| 2019 | -2,959.9 | -$312,372,014 | -$95,262,165 |
| 2020 | -3,244.6 | -$347,149,767 | -$109,245,458 |
| ***Average*** | ***-1,555.9*** | ***-$163,778,343*** | ***-$43,887,516*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy under enhancement will result in approximately 3,245 forgone jobs by 2020, approximately $163.8 million in forgone output and $43.9 million in forgone wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy are those (such as *Farm, fishing, and forestry occupations)* which provide goods and services that households demand. New households are likely to be created due to the development of a renewable energy industry in Maryland as a result of job creation and wage generation in industries—such as *Farm, fishing, and forestry occupations*—associated with RPS.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $184,296,290 for the investment phase and decrease by $23,268,807 for the operation phase.

If the strategy was enhanced, the total state and local tax revenues would increase by approximately $188,794,735 in the investment phase and decrease by $23,836,770 in the operation phase.

### 3.1.10 Incentives and Grant Subprograms to Support Renewable Energy

MEA administers a number of incentives and grant programs to promote and accelerate the development of renewable energy production in Maryland, from utility scale facilities to on-site distributed generation.

[41] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

This is a voluntary incentive based program. Funding for the incentive and grant programs comes from the Strategic Energy Investment Fund.

**Investment Phase**
The average annual economic impacts of the investment phase of the *Incentives and Grant Subprograms to Support Renewable Energy* strategy can be found in Figure 35.

**Figure 35: Incentives and Grant Subprograms to Support Renewable Energy—Investment Phase**[42]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 241.4 | $18,615,723 | $8,682,251 |
| 2011 | 323.8 | $26,702,881 | $14,129,639 |
| 2012 | 5.1 | $4,638,672 | $5,615,234 |
| 2013 | -254.2 | -$12,451,172 | -$1,464,844 |
| 2014 | -320.0 | -$16,235,352 | -$3,784,180 |
| 2015 | -330.3 | -$16,135,742 | -$4,456,848 |
| 2016 | -355.5 | -$18,543,091 | -$7,043,121 |
| 2017 | -285.0 | -$13,598,267 | -$5,611,725 |
| 2018 | -244.8 | -$11,255,981 | -$5,400,269 |
| 2019 | -170.7 | -$6,246,094 | -$3,188,110 |
| 2020 | -107.0 | -$2,016,968 | -$1,073,547 |
| ***Average*** | ***-136.1*** | ***-$4,229,581*** | ***-$326,865*** |

Source: REMI PI+, RESI

As shown in the previous figure, the investment phase of this strategy's implementation will result in approximately 107 forgone jobs by 2020, approximately $4.2 million in forgone output and $0.3 million in forgone wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of the government spending associated with this strategy is *Protective services* occupations, which results from the government spending associated with the grant program.

**Operation Phase**
The average annual economic impacts of the operation phase of the *Incentives and Grant Subprograms to Support Renewable Energy* strategy can be found in Figure 36.

[42] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 36: Incentives and Grant Subprograms to Support Renewable Energy—Operation Phase**[43]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | -23.7 | -$6,317,139 | -$4,211,426 |
| 2011 | 25.0 | -$2,014,160 | -$3,524,780 |
| 2012 | 64.0 | $1,708,984 | -$2,868,652 |
| 2013 | 93.3 | $4,882,813 | -$2,319,336 |
| 2014 | 114.8 | $7,568,359 | -$1,907,349 |
| 2015 | 119.2 | $9,007,080 | -$1,659,119 |
| 2016 | 128.3 | $10,717,285 | -$1,366,333 |
| 2017 | 133.0 | $12,142,456 | -$1,171,143 |
| 2018 | 132.0 | $13,168,579 | -$1,138,611 |
| 2019 | 125.5 | $13,795,654 | -$1,301,270 |
| 2020 | 117.6 | $14,194,702 | -$1,577,789 |
| ***Average*** | ***93.5*** | ***$7,168,601*** | ***-$2,095,073*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 118 jobs by 2020, generate $7.2 million in output and result in $2.1 million in forgone wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Building, grounds, personal care, and service occupations.* A wide variety of business are expected to take advantage of the commercial grants and would therefore experience cost savings as a result. These cost savings could be used for business growth. Similar effects would be experienced by residential consumers under the residential programs, and household spending on a variety of goods and sectors would increase as a result.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would decrease by $564,654 for the investment phase and increase by $6,604,798 for the operation phase.

### 3.1.11 Offshore Wind Initiatives to Support Renewable Energy

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. Research indicates that the potential power supply available from offshore wind substantially exceeds the region's current energy use. Maryland, therefore, has the potential to access large energy resources off

[43] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

the coast that could contribute to meeting future energy demands while simultaneously displacing fossil fuel generation.

Maryland has taken a lead among Mid-Atlantic States working to harness offshore wind resources. We are moving forward expeditiously to put in place financial support, regulatory parameters, lease conditions, and data-gathering initiatives to support the deployment of a first-phase major offshore wind project in the Maryland Wind Energy Area (WEA) by 2018.

**Investment Phase**

The average annual economic impacts of the investment phase of the *Offshore Wind Initiatives to Support Renewable Energy* strategy can be found in Figure 37.

**Figure 37: Offshore Wind Initiatives to Support Renewable Energy—Investment Phase**[44]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 2,167.9 | $88,134,766 | $56,182,861 |
| 2018 | 25.9 | $1,159,668 | $3,005,981 |
| 2019 | -7.7 | -$1,037,598 | $1,098,633 |
| 2020 | -25.1 | -$2,258,301 | -$137,329 |
| ***Average*** | ***540.2*** | ***$21,499,634*** | ***$15,037,537*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will result in approximately 25 forgone jobs by 2020, and generate $21.5 million in output and $15.0 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Sales, office, and administrative occupations*, primarily due to the expectation that the expertise of environmental consultants and engineers would be in demand as offshore wind is established and in need of proper development and management.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Offshore Wind Initiatives to Support Renewable Energy* strategy can be found in Figure 38.

[44] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 38: Offshore Wind Initiatives to Support Renewable Energy—Operation Phase**[45]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 281.8 | $16,662,598 | $37,902,832 |
| 2019 | 291.2 | $17,333,984 | $39,627,075 |
| 2020 | 290.2 | $17,333,984 | $40,908,813 |
| ***Average*** | ***287.7*** | ***$17,110,189*** | ***$39,479,574*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 290 jobs by 2020, and generate $17.1 million in output and $39.5 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Sales, office, and administrative occupations.* A wide variety of businesses will benefit positively from the need for management and maintenance of offshore wind once implemented, and may hire additional employees.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by $2,388,305 for the investment phase and $10,175,236 for the operation phase.

### 3.1.12 Title V Permits for GHG Sources

The Title V operating permits program was established through the Clean Air Act amendments of 1990. Before 1990, states were required to issue air pollution permits to businesses which created new pollution sources or modified existing pollution sources. Title V of the amendments required all states to develop and implement permit programs for sources already in operation. The program is achieving enhanced compliance with industrial and commercial air pollution requirements. The Title V Program does not establish any new emissions limitations, standards, or work practices on an affected facility. However, there may be additional recordkeeping, monitoring, or reporting requirements. EPA granted Maryland final full approval for its Title V permit program in February 2003.

[45] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase**

The average annual economic impacts of the investment phase of the *Title V Permits for GHG Sources* strategy can be found in Figure 39.

**Figure 39: Title V Permits for GHG Sources—Investment Phase**[46]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 1.5 | $122,070 | $61,035 |
| 2013 | 1.3 | $91,553 | $45,776 |
| 2014 | 1.0 | $122,070 | $45,776 |
| 2015 | 1.0 | $61,035 | $45,776 |
| 2016 | 1.5 | $122,070 | $76,294 |
| 2017 | 1.0 | $122,070 | $61,035 |
| 2018 | 1.5 | $61,035 | $61,035 |
| 2019 | 0.6 | $122,070 | $61,035 |
| 2020 | 0.5 | $61,035 | $45,776 |
| ***Average*** | ***0.9*** | ***$80,455*** | ***$45,776*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately one job by 2020, and generate $80,455 in output and $45,776 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations.* The companies and enterprises required to purchase Title V permits are likely to demand services in this industry relating to energy efficiency and emissions reductions to lower the amount of permits they need to purchase through auctions. This industry will also benefit from auction proceeds being invested into various energy efficiency programs relating to the services provided within this industry.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Title V Permits for GHG Sources* strategy can be found in Figure 40.

[46] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 40: Title V Permits for GHG Sources—Operation Phase**[47]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 8.2 | $549,316 | $289,917 |
| 2012 | 7.1 | $457,764 | $305,176 |
| 2013 | 6.2 | $335,693 | $305,176 |
| 2014 | 5.4 | $335,693 | $289,917 |
| 2015 | 3.4 | $122,070 | $259,399 |
| 2016 | 3.2 | $122,070 | $244,141 |
| 2017 | 3.0 | $122,070 | $274,658 |
| 2018 | 2.9 | $122,070 | $274,658 |
| 2019 | 2.1 | $122,070 | $228,882 |
| 2020 | 2.0 | $61,035 | $259,399 |
| ***Average*** | ***4.0*** | ***$213,623*** | ***$248,302*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 2 jobs by 2020, and generate $0.2 million in output and $0.2 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment from this phase of the strategy is *Protective service occupations* and *Sales, office, and administrative occupations*, primarily due to the expectation that the ongoing permit auctions and the resulting proceeds will need to be administered and monitored by individuals employed by the state government.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $17,022 for the investment phase and $6,597,563 for the operation phase.

### 3.1.13 BeSMART

The Department of Housing and Community Development (DHCD) has pursued new opportunities to help people and communities through energy efficiency retrofits for homes and small businesses. With a "Main Street" approach, DHCD competed for and won an award of $20 million from the U.S. Department of Energy's (DOE) Better Buildings/EECBG program. This Recovery Act-funded award was a three-year commitment that funded energy efficiency retrofits through a new DHCD program called BeSMART. The BeSMART investments and initiatives subsequently provided the foundation for DHCD's newly created Housing and Building Energy unit, which was launched in 2012.

[47] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

*BeSMART* has been identified as a program that could increase GHG benefits to Maryland if enhanced.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *BeSMART* strategy can be found in Figure 41.

**Figure 41: BeSMART—Investment Phase**[48]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 966.9 | $49,652,100 | $20,587,921 |
| 2012 | 2,515.1 | $130,035,400 | $56,217,194 |
| 2013 | 2,288.5 | $120,269,775 | $55,957,794 |
| 2014 | 2,750.0 | $145,202,637 | $70,240,021 |
| 2015 | 7,222.5 | $380,615,234 | $182,254,791 |
| 2016 | 3,306.3 | $178,222,656 | $99,102,020 |
| 2017 | 3,202.0 | $171,569,824 | $98,339,081 |
| 2018 | 902.5 | $47,119,141 | $38,482,666 |
| 2019 | -291.4 | -$20,141,602 | $1,190,186 |
| 2020 | 689.0 | $31,433,105 | $23,464,203 |
| ***Average*** | ***2,141.0*** | ***$112,179,843*** | ***$58,712,352*** |

Source: REMI PI+, RESI

As shown in the figure above, investment phase of this strategy's implementation will maintain approximately 689 jobs by 2020, and generate $112.2 million in output and $58.7 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction.* This industry would be in higher demand to equip and accommodate energy reduction measures in households and businesses.

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase of the *BeSMART* strategy can be found in Figure 42.

[48] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 42: BeSMART—Investment Phase**[49]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 966.9 | $49,652,100 | $20,587,921 |
| 2012 | 2,515.1 | $130,035,400 | $56,217,194 |
| 2013 | 2,288.5 | $120,269,775 | $55,957,794 |
| 2014 | 4,914.2 | $257,751,465 | $120,670,319 |
| 2015 | 13,037.6 | $686,706,543 | $325,931,549 |
| 2016 | 6,032.0 | $325,500,488 | $178,768,158 |
| 2017 | 5,859.6 | $314,941,406 | $178,955,078 |
| 2018 | 1,723.1 | $91,125,488 | $72,177,887 |
| 2019 | -435.8 | -$30,395,508 | $5,409,241 |
| 2020 | 1,320.4 | $61,950,684 | $45,745,850 |
| ***Average*** | ***3,474.7*** | ***$182,503,440*** | ***$96,401,908*** |

Source: REMI PI+, RESI

As shown in the figure above, investment phase of this strategy's implementation will maintain approximately 1,320 jobs by 2020, and generate $182.5 million in output and $96.4 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction.* This industry would be in higher demand to equip and accommodate energy reduction measures in households and businesses.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *BeSMART* strategy can be found in Figure 43.

[49] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 43: BeSMART—Operation Phase[50]**

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.1 | $0 | -$3,815 |
| 2012 | -0.1 | $0 | $0 |
| 2013 | 0.5 | $30,518 | $7,629 |
| 2014 | 0.5 | $61,035 | $0 |
| 2015 | 0.5 | $0 | $19,073 |
| 2016 | 0.6 | $0 | $19,073 |
| 2017 | 0.5 | $0 | $15,259 |
| 2018 | 1.3 | $122,070 | $34,332 |
| 2019 | 1.8 | $61,035 | $49,591 |
| 2020 | 1.2 | $61,035 | $26,703 |
| ***Average*** | ***0.6*** | ***$30,518*** | ***$15,259*** |

Source: REMI PI+, RESI

As shown in Figure 43, the strategy will maintain approximately one job by 2020, and generate $30,518 in output and $15,259 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Management of companies and enterprises*, primarily due to the expectation that operation of this strategy will likely require management of funds distributed through the Energy Efficiency and Conservation Block Program. Another top-gaining industry is *Health care and social assistance*, which is driven by indirect and induced job creation in healthcare associated with the relatively high job creation from *Management of companies and enterprises* and other industries. The new employees and households directly associated with this policy as well as the indirect beneficiaries of the grant program will increase demand for healthcare.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *BeSMART* strategy can be found in Figure 44.

[50] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 44: BeSMART—Operation Phase**[51]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.1 | $0 | -$3,815 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.9 | $30,518 | $15,259 |
| 2014 | 1.0 | $61,035 | $15,259 |
| 2015 | 0.7 | $0 | $19,073 |
| 2016 | 1.2 | $61,035 | $30,518 |
| 2017 | 1.0 | $61,035 | $30,518 |
| 2018 | 2.1 | $183,105 | $53,406 |
| 2019 | 2.4 | $122,070 | $68,665 |
| 2020 | 2.1 | $122,070 | $57,220 |
| ***Average*** | ***1.0*** | ***$58,261*** | ***$26,009*** |

Source: REMI PI+, RESI

As shown in Figure 44, the strategy will maintain approximately 2 jobs by 2020, and generate $58,261 in output and $26,009 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Management of companies and enterprises*, primarily due to the expectation that operation of this strategy will likely require management of funds distributed through the Energy Efficiency and Conservation Block Program. Another top-gaining industry is *Health care and social assistance*, which is driven by indirect and induced job creation in healthcare associated with the relatively high job creation from *Management of companies and enterprises* and other industries. The new employees and households directly associated with this policy as well as the indirect beneficiaries of the grant program will increase demand for healthcare.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $1,688,278,413 for the investment phase, and $2,142 for the operation phase.

If this strategy was enhanced, the total state and local tax revenues would increase by approximately $2,739,963,103 for the investment phase and $3,571 for the operation phase.

### 3.1.14 Weatherization and Energy Efficiency for Low-Income Houses

Since inception of the federally-funded Weatherization Assistance Program (WAP) in the seventies, more than seven million homes have been weatherized across the nation. Scientific Studies and the energy industry recognize that energy efficiency is among the most viable

[51] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

options for decreasing fossil fuel consumption and consequently reducing GHG emissions. Energy-efficiency is cost-effective and can be implemented quickly. A weatherized household can realize up to $400 in first-year energy savings and an annual CO2 reduction of 2.65 metric tons on average.[52] WAP is designed to help eligible low income households with the installation of energy conservation materials to reduce the consumption of energy and the cost of maintenance. The U.S. Department of Energy (DOE) has funded WAP since 1976, with major funding increases to the program under the American Recovery and Reinvestment Act of 2009.

*Weatherization and Energy Efficiency for Low-Income Houses* is a strategy that has been identified as providing greater GHG benefits for Maryland if enhanced.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *Weatherization and Energy Efficiency for Low-Income Houses* strategy can be found in Figure 45.

**Figure 45: Weatherization and Energy Efficiency for Low-Income Houses—Investment Phase[53]**

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 685.4 | $15,014,648 | $7,980,347 |
| 2011 | 1,602.1 | $36,254,883 | $19,676,208 |
| 2012 | 1,790.5 | $42,388,916 | $24,169,922 |
| 2013 | 837.2 | $21,575,928 | $14,179,230 |
| 2014 | 1,479.3 | $35,644,531 | $21,942,139 |
| 2015 | 1,789.6 | $43,395,996 | $27,004,242 |
| 2016 | 1,796.6 | $44,311,523 | $28,453,827 |
| 2017 | 1,242.1 | $30,883,789 | $21,354,675 |
| 2018 | 208.6 | $3,906,250 | $5,245,209 |
| 2019 | 157.1 | $183,105 | $1,724,243 |
| 2020 | 137.6 | -$1,281,738 | -$362,396 |
| ***Average*** | ***1,066.0*** | ***$24,752,530*** | ***$15,578,877*** |

Source: REMI PI+, RESI

As shown in Figure 45, the investment phase of this strategy's implementation will maintain approximately 138 jobs by 2020, and generate $24.8 million in output and $15.6 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Other services except Public Administration*, primarily due to the expectation that the policy will drive increased demand for energy auditing services, which are contained within this industry. Another top-gaining industry is *Construction*, which includes repair and maintenance associated with weatherization.

[52] U.S. Department of Energy, Oak Ridge National Laboratory, "Weatherization Assistance Program Technical Memorandum Background Data and Statistics," http://energy.gov, March 2010

[53] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase of the *Weatherization and Energy Efficiency for Low-Income Houses* strategy can be found in Figure 46.

**Figure 46: Weatherization and Energy Efficiency for Low-Income Houses—Investment Phase**[54]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 685.4 | $15,014,648 | $7,980,347 |
| 2011 | 1,602.1 | $36,254,883 | $19,676,208 |
| 2012 | 1,790.5 | $42,388,916 | $24,169,922 |
| 2013 | 837.2 | $21,575,928 | $14,179,230 |
| 2014 | 2,915.2 | $69,458,008 | $40,481,567 |
| 2015 | 3,578.4 | $88,012,695 | $53,150,177 |
| 2016 | 3,607.3 | $91,064,453 | $57,529,449 |
| 2017 | 2,498.8 | $64,392,090 | $44,193,268 |
| 2018 | 422.2 | $9,887,695 | $12,279,510 |
| 2019 | 310.9 | $2,014,160 | $5,302,429 |
| 2020 | 261.9 | -$1,586,914 | $1,052,856 |
| ***Average*** | ***1,682.7*** | ***$39,861,506*** | ***$25,454,088*** |

Source: REMI PI+, RESI

As shown in Figure 46, the investment phase of this strategy's implementation will maintain approximately 262 jobs by 2020, and generate $39.9 million in output and $25.5 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Other services except Public Administration*, primarily due to the expectation that the policy will drive increased demand for energy auditing services, which are contained within this industry. Another top-gaining industry is *Construction*, which includes repair and maintenance associated with weatherization.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Weatherization and Energy Efficiency for Low-Income Houses* strategy can be found in Figure 47.

[54] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 47: Weatherization and Energy Efficiency for Low-Income Houses—Operation Phase**[55]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 3.6 | $30,518 | $49,591 |
| 2011 | 3.9 | $30,518 | $53,406 |
| 2012 | 2.8 | -$30,518 | $38,147 |
| 2013 | 4.2 | $30,518 | $61,035 |
| 2014 | 3.3 | $0 | $49,591 |
| 2015 | 3.0 | -$61,035 | $49,591 |
| 2016 | 2.3 | -$61,035 | $57,220 |
| 2017 | 2.9 | -$61,035 | $49,591 |
| 2018 | 3.6 | $61,035 | $72,479 |
| 2019 | 4.8 | $0 | $95,367 |
| 2020 | 3.7 | $0 | $72,479 |
| ***Average*** | ***3.5*** | ***-$5,549*** | ***$58,954*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 4 jobs by 2020, result in approximately $5,549 in forgone output and generate $58,954 in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy are *Health Care and Social Assistance*. It is expected that households receiving weatherization services as a result of this policy will save on energy costs and experience an increase in disposable income, which will be spent on a wide variety of goods and services in such industries.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *Weatherization and Energy Efficiency for Low-Income Houses* strategy can be found in Figure 48.

[55] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 48: Weatherization and Energy Efficiency for Low-Income Houses—Operation Phase**[56]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 3.6 | $30,518 | $49,591 |
| 2011 | 3.9 | $30,518 | $53,406 |
| 2012 | 2.8 | -$30,518 | $38,147 |
| 2013 | 4.2 | $30,518 | $61,035 |
| 2014 | 7.1 | $0 | $118,256 |
| 2015 | 6.2 | -$61,035 | $99,182 |
| 2016 | 5.1 | -$122,070 | $83,923 |
| 2017 | 5.6 | -$122,070 | $91,553 |
| 2018 | 5.7 | -$61,035 | $99,182 |
| 2019 | 6.2 | -$122,070 | $110,626 |
| 2020 | 5.9 | -$122,070 | $106,812 |
| ***Average*** | ***5.1*** | ***-$49,938*** | ***$82,883*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 6 jobs by 2020, result in approximately $49,938 in forgone output and generate $82,883 in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy are *Health Care and Social Assistance*. It is expected that households receiving weatherization services as a result of this policy will save on energy costs and experience an increase in disposable income, which will be spent on a wide variety of goods and services in such industries.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $748,166,237 during the investment phase and $1,657 during the operation phase.

If the strategy is enhanced, the total state and local tax revenues would accumulate to approximately $1,180,993,740 for the investment phase and $2,414 during the operation phase.

### 3.1.15 GHG Prevention of Significant Deterioration Permitting Program

The Prevention of Significant Deterioration (PSD) program is a federal preconstruction review and permitting program applicable to new major stationary sources and major modifications at existing major stationary sources. It requires the application of Best Available Control Technology (BACT) to control emissions of certain pollutants, which now include GHGs. A BACT determination is based on consideration of a number of factors, including the cost-

[56] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

effectiveness of the controls and the energy and environmental impacts. The BACT requirements apply to all new major sources of GHG emissions and major modifications at GHG emitting facilities. This means that GHG sources subject to the requirements must evaluate and apply currently available measures (and later technology as it develops) to reduce GHG emissions.

**Investment Phase**

The average annual economic impacts of the investment phase of the *Prevention of Significant Deterioration* strategy can be found in Figure 49.

**Figure 49: Prevention of Significant Deterioration—Investment Phase**[57]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 1.5 | $122,070 | $61,035 |
| 2013 | 1.3 | $91,553 | $45,776 |
| 2014 | 1.0 | $122,070 | $45,776 |
| 2015 | 1.0 | $61,035 | $45,776 |
| 2016 | 1.5 | $122,070 | $76,294 |
| 2017 | 1.0 | $122,070 | $61,035 |
| 2018 | 1.5 | $61,035 | $61,035 |
| 2019 | 0.6 | $122,070 | $61,035 |
| 2020 | 0.5 | $61,035 | $45,776 |
| ***Average*** | ***0.9*** | ***$80,455*** | ***$45,776*** |

Source: REMI PI+, RESI

As shown in the previous figure, the investment phase of this strategy's implementation will maintain approximately one job by 2020, and generate $80,455 in output and $45,776 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Sales, office, and administrative occupations*, primarily due to the expectation that processing and management will be required for tracking stationary sources subject to preconstruction reviews.

**Operation Phase**

The total economic impacts of the operation phase of the *Prevention of Significant Deterioration* strategy can be found in Figure 50.

[57] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 50: Prevention of Significant Deterioration—Operation Phase**[58]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 2.7 | $183,105 | $106,812 |
| 2013 | 2.4 | $152,588 | $106,812 |
| 2014 | 2.1 | $152,588 | $76,294 |
| 2015 | 0.6 | $0 | $76,294 |
| 2016 | 0.5 | $0 | $76,294 |
| 2017 | 0.4 | $0 | $61,035 |
| 2018 | 0.5 | $0 | $76,294 |
| 2019 | 0.0 | $61,035 | $76,294 |
| 2020 | -0.1 | $0 | $61,035 |
| ***Average*** | ***0.8*** | ***$49,938*** | ***$65,197*** |

Source: REMI PI+, RESI

As shown in Figure 50, the strategy will result in less than one forgone job by 2020, and generate $49,938 in output and $65,197 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Sales, office, and administrative occupations,* primarily due to the expectation that public administration will conduct the preconstruction reviews during operation of the strategy.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $17,022 for the investment phase and $6,545,005 for the operation phase.

## 3.2 Transportation

### 3.2.1 Transportation Technology Initiatives

This suite of programs reduces GHG emissions in several ways. "Upstream" fuel standards, such as the federal Renewable Fuels Standard, require transportation fuel producers to blend renewable fuels into their petroleum products. Depending on manufacturers' choices of renewable fuels, this program has the potential to reduce the per unit carbon intensity of their product inventory over time. The Maryland Clean Cars Program requires car manufacturers to meet a fleet-wide average GHG emissions standard for vehicles sold in the State. The national CAFE standards for light-duty vehicles and medium and heavy-duty vehicle standards require car and truck manufacturers to both reduce GHG emissions and increase the fuel efficiency (i.e., more miles per gallon) of their vehicle fleets over time. Maryland, California and other leadership states have played a key role in advancing more stringent national standards. In

[58] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

addition to achieving significant GHG reductions over time, these programs will produce public health, air quality, water quality and economic benefits for Marylanders.

Transportation technologies include both a current status quo scenario and an enhanced scenario.

**Investment Phase—Status Quo**
The average annual economic impacts of the investment phase of the *Transportation Technology Initiatives* strategy during status quo can be found in Figure 51.

**Figure 51: Transportation Technology Initiatives—Investment Phase**[59]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 517.6 | $65,845,850 | $25,296,600 |
| 2011 | 548.0 | $70,135,500 | $28,805,575 |
| 2012 | 555.4 | $72,308,700 | $31,217,325 |
| 2013 | 547.7 | $72,487,750 | $32,634,925 |
| 2014 | 532.7 | $71,648,375 | $33,352,875 |
| 2015 | 737.6 | $97,142,425 | $44,357,650 |
| 2016 | 727.3 | $97,170,075 | $46,059,275 |
| 2017 | 711.7 | $96,306,975 | $47,099,150 |
| 2018 | 692.5 | $94,797,500 | $47,631,675 |
| 2019 | 673.8 | $93,433,625 | $48,019,325 |
| 2020 | 655.2 | $92,129,300 | $48,255,650 |
| ***Average*** | ***627.2*** | ***$83,946,007*** | ***$39,339,093*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 655 jobs by 2020, and generate $83.9 million in output and $39.3 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction,* due to the needed labor to complete transportation roadway programs through 2020. Other sectors include *Professional, scientific, and technical services,* as the program would require land planning and architecture expertise to complete.

**Investment Phase—Enhancement**
The average annual economic impacts of the investment phase of the *Transportation Technology Initiatives* strategy during enhancement can be found in Figure 52.

[59] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 52: Transportation Technology Initiatives—Investment Phase**[60]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 569.4 | $72,430,435 | $27,826,260 |
| 2011 | 602.8 | $77,149,050 | $31,686,133 |
| 2012 | 610.9 | $79,539,570 | $34,339,058 |
| 2013 | 602.5 | $79,736,525 | $35,898,418 |
| 2014 | 586.0 | $78,813,213 | $36,688,163 |
| 2015 | 811.3 | $106,856,668 | $48,793,415 |
| 2016 | 800.0 | $106,887,083 | $50,665,203 |
| 2017 | 782.8 | $105,937,673 | $51,809,065 |
| 2018 | 761.7 | $104,277,250 | $52,394,843 |
| 2019 | 741.1 | $102,776,988 | $52,821,258 |
| 2020 | 720.7 | $101,342,230 | $53,081,215 |
| ***Average*** | ***689.9*** | ***$92,340,608*** | ***$43,273,003*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 721 jobs by 2020, and generate $92.3 million in output and $42.3 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction,* due to the needed labor to complete transportation roadway programs through 2020. Other sectors include *Professional, scientific, and technical services,* as the program would require land planning and architecture expertise to complete.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Transportation Technology Initiatives* strategy during the status quo can be found in Figure 53.

[60] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 53: Transportation Technology Initiatives—Operation Phase**[61]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 457.2 | $24,060,060 | $10,354,615 |
| 2013 | 470.9 | $24,609,377 | $11,549,376 |
| 2014 | 458.3 | $23,730,469 | $12,098,693 |
| 2015 | 434.9 | $22,192,384 | $12,222,292 |
| 2016 | 413.6 | $20,654,298 | $12,222,292 |
| 2017 | 394.6 | $19,335,938 | $12,181,090 |
| 2018 | 390.2 | $19,116,212 | $12,387,085 |
| 2019 | 384.8 | $18,237,305 | $12,593,077 |
| 2020 | 375.8 | $17,358,397 | $12,716,676 |
| ***Average*** | ***343.7*** | ***$17,208,585*** | ***$9,847,745*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 376 jobs by 2020, and generate $17.2 million in output and $9.8 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Health Care and Social Assistance.* The increase in this sector may be reflective of the newly employed transit workers, and an increase in potential population needs through 2020.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *Transportation Technology Initiatives* strategy during the enhancement can be found in Figure 54.

[61] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 54: Transportation Technology Initiatives—Operation Phase**[62]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 502.9 | $26,466,066 | $11,390,077 |
| 2013 | 518.0 | $27,070,314 | $12,704,314 |
| 2014 | 504.1 | $26,103,516 | $13,308,562 |
| 2015 | 478.4 | $24,411,622 | $13,444,521 |
| 2016 | 455.0 | $22,719,728 | $13,444,521 |
| 2017 | 434.0 | $21,269,532 | $13,399,199 |
| 2018 | 429.3 | $21,027,834 | $13,625,794 |
| 2019 | 423.3 | $20,061,035 | $13,852,385 |
| 2020 | 413.4 | $19,094,237 | $13,988,344 |
| ***Average*** | ***462.0*** | ***$23,135,987*** | ***$13,239,746*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 413 jobs by 2020, and generate $23.1 million in output and $13.2 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Health Care and Social Assistance.* The increase in this sector may be reflective of the newly employed transit workers, and an increase in potential population needs through 2020.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $8,849,380 for the investment phase and $5,299,912 for the operation phase.

If this strategy was enhanced, the total state and local tax revenues would increase by approximately $11,504,194 in the investment phase and $7,600,903 during the operation phase.

### 3.2.2 Public Transportation Initiatives

For several decades, vehicle miles traveled (VMT) has risen faster than the increase in population, in Maryland and nationwide. Land use development over the past 40 to 50 years has put more people living beyond the reach of easy access to transit facilities, increasing automobile driving and tailpipe emissions of GHGs and other air pollutants. This program is designed to advance the effort to meet a goal set by the O'Malley-Brown Administration of doubling transit ridership by 2020 and the continuation of that same growth rate beyond 2020. In order to achieve this growth, actions are needed to increase the availability, attractiveness

[62] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

and convenience of public transportation, improve the operational efficiency of the system, and increase system capacity.  Actions related to land use planning, pricing disincentives for driving cars, and bike and pedestrian access improvements, addressed in other sections of this Chapter, are also necessary to achieve the ridership goal.

*Public Transportation Initiatives* is another program that has great potential to increase GHG reduction benefits if an enhanced scenario is pursued.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *Public Transportation Initiatives* strategy during status quo can be found in Figure 55.

**Figure 55: Public Transportation Initiatives—Investment Phase**[63]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 868.7 | $105,544,450 | $39,934,150 |
| 2011 | 903.6 | $110,690,500 | $45,252,650 |
| 2012 | 905.5 | $113,008,900 | $49,022,400 |
| 2013 | 887.6 | $112,705,950 | $51,384,225 |
| 2014 | 861.0 | $111,164,125 | $52,747,475 |
| 2015 | 816.6 | $106,163,400 | $51,892,325 |
| 2016 | 789.8 | $104,092,125 | $52,167,975 |
| 2017 | 764.6 | $102,040,450 | $52,273,250 |
| 2018 | 741.1 | $100,045,075 | $52,276,000 |
| 2019 | 720.8 | $98,620,850 | $52,436,250 |
| 2020 | 702.2 | $97,478,350 | $52,642,600 |
| ***Average*** | ***814.7*** | ***$105,595,834*** | ***$50,184,482*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 702 jobs by 2020, and generate $105.6 million in output and $50.2 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction,* as the additional labor in this industry will be needed to complete projects associated with this strategy.

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase of the *Public Transportation Initiatives* strategy during enhancement can be found in Figure 56.

[63] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 56: Public Transportation Initiatives—Investment Phase**[64]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 1,737.5 | $211,088,900 | $79,868,300 |
| 2011 | 1,807.2 | $221,381,000 | $90,505,300 |
| 2012 | 1,811.0 | $226,017,800 | $98,044,800 |
| 2013 | 1,775.3 | $225,411,900 | $102,768,450 |
| 2014 | 1,722.0 | $222,328,250 | $105,494,950 |
| 2015 | 1,633.2 | $212,326,800 | $103,784,650 |
| 2016 | 1,579.6 | $208,184,250 | $104,335,950 |
| 2017 | 1,529.2 | $204,080,900 | $104,546,500 |
| 2018 | 1,482.1 | $200,090,150 | $104,552,000 |
| 2019 | 1,441.7 | $197,241,700 | $104,872,500 |
| 2020 | 1,404.5 | $194,956,700 | $105,285,200 |
| ***Average*** | ***1,629.4*** | ***$211,191,668*** | ***$100,368,964*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 1,405 jobs by 2020, and generate $211.2 million in output and $100.4 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction,* as the additional labor in this industry will be needed to complete additional projects associated with this strategy.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Public Transportation Initiatives* strategy during status quo can be found in Figure 57.

[64] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 57: Public Transportation Initiatives—Operation Phase**[65]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 52.9 | $966,796 | $611,800 |
| 2018 | 112.3 | $2,175,293 | $1,450,196 |
| 2019 | 168.5 | $3,383,788 | $2,364,120 |
| 2020 | 224.7 | $4,350,587 | $3,368,683 |
| ***Average*** | ***139.6*** | ***$2,719,116*** | ***$1,948,700*** |

Source: REMI PI+, RESI

As shown in Figure 57, the strategy will maintain approximately 225 jobs by 2020, and generate $2.7 million in output and $1.9 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy are *Transportation and Warehousing,* as new occupations will arise from more public transit offerings.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *Public Transportation Initiatives* strategy during enhancement can be found in Figure 58.

[65] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 58: Public Transportation Initiatives—Operation Phase**[66]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 105.7 | $1,933,593 | $1,223,600 |
| 2018 | 224.5 | $4,350,587 | $2,900,391 |
| 2019 | 337.0 | $6,767,577 | $4,728,240 |
| 2020 | 449.5 | $8,701,173 | $6,737,366 |
| ***Average*** | ***279.2*** | ***$5,438,232*** | ***$3,897,399*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 450 jobs by 2020, and generate $5.4 million in output and $3.9 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy are *Transportation and Warehousing,* as new occupations will arise from more public transit offerings.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by $40,562,409 for the investment phase and decrease by $287,587 for the operation phase.

If the strategy was enhanced, the total state and local tax revenues would increase by $52,895,164 during the investment phase and decrease by $779,438 for the operation phase.

### 3.2.3 Intercity Transportation Initiatives

Traffic congestion along the I-95 corridor between the Wilmington region, Baltimore and Washington, D.C. has been steadily increasing over the past few decades. The State is implementing strategies to reduce congestion and mobile emissions, including GHGs, by providing alternatives to single occupant vehicle use as well as improvements to Maryland's transportation systems. These strategies enhance connectivity and reliability of non-automobile intercity passenger options through infrastructure and technology investments. 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.

[66] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

*Intercity Transportation Initiatives* is a strategy that has been identified as providing more GHG benefits if enhanced.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *Intercity Transportation Initiatives* strategy during the status quo can be found in Figure 59.

**Figure 59: Intercity Transportation Initiatives—Investment Phase**[67]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 125.2 | $15,191,250 | $5,744,500 |
| 2011 | 130.2 | $15,933,000 | $6,510,250 |
| 2012 | 130.5 | $16,267,750 | $7,053,250 |
| 2013 | 127.9 | $16,224,000 | $7,393,250 |
| 2014 | 124.1 | $16,001,250 | $7,589,250 |
| 2015 | 126.2 | $16,885,250 | $8,278,000 |
| 2016 | 122.3 | $16,609,750 | $8,395,000 |
| 2017 | 118.6 | $16,317,000 | $8,472,000 |
| 2018 | 115.0 | $16,023,250 | $8,523,500 |
| 2019 | 111.9 | $15,805,750 | $8,589,250 |
| 2020 | 91.4 | $12,596,250 | $7,080,750 |
| ***Average*** | ***120.3*** | ***$15,804,955*** | ***$7,602,636*** |

Source: REMI PI+, RESI

As shown in the previous figure, the investment phase of this strategy's implementation will maintain approximately 91 jobs by 2020, and generate $15.8 million in output and $7.6 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction,* as a result of the Department of Transportation's goal to complete intercity projects associated with increasing public transportation.

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase of the *Intercity Transportation Initiatives* strategy during the enhancement can be found in Figure 60.

[67] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 60: Intercity Transportation Initiatives—Investment Phase**[68]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 156.5 | $18,989,063 | $7,180,625 |
| 2011 | 162.8 | $19,916,250 | $8,137,813 |
| 2012 | 163.1 | $20,334,688 | $8,816,563 |
| 2013 | 159.9 | $20,280,000 | $9,241,563 |
| 2014 | 155.1 | $20,001,563 | $9,486,563 |
| 2015 | 157.7 | $21,106,563 | $10,347,500 |
| 2016 | 152.9 | $20,762,188 | $10,493,750 |
| 2017 | 148.2 | $20,396,250 | $10,590,000 |
| 2018 | 143.8 | $20,029,063 | $10,654,375 |
| 2019 | 139.8 | $19,757,188 | $10,736,563 |
| 2020 | 114.2 | $15,745,313 | $8,850,938 |
| ***Average*** | ***150.4*** | ***$19,756,193*** | ***$9,503,295*** |

Source: REMI PI+, RESI

As shown in the previous figure, the investment phase of this strategy's implementation will maintain approximately 114 jobs by 2020, and generate $19.8 million in output and $9.5 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction,* as a result of increased transportation construction projects in the region.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Intercity Transportation Initiatives* strategy during the status quo can be found in Figure 61.

[68] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 61: Intercity Transportation Initiatives—Operation Phase**[69]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 7.9 | $109,863 | $96,131 |
| 2013 | 9.4 | $164,795 | $130,462 |
| 2014 | 8.1 | $109,863 | $130,462 |
| 2015 | 8.8 | $109,863 | $157,928 |
| 2016 | 8.3 | $109,863 | $164,795 |
| 2017 | 9.7 | $219,726 | $185,395 |
| 2018 | 10.1 | $329,589 | $226,593 |
| 2019 | 10.6 | $219,726 | $247,192 |
| 2020 | 10.1 | $219,726 | $205,994 |
| ***Average*** | ***9.2*** | ***$177,002*** | ***$171,661*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 10 jobs by 2020, and generate $0.2 million in output and $0.2 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Transportation and Warehousing*, primarily due to the expectation that this strategy will encourage increased ridership. Publicly managed transportation providers such as MARC will likely require increased staff to manage increased demand for these transit systems.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *Intercity Transportation Initiatives* strategy during the enhancement can be found in Figure 62.

[69] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 62: Intercity Transportation Initiatives—Operation Phase**[70]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 9.9 | $137,329 | $120,164 |
| 2013 | 11.7 | $205,994 | $163,078 |
| 2014 | 10.1 | $137,329 | $163,078 |
| 2015 | 11.0 | $137,329 | $197,411 |
| 2016 | 10.4 | $137,329 | $205,994 |
| 2017 | 12.2 | $274,658 | $231,743 |
| 2018 | 12.6 | $411,986 | $283,241 |
| 2019 | 13.3 | $274,658 | $308,990 |
| 2020 | 12.6 | $274,658 | $257,492 |
| ***Average*** | ***11.5*** | ***$221,252*** | ***$214,577*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 13 jobs by 2020, and generate $0.2 million in output and $0.2 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Transportation and Warehousing*, primarily due to the expectation that this strategy will encourage increased ridership. Publicly managed transportation providers such as MARC will likely require increased staff to manage increased demand for these transit systems.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $13,666,556 for the investment phase and $13,583 for the operation phase.

If the strategy is enhanced, the total state and local tax revenues would increase by approximately $14,417,582 during the investment phase and $16,087 for the operation phase.

### 3.2.4 Pricing Initiatives

This program includes transportation pricing disincentives and travel demand management incentive programs. Projects are tied to commute alternatives and programs including ride sharing (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 fees, and vanpool programs.

[70] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

*Pricing Initiatives* is a strategy that has been identified as providing a greater GHG benefit if enhancement was pursued.

**Investment Phase—Status Quo**
The average annual economic impacts of the investment phase of the *Pricing Initiatives* strategy during status quo can be found in Figure 63.

**Figure 63: Pricing Initiatives—Investment Phase[71]**

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.0 | $0 | $0 |
| 2020 | 0.0 | $0 | $0 |
| ***Average*** | ***0.0*** | ***$0*** | ***$0*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment of strategy implementation will have no discernable economic impact under status quo. At the current time, this program does not have any funds associated with GHG reduction.

**Investment Phase—Enhancement**
The average annual economic impacts of the investment phase of the *Pricing Initiatives* strategy during enhancement can be found in Figure 64.

[71] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 64: Pricing Initiatives—Investment Phase**[72]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 1,874.6 | $226,861,000 | $85,268,250 |
| 2011 | 1,959.6 | $239,203,500 | $96,962,750 |
| 2012 | 1,969.9 | $244,996,750 | $105,147,750 |
| 2013 | 1,934.3 | $244,679,500 | $110,123,250 |
| 2014 | 1,877.5 | $241,410,750 | $112,843,000 |
| 2015 | 251.4 | $30,442,000 | $26,925,250 |
| 2016 | 129.5 | $13,628,500 | $14,974,750 |
| 2017 | 60.4 | $3,866,250 | $6,806,000 |
| 2018 | 32.2 | -$259,500 | $1,861,500 |
| 2019 | 25.3 | -$1,270,250 | -$924,500 |
| 2020 | 31.5 | -$301,000 | -$2,063,000 |
| ***Average*** | ***922.4*** | ***$113,023,409*** | ***$50,720,455*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment of strategy implementation will maintain approximately 32 jobs by 2020, and generate $113.0 million in output and $50.7 million in wages on average each year. The sector experiencing the most significant gains for this strategy is *Construction.* A vital sector in completing programs to would increase public transportation and reduce congestion along Maryland roadways.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Pricing Initiatives* strategy can be found in Figure 65.

[72] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 65: Pricing Initiatives—Operation Phase**[73]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.0 | $0 | $0 |
| 2020 | 0.0 | $0 | $0 |
| ***Average*** | ***0.0*** | ***$0*** | ***$0*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment of strategy implementation will have no discernable impact on the economy under status quo. At the current time, this program does not have any funds associated with GHG reduction.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *Pricing Initiatives* strategy can be found in Figure 66.

[73] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 66: Pricing Initiatives—Operation Phase**[74]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 375.6 | $7,250,977 | $4,446,030 |
| 2013 | 382.7 | $7,594,299 | $5,278,587 |
| 2014 | 385.4 | $7,662,964 | $5,893,135 |
| 2015 | 384.4 | $7,443,237 | $6,305,122 |
| 2016 | 381.1 | $7,086,182 | $6,574,631 |
| 2017 | 379.4 | $6,811,524 | $6,801,224 |
| 2018 | 377.7 | $6,564,331 | $6,967,735 |
| 2019 | 375.3 | $6,207,275 | $7,105,064 |
| 2020 | 373.5 | $5,960,083 | $7,245,827 |
| ***Average*** | ***379.4*** | ***$6,953,430*** | ***$6,290,817*** |

Source: REMI PI+, RESI

As shown in Figure 66, the investment of strategy implementation will maintain approximately 374 jobs by 2020, and generate $7.0 million in output and $6.3 million in wages on average each year. The sector with the most significant job growth for this strategy is *Transportation and Warehousing.* As increased mobility within the region becomes easier, industries that rely on fast and safe roadways with minimal congestion can flourish.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $0 for the investment phase and $0 for the operation phase.

If the strategy is enhanced, the total state and local tax revenues would increase by approximately $22,080,096 during the investment phase and decrease by $2,490,073 during the operation phase.

### 3.2.5 Bike and Pedestrian Initiatives

This program is part of the State's effort to reduce GHG and other motor vehicle emissions from cars by providing alternatives to single occupant vehicle use. Building appropriate infrastructure for additional bicycle and pedestrian travel in urban areas increases access to and use of public transit and supports the State’s 2020 transit ridership goal.

*Bike and Pedestrian Initiatives* is a strategy that has been identified as providing greater GHG benefits to Maryland if enhanced.

[74] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *Bike and Pedestrian Initiatives* strategy can be found in Figure 67.

**Figure 67: Bike and Pedestrian Initiatives—Investment Phase**[75]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 347.4 | $60,563,443 | $10,017,395 |
| 2011 | 568.9 | $91,360,906 | $14,820,645 |
| 2012 | 1,870.4 | $284,397,672 | $46,240,126 |
| 2013 | 1,317.2 | $193,626,186 | $34,671,237 |
| 2014 | 1,229.2 | $68,994,140 | $34,078,217 |
| 2015 | 1,181.2 | $65,588,378 | $34,263,610 |
| 2016 | 1,133.8 | $62,402,344 | $34,263,610 |
| 2017 | 1,103.2 | $60,095,214 | $34,442,138 |
| 2018 | 1,079.8 | $58,337,402 | $34,641,266 |
| 2019 | 1,056.6 | $56,579,589 | $34,881,592 |
| 2020 | 1,041.1 | $55,480,957 | $35,327,911 |
| ***Average*** | ***1,084.4*** | ***$96,129,658*** | ***$31,604,341*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 1,041 jobs by 2020, and generate $96.1 million in output and $31.6 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction*. The development and creation of bike and pedestrian paths will likely require engineers, planners, and construction workers within this industry.

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase of the *Bike and Pedestrian Initiatives* strategy can be found in Figure 68.

[75] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 68: Bike and Pedestrian Initiatives—Investment Phase**[76]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 347.4 | $60,563,443 | $10,017,395 |
| 2011 | 568.9 | $91,360,906 | $14,820,645 |
| 2012 | 1,870.4 | $284,397,672 | $46,240,126 |
| 2013 | 1,317.2 | $193,626,186 | $34,671,237 |
| 2014 | 1,268.3 | $185,079,518 | $35,160,065 |
| 2015 | 3,135.0 | $452,746,585 | $90,969,087 |
| 2016 | 3,017.4 | $431,323,246 | $91,129,302 |
| 2017 | 2,930.1 | $414,184,571 | $91,312,407 |
| 2018 | 2,859.3 | $400,854,496 | $91,701,507 |
| 2019 | 2,793.6 | $388,476,566 | $92,182,158 |
| 2020 | 2,747.7 | $380,383,302 | $93,223,572 |
| ***Average*** | ***2,077.8*** | ***$298,454,226*** | ***$62,857,046*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 2,748 jobs by 2020, and generate $298.5 million in output and $62.9 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Construction*. The development and creation of bike and pedestrian paths will likely require engineers, planners, and construction workers within this industry.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Bike and Pedestrian Initiatives* strategy can be found in Figure 69.

[76] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 69: Bike and Pedestrian Initiatives—Operation Phase**[77]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.9 | $0 | $0 |
| 2014 | 0.2 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | -0.5 | $0 | -$6,867 |
| 2017 | 0.5 | $0 | $27,466 |
| 2018 | 0.0 | $0 | -$6,867 |
| 2019 | 0.7 | $0 | $27,466 |
| 2020 | -0.9 | $0 | -$27,466 |
| ***Average*** | ***0.0*** | ***$0*** | ***$2,746*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will result in less than one forgone job by 2020, and generate $0 in output and $2,746 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Accommodation and Food Services*; primarily due to the expectation that one of the reasons households will increase use of bike and pedestrian paths is transportation cost savings. The increase in disposable income may result in households eating out more, or taking increased family trips.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *Bike and Pedestrian Initiatives* strategy can be found in Figure 70.

[77] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 70: Bike and Pedestrian Initiatives—Operation Phase**[78]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.9 | $0 | $0 |
| 2014 | 0.3 | $0 | $0 |
| 2015 | 1.6 | $0 | $15,260 |
| 2016 | -1.2 | $0 | -$15,260 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | -$15,260 |
| 2019 | 1.2 | $0 | $30,516 |
| 2020 | 0.0 | $0 | $0 |
| ***Average*** | ***0.3*** | ***$0*** | ***$1,387*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will result in no additional jobs by 2020, and generate $0 in output and $1,387 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Accommodation and Food Services*; primarily due to the expectation that one of the reasons households will increase use of bike and pedestrian paths is transportation cost savings. The increase in disposable income may result in households eating out more, or taking increased family trips.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $19,085,227 for the investment phase and $5,769 for the operation phase.

If the strategy was enhanced, the total state and local tax revenues would increase by approximately $30,365,541 during the investment phase and $5,362 during the operation phase.

## 3.3 Agriculture and Forestry

### 3.3.1 Creating Ecosystem Markets to Encourage GHG Emissions Reductions

Increased attention to the benefits and cost efficiencies that ecosystem markets could provide has spurred evaluation of the potential its programs and policies may have for fostering carbon market development. Maryland's Forest Conservation Act and Critical Area Act require

[78] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

mitigation for natural resource impacts generated through land development, and mitigation banking is an option to address these mitigation requirements

The goal of this program is the establishment of ecosystem markets, creation of a tracking mechanism and the development of protocols to assess/quantify GHG benefits of individual markets. However, no quantification target has been assigned.

**Investment Phase**

The average annual economic impacts of the investment phase of the *Creating Ecosystem Markets to Encourage GHG Emissions Reductions* strategy can be found in Figure 71.

**Figure 71: Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Investment Phase**[79]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 1.6 | $122,070 | $61,035 |
| 2011 | 2.1 | $122,070 | $45,776 |
| 2012 | 1.7 | $122,070 | $76,294 |
| 2013 | 1.8 | $122,070 | $91,553 |
| 2014 | 1.6 | $183,105 | $76,294 |
| 2015 | 1.6 | $122,070 | $76,294 |
| 2016 | 1.6 | $122,070 | $76,294 |
| 2017 | 1.5 | $122,070 | $122,070 |
| 2018 | 1.6 | $122,070 | $91,553 |
| 2019 | 1.3 | $122,070 | $76,294 |
| 2020 | 0.6 | $61,035 | $76,294 |
| ***Average*** | ***1.5*** | ***$122,070*** | ***$79,068*** |

Source: REMI PI+, RESI

As shown in the previous figure, the investment phase of this strategy's implementation will maintain approximately one job by 2020, and generate $0.1 million in output and $79,068 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment resulting from this phase of the strategy is *Sales, office, and administrative occupations*, primarily due to the expectation that trained experts in the financial services industry will implement and manage the various ecosystem markets.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Creating Ecosystem Markets to Encourage GHG Emissions Reductions* strategy can be found in Figure 72.

[79] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 72: Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Operation Phase**[80]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 420.6 | $85,632,324 | $49,926,758 |
| 2014 | -284.6 | $68,695,068 | $49,041,748 |
| 2015 | -822.1 | $55,847,168 | $47,042,847 |
| 2016 | -1,237.8 | $46,325,684 | $44,494,629 |
| 2017 | -1,489.9 | $41,748,047 | $42,602,539 |
| 2018 | -1,581.2 | $42,114,258 | $42,053,223 |
| 2019 | -1,691.6 | $40,893,555 | $41,198,730 |
| 2020 | -1,758.1 | $40,832,520 | $40,939,331 |
| ***Average*** | ***-1,055.6*** | ***$52,761,078*** | ***$44,662,476*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will result in 1,758 forgone jobs by 2020, and generate $52.8 million in output and $44.7 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Protective service occupations*. 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. As companies seek enter the market or expand, an increase in protective workforce may be necessary to ensure employee safety during expansionary periods.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $28,821 for the investment phase, and $10,557,326 for the operation phase.

### 3.3.2 Nutrient Trading for GHG 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 could provide a platform for the addition of a voluntary carbon component. Just like the nutrient and sediment markets, carbon trading offers entities under regulatory requirements a potentially more cost-effective means to meet their obligations while giving farmers and landowners the opportunity to receive compensation for implementing and maintaining conservation practices. MDA will add carbon credits and

[80] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

enhanced nutrient credits to the Maryland Nutrient Trading Program. Carbon and enhanced nutrient credits would be "stacked" onto existing nutrient and sediment credits as tradable commodities, thereby increasing the potential value of the total credit package and taking another incremental step toward building a comprehensive environmental marketplace. Encouraging trades between nonpoint sources, such as agricultural operations, and point sources, such as wastewater treatment plants, and industrial facilities, or other nonpoint sources, such as highway contract and development projects, would not only create new possibilities for GHG reductions, but also improve water quality, reduce fertilizer use and soil erosion, restore wetlands and wildlife habitat, provide supplemental income for farmers and foresters, and promote Smart Growth goals by preserving agricultural and forested lands.

*Nutrient Trading for GHG Benefits* is a strategy that has been identified to provide greater GHG benefit under an enhanced scenario.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *Nutrient Trading for GHG Benefits* strategy can be found in Figure 73.

**Figure 73: Nutrient Trading for GHG Benefits—Investment Phase**[81]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 2.5 | $183,105 | $80,109 |
| 2011 | 2.9 | $213,623 | $95,367 |
| 2012 | 3.1 | $213,623 | $91,553 |
| 2013 | 5.1 | $305,176 | $156,403 |
| 2014 | 0.1 | $0 | $3,815 |
| 2015 | -0.2 | $0 | $0 |
| 2016 | -0.2 | $0 | $0 |
| 2017 | -0.4 | -$61,035 | -$22,888 |
| 2018 | 0.4 | $61,035 | $0 |
| 2019 | 0.2 | $0 | $0 |
| 2020 | 0.1 | $0 | $3,815 |
| ***Average*** | ***1.2*** | ***$83,230*** | ***$37,107*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately less than one job by 2020, and generate $83,230 in output and $37,107 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this strategy is *Agriculture, forestry, fishing, and hunting*. Nutrient trading program will provide incremental revenues to farmers and

[81] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

landowners allowing them to expand their business. The strategy will also generate employment opportunities in industries facilitating the credit-trading market, such as in *Management, business, and financial occupations* and *Professional, scientific, and technical services*.

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase of the *Nutrient Trading for GHG Benefits* strategy can be found in Figure 75.

**Figure 74: Nutrient Trading for GHG Benefits—Investment Phase**[82]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 15.6 | $1,159,607 | $507,328 |
| 2011 | 18.3 | $1,352,875 | $603,962 |
| 2012 | 19.9 | $1,352,875 | $579,803 |
| 2013 | 32.5 | $1,932,678 | $990,498 |
| 2014 | 0.9 | $0 | $24,158 |
| 2015 | -1.0 | $0 | $0 |
| 2016 | -1.5 | $0 | $0 |
| 2017 | -2.6 | -$386,536 | -$144,951 |
| 2018 | 2.5 | $386,536 | $0 |
| 2019 | 1.4 | $0 | $0 |
| 2020 | 0.5 | $0 | $24,158 |
| ***Average*** | ***7.9*** | ***$527,094*** | ***$234,996*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately one job by 2020, and generate $0.5 million in output and $0.2 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this strategy is *Professional, Scientific, and Technical Services.* As the program begins to take shape, increased need for technical assistance to create the exchange will be needed.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Nutrient Trading for GHG Benefits* strategy can be found in Figure 76**.**

[82] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 75: Nutrient Trading for GHG Benefits—Operation Phase**[83]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.0 | $0 | $0 |
| 2020 | 0.0 | $0 | $0 |
| ***Average*** | ***0.0*** | ***$0*** | ***$0*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will have no discernable impact on the economy during the operation phase.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *Nutrient Trading for GHG Benefits* strategy can be found in Figure 77**.**

[83] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 76: Nutrient Trading for GHG Benefits—Operation Phase**[84]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.0 | $0 | $0 |
| 2020 | 0.0 | $0 | $0 |
| ***Average*** | ***0.0*** | ***$0*** | ***$0*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will have no discernable impact during the operation phase.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $22,127 for the investment phase and experience no change for the operation phase.

If the strategy is enhanced, the total state and local tax revenues would accumulate to approximately $145,669 during the investment phase and experience no change during the operation phase.

### 3.3.3 Managing Forests to Capture Carbon

Managing forests to capture carbon will promote sustainable forestry management practices in existing Maryland forests on both public and private lands. The enhanced productivity resulting from enrolling unmanaged forests into management regimes will increase rates of carbon dioxide sequestration in forest biomass, increase amounts of carbon stored in harvested, durable wood products which will result in economic benefits, and increased availability of renewable biomass for energy production.

The goals of this program are to improve sustainable forest management on 30,000 acres of private land annually and on 100 percent of State-owned resource lands, and ensure 50 percent of State-owned forest lands will be third-party certified as sustainably managed.

[84] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase**

From 2010 to 2020 a total of $37.7 million was allocated to the *Managing Forests to Capture Carbon* strategy. The average annual economic impacts of the investment phase of the strategy can be found in Figure 78.

**Figure 77: Managing Forests to Capture Carbon—Investment Phase**[85]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 387.8 | $2,227,783 | $1,617,432 |
| 2011 | 383.4 | $2,258,301 | $1,892,090 |
| 2012 | 377.5 | $2,136,230 | $2,059,937 |
| 2013 | 371.4 | $1,953,125 | $2,182,007 |
| 2014 | 362.7 | $1,739,502 | $2,227,783 |
| 2015 | 353.4 | $1,464,844 | $2,258,301 |
| 2016 | 346.3 | $1,220,703 | $2,304,077 |
| 2017 | 339.5 | $1,098,633 | $2,273,560 |
| 2018 | 331.9 | $976,563 | $2,319,336 |
| 2019 | 328.1 | $915,527 | $2,258,301 |
| 2020 | 324.3 | $732,422 | $2,212,524 |
| ***Average*** | ***355.1*** | ***$1,520,330*** | ***$2,145,941*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 324 jobs by 2020, and generate $1.5 million in output and $2.1 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations*. Sustainable forest management will be carried out by professionals in this industry. To a lesser extent, environmental consultants or management firms within the industry will likely be needed to determine and advise on best practices in sustainable forest management.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Managing Forests to Capture Carbon* strategy can be found in Figure 79.

[85] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 78: Managing Forests to Capture Carbon—Operation Phase**[86]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 47.8 | $1,403,809 | $350,952 |
| 2013 | 48.7 | $1,403,809 | $427,246 |
| 2014 | 48.5 | $1,464,844 | $457,764 |
| 2015 | 47.6 | $1,342,773 | $518,799 |
| 2016 | 47.0 | $1,281,738 | $534,058 |
| 2017 | 46.9 | $1,281,738 | $564,575 |
| 2018 | 46.1 | $1,220,703 | $564,575 |
| 2019 | 45.0 | $1,281,738 | $579,834 |
| 2020 | 43.9 | $1,159,668 | $534,058 |
| ***Average*** | ***46.8*** | ***$1,315,647*** | ***$503,540*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 44 jobs by 2020, and generate $1.3 million in output and $0.5 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Farming, fishing, and forestry.* It is expected that the implementation of sustainable forest management is likely to have ripple effects for a wide variety of businesses which may be contracted to facilitate management.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $1,005,298 for the investment phase and $208,681 for the operation phase.

### 3.3.4 Increasing Urban Trees to Capture Carbon

Trees in urban areas directly impact Maryland's carbon budget by absorbing GHG emissions from power production and vehicles, reducing heating and cooling costs and energy demand by moderating temperatures around buildings, and slowing the formation of ground level ozone as well as the evaporation of fuel from motor vehicles. Implementation of this program is supported by several other Maryland laws and programs that include outreach and technical assistance for municipalities to assess and evaluate their urban tree canopy goals, and plant trees to meet those goals.

[86] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

The goals of this program are to plant 12.5 million trees in urban areas through the Forest Conservation Act, Marylanders Plant Trees, Tree-Mendous Maryland, and 5-103 State Highway Reforestation Act planting programs.

**Investment Phase**
The average annual economic impacts of the investment phase of the *Increasing Urban Trees to Capture Carbon* strategy can be found in Figure 80.

**Figure 79: Increasing Urban Trees to Capture Carbon—Investment Phase**[87]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 5.5 | $91,553 | $61,035 |
| 2011 | 5.6 | $91,553 | $45,776 |
| 2012 | 5.3 | $91,553 | $45,776 |
| 2013 | 5.7 | $122,070 | $76,294 |
| 2014 | 5.4 | $152,588 | $76,294 |
| 2015 | 4.7 | $61,035 | $45,776 |
| 2016 | 4.9 | $122,070 | $45,776 |
| 2017 | 4.4 | $61,035 | $61,035 |
| 2018 | 5.1 | $61,035 | $61,035 |
| 2019 | 4.8 | $122,070 | $61,035 |
| 2020 | 3.8 | $61,035 | $61,035 |
| ***Average*** | ***5.0*** | ***$94,327*** | ***$58,261*** |

Source: REMI PI+, RESI

As shown in the previous figure, the investment phase of this strategy's implementation will maintain approximately 4 jobs by 2020, and generate $94,327 in output and $58,261 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations*. This strategy will require cooperation between local community organizers and governments in planning and implementation, and funds will be passed through to this industry for administration purposes.

**Operation Phase**
The average annual economic impacts of the operation phase of the *Increasing Urban Trees to Capture Carbon* strategy can be found in Figure 81.

[87] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 80: Increasing Urban Trees to Capture Carbon—Operation Phase[88]**

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 234.2 | $10,406,494 | $3,814,697 |
| 2011 | 292.2 | $15,594,482 | $5,294,800 |
| 2012 | 336.0 | $19,866,943 | $6,561,279 |
| 2013 | 363.7 | $23,132,324 | $7,476,807 |
| 2014 | 381.2 | $26,031,494 | $8,346,558 |
| 2015 | 390.5 | $28,259,277 | $9,124,756 |
| 2016 | 396.9 | $30,273,438 | $9,704,590 |
| 2017 | 396.9 | $31,799,316 | $10,208,130 |
| 2018 | 394.1 | $33,203,125 | $10,620,117 |
| 2019 | 383.2 | $33,996,582 | $10,635,376 |
| 2020 | 371.5 | $34,545,898 | $10,589,600 |
| ***Average*** | ***358.2*** | ***$26,100,852*** | ***$8,397,883*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 372 jobs by 2020, and generate $26.1 million in output and $8.4 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Sales, office, and administrative occupations*, primarily due to the expectation that a wide variety of businesses in the urban areas where trees are being planted will experience benefits in terms of building operation costs as carbon capture lowers ambient temperature.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $33,062 for the investment phase, and $5,328,250 for the operation phase.

### 3.3.5 Creating and Protecting Wetlands and Waterway Borders to Capture Carbon

In addition to forests, wetlands and marshlands are known to be very efficient at sequestering carbon. Therefore, 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.

[88] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

The goals of this program are 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.

**Investment Phase**
The average annual economic impacts of the investment phase of the *Creating and Protecting Wetlands and Waterway Borders to Capture Carbon* strategy can be found in Figure 82.

**Figure 81: Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Investment Phase[89]**

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 2.1 | $61,035 | $15,259 |
| 2011 | 2.1 | $61,035 | $15,259 |
| 2012 | 2.2 | $30,518 | $15,259 |
| 2013 | 18.2 | $396,729 | $183,105 |
| 2014 | 18.3 | $457,764 | $183,105 |
| 2015 | 18.1 | $366,211 | $213,623 |
| 2016 | 18.7 | $366,211 | $213,623 |
| 2017 | 18.9 | $427,246 | $259,399 |
| 2018 | 18.9 | $366,211 | $244,141 |
| 2019 | 18.9 | $427,246 | $259,399 |
| 2020 | 17.7 | $366,211 | $228,882 |
| ***Average*** | ***14.0*** | ***$302,401*** | ***$166,460*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 18 jobs by 2020, and generate $0.3 million in output and $0.2 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this strategy is *Sales, office, and administrative occupations.* It is expected that creating and protecting wetland and waterway borders will require planning and supervision from experts knowledgeable in land management.

**Operation Phase**
The average annual economic impacts of the operation phase of the *Creating and Protecting Wetlands and Waterway Borders to Capture Carbon* strategy can be found in Figure 83.

[89] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 82: Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Operation Phase**[90]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 152.9 | $4,119,873 | $1,632,690 |
| 2011 | 151.8 | $4,150,391 | $1,770,020 |
| 2012 | 149.8 | $4,119,873 | $1,922,607 |
| 2013 | 200.9 | $5,462,646 | $2,593,994 |
| 2014 | 52.2 | $1,373,291 | $976,563 |
| 2015 | 47.6 | $1,098,633 | $823,975 |
| 2016 | 45.1 | $915,527 | $701,904 |
| 2017 | 44.9 | $976,563 | $717,163 |
| 2018 | 44.3 | $976,563 | $686,646 |
| 2019 | 44.7 | $1,098,633 | $701,904 |
| 2020 | 44.4 | $1,098,633 | $686,646 |
| ***Average*** | ***89.0*** | ***$2,308,239*** | ***$1,201,283*** |

Source: REMI PI+, RESI

As shown in the previous figure, the strategy will maintain approximately 44 jobs by 2020, and generate $2.3 million in output and $1.2 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment due to this strategy are mostly service-based sectors such as *Food preparation, serving related occupations* and *Sales, office, and administrative occupations*, primarily due to the expectation that the expanded wetlands resulting from implementation of this strategy will create tourism opportunities and increase overall household spending on a variety of both necessary and desired services (healthcare, retail, food, etc.) as a result.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $75,431 for the investment phase, and $556,621 for the operation phase.

### 3.3.6 Geological Opportunities to Store Carbon

Geological carbon sequestration differs from other discussed sequestration methods as it captures carbon at the source, transports it to the sequestration site, and then sequesters it. Maryland is one of eight partner states in the Midwest Region Carbon Sequestration Partnership whose role is to identify, locate, and characterize potential geologic storage levels. More than 10 gigatonnes of storage capacity has been identified to be available within Maryland (103 years of storage capacity at current $CO_2$ estimated production rate of 97 million metric tons per year).

[90] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

The goal of this program is to identify and assess geologic storage opportunities. However, no quantification target has been assigned.

**Investment Phase**

From 2010 to 2020 a total of four state employees were allocated to the *Geological Opportunities to Store Carbon* strategy. The average annual economic impacts of the investment phase of the strategy can be found in Figure 84.

**Figure 83: Geological Opportunities to Store Carbon—Investment Phase[91]**

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.4 | $30,518 | $0 |
| 2011 | 0.4 | $0 | -$15,259 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.1 | $0 | $15,259 |
| 2014 | 0.4 | $61,035 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.5 | $0 | $15,259 |
| 2017 | 0.0 | $61,035 | $15,259 |
| 2018 | 0.5 | $0 | $0 |
| 2019 | 0.5 | $61,035 | $30,518 |
| 2020 | 0.5 | $61,035 | $15,259 |
| ***Average*** | ***0.3*** | ***$24,969*** | ***$6,936*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately one job by 2020, and generate $24,969 in output and $6,936 in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this strategy is *Sales, office, and administrative occupations*, mainly from the expectation that environmental and geological consultants within this industry will be needed to help with development, planning, and implementation of carbon sequestration associated with this strategy.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Geological Opportunities to Store Carbon* strategy can be found in Figure 85.

[91] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 84: Geological Opportunities to Store Carbon—Operation Phase**[92]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 138.6 | $12,237,549 | $2,761,841 |
| 2011 | 193.4 | $18,524,170 | $4,089,355 |
| 2012 | 226.6 | $23,132,324 | $5,081,177 |
| 2013 | 243.0 | $26,397,705 | $5,661,011 |
| 2014 | 250.4 | $28,930,664 | $6,072,998 |
| 2015 | 251.0 | $30,822,754 | $6,378,174 |
| 2016 | 248.2 | $32,287,598 | $6,484,985 |
| 2017 | 244.6 | $33,630,371 | $6,607,056 |
| 2018 | 236.0 | $34,606,934 | $6,546,021 |
| 2019 | 225.7 | $35,278,320 | $6,347,656 |
| 2020 | 217.2 | $35,888,672 | $6,088,257 |
| ***Average*** | ***225.0*** | ***$28,339,733*** | ***$5,647,139*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 217 jobs by 2020, and generate $28.3 million in output and $5.6 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Sales, office, and administrative occupations*. Companies will attempt to harness carbon sequestration associated with natural geologic reservoirs because carbon dioxide injections into these reservoirs and the resulting creation, extraction, and consumption of shale and natural gas could potentially offset higher costs associated with energy generation. Savings resulting from decreased energy costs should be passed on to consumers, who will then have more disposable income to spend on a variety of goods and services in many other industries.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $9,101 for the investment phase and $4,576,841 for the operation phase.

### 3.3.7 Planting Forests in Maryland

Planting trees expands forest cover and associated carbon stocks by regenerating or establishing healthy, functional forests through practices such as soil preparation, erosion control, and supplemental planting, to ensure optimum conditions to support forest growth. By 2020, the implementation goal of this program is to achieve the afforestation and/or reforestation of 43,030 acres in Maryland.

[92] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase**

From 2010 to 2020 a total of $7.7 million was allocated to the *Planting Forests in Maryland* strategy. The average annual economic impacts of the investment phase of the strategy can be found in Figure 86.

**Figure 85: Planting Forests in Maryland—Investment Phase**[93]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 190.3 | $2,258,301 | $1,632,690 |
| 2012 | 190.3 | $2,380,371 | $1,983,643 |
| 2013 | 99.8 | $1,190,186 | $1,373,291 |
| 2014 | 107.8 | $1,190,186 | $1,419,067 |
| 2015 | 103.4 | $915,527 | $1,419,067 |
| 2016 | 100.7 | $793,457 | $1,419,067 |
| 2017 | 97.2 | $671,387 | $1,388,550 |
| 2018 | 95.4 | $610,352 | $1,419,067 |
| 2019 | 93.7 | $610,352 | $1,373,291 |
| 2020 | 91.9 | $488,281 | $1,358,032 |
| ***Average*** | ***106.4*** | ***$1,009,854*** | ***$1,344,161*** |

Source: REMI PI+, RESI

As shown in the previous figure, the investment phase of this strategy's implementation will maintain approximately 92 jobs by 2020, and generate $1.0 million in output and $1.3 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this strategy is *Farming, fishing, and forestry occupations*, primarily due to the expectation that the implementation of this strategy will require planning from experts in forestry-related areas such as soil preparation, erosion control, and supplemental planting.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Planting Forests in Maryland* strategy can be found in Figure 87.

[93] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 86: Planting Forests in Maryland—Operation Phase**[94]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.8 | $0 | $0 |
| 2012 | 0.9 | $0 | $15,259 |
| 2013 | 0.3 | -$30,518 | $0 |
| 2014 | 0.3 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.7 | $0 | $15,259 |
| 2017 | 0.5 | $0 | $30,518 |
| 2018 | 0.4 | $0 | $0 |
| 2019 | 0.0 | $0 | $15,259 |
| 2020 | 0.0 | $0 | $0 |
| ***Average*** | ***0.4*** | ***-$2,774*** | ***$6,936*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will result in no additional jobs by 2020, approximately $2,774 in forgone output and generate $6,936 in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment due to this strategy are those (such as *Sales, office, and administrative occupations* and *Healthcare occupations)* providing goods and services in demand by households. It is likely that private landowners will experience economic benefits from effective management and operation of this strategy, which will encourage increased household spending as a result.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $673,447 for the investment phase and $2,689 for the operation phase.

### 3.3.8 Biomass for Energy Production

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.

[94] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

The goal of this program is to develop policies that recognize wood as a preferred renewable energy source, recognize wood as the largest source of energy consumption in Maryland, and offer incentives to utilize locally produced wood to meet thermal energy needs.

**Investment Phase**
From 2010 to 2020 a total of $100.0 million was allocated to the *Biomass for Energy Production* strategy. The average annual economic impacts of the investment phase of the strategy can be found in Figure 88.

**Figure 87: Biomass for Energy Production—Investment Phase**[95]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 38.1 | $1,708,984 | $869,751 |
| 2014 | 57.0 | $2,502,441 | $1,358,032 |
| 2015 | 56.3 | $2,380,371 | $1,449,585 |
| 2016 | 37.1 | $1,464,844 | $1,022,339 |
| 2017 | 36.1 | $1,403,809 | $1,037,598 |
| 2018 | 36.0 | $1,342,773 | $1,052,856 |
| 2019 | 36.2 | $1,403,809 | $1,098,633 |
| 2020 | 35.8 | $1,342,773 | $1,098,633 |
| ***Average*** | ***30.3*** | ***$1,231,800*** | ***$817,039*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 36 jobs by 2020, and generate $1.2 million in output and $0.8 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment resulting from this strategy is *Sales, office, and administrative occupations*, primarily due to the expectation that the creation of woody biomass will be carried out by professionals in this industry. Environmental consultants and experts within the industry will also likely be contracted to provide guidance in the implementation and organization of sustainable woody biomass production.

**Operation Phase**
The average annual economic impacts of the operation phase of the *Biomass for Energy Production* strategy can be found in Figure 89.

[95] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 88: Biomass for Energy Production—Operation Phase**[96]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 5.3 | $579,834 | $152,588 |
| 2014 | 8.9 | $976,563 | $259,399 |
| 2015 | 11.1 | $1,159,668 | $381,470 |
| 2016 | 13.0 | $1,403,809 | $473,022 |
| 2017 | 15.2 | $1,647,949 | $564,575 |
| 2018 | 16.2 | $1,770,020 | $610,352 |
| 2019 | 16.3 | $1,892,090 | $671,387 |
| 2020 | 15.6 | $1,892,090 | $656,128 |
| ***Average*** | ***9.2*** | ***$1,029,275*** | ***$342,629*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 16 jobs by 2020, and generate $1.0 million in output and $0.3 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this strategy is *Construction,* primarily from the expectation that the use of woody biomass which was produced during implementation of this strategy will benefit energy-producing entities which switch to this type of fuel as it is more energy efficient. Other industries will experience slight gains from the energy cost savings passed on by utilities, and residential consumers also experiencing these energy cost savings will spend more on other goods and services.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $368,176 for the investment phase, and $210,694 for the operation phase.

### 3.3.9 Conservation of Agricultural Land for GHG Benefits

MDA is working to safeguard Maryland's network of natural areas, agricultural lands, and coastal lands through its 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 or promoting forested, grassed, and wetland areas on agricultural land.

The Maryland Agricultural Land Preservation Foundation (MALPF), which was established in 1977, is one of the first and most successful programs of its kind in the country. Besides

[96] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

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. The state's forward reaching goal is to protect 962,000 acres from commercial, residential, or industrial development by 2020.

Since 1997, Maryland has partnered with the USDA in the Conservation Reserve Enhancement Program (CREP) to offer rental payments for leased easements along with other incentives to encourage agricultural producers to protect environmentally sensitive lands, improve wildlife habitat, and reduce sediment and nutrient loss. If fully implemented at its authorized 100,000 acres, CREP has the potential to plant up to 16,000 acres of marginal land into grass, shrubs, and trees, establish 77,000 acres of grassland and forest buffers and 5,000 acres of water and wetland habitat, and restore 2,000 acres of habitat for declining, threatened, or endangered species.

**Investment Phase**

The average annual economic impacts of the investment phase of the *Conservation of Agricultural Land for GHG Benefits* strategy can be found in Figure 90.

**Figure 89: Conservation of Agricultural Land for GHG Benefits—Investment Phase**[97]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 44.5 | $2,349,854 | $850,677 |
| 2011 | 45.5 | $2,410,889 | $911,713 |
| 2012 | 42.8 | $2,288,818 | $911,713 |
| 2013 | 32.7 | $1,708,984 | $747,681 |
| 2014 | 31.4 | $1,647,949 | $751,495 |
| 2015 | 29.5 | $1,525,879 | $724,792 |
| 2016 | 27.4 | $1,403,809 | $698,090 |
| 2017 | 25.6 | $1,281,738 | $667,572 |
| 2018 | 25.7 | $1,342,773 | $671,387 |
| 2019 | 24.1 | $1,159,668 | $644,684 |
| 2020 | 23.7 | $1,159,668 | $656,128 |
| ***Average*** | ***32.1*** | ***$1,661,821*** | ***$748,721*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 24 jobs by 2020, and generate $1.7 million in output and $0.7 million in wages on average each year. The industry experiencing the greatest positive economic impacts

[97] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

in terms of employment due to this strategy is *Construction.* It is expected that new employees will be hired to manage and track the conservation and development of agricultural lands.

**Operation Phase**
The total economic impacts of the operation phase of the *Conservation of Agricultural Land for GHG Benefits* strategy can be found in Figure 91.

**Figure 90: Conservation of Agricultural Land for GHG Benefits—Operation Phase**[98]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 600.3 | $122,802,734 | $15,861,511 |
| 2012 | 609.2 | $123,626,709 | $19,195,557 |
| 2013 | 597.1 | $122,833,252 | $21,171,570 |
| 2014 | 434.8 | $91,918,945 | $18,211,365 |
| 2015 | 387.9 | $88,745,117 | $17,253,876 |
| 2016 | 348.3 | $85,998,535 | $16,269,684 |
| 2017 | 320.4 | $84,045,410 | $15,361,786 |
| 2018 | 298.6 | $82,519,531 | $14,526,367 |
| 2019 | 281.9 | $81,237,793 | $13,854,980 |
| 2020 | 269.0 | $80,322,266 | $13,286,591 |
| ***Average*** | ***377.0*** | ***$87,640,936*** | ***$14,999,390*** |

Source: REMI PI+, RESI

As shown in Figure 91, the strategy will maintain approximately 269 jobs by 2020, and generate $87.6 million in output and $15.0 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment resulting from this strategy is *Farm, fishing, and forestry occupations*, primarily due to the increased demand for individuals familiar with agricultural land and productive uses.

**Fiscal Impacts**
As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $204,733 for the investment phase and $14,106,601 for the operation phase.

## 3.4 Zero Waste

### 3.4.1 Zero Waste

In Maryland, waste diversion is defined as the volume of waste that is diverted from entering the waste stream through recycling or source reduction activities. Source reduction activities are those that reduce or prevent the creation of waste. Maryland estimates the source

[98] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

reduction rate using a checklist for counties to document their source reduction activities, including backyard composting, reuse programs, and technical assistance. The counties' responses are tallied and correspond with a source reduction credit, up to a maximum of 5%, which is added to the recycling rate to produce the waste diversion rate.

Reducing the generation and disposal of waste has many benefits. It saves energy and natural resources, preserves the capacity of existing solid waste disposal facilities and reduces greenhouse gases and other pollutants generated by landfills and manufacturing processes.

*Zero Waste* is a strategy that has been identified as providing greater GHG benefits if enhanced.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *Recycling and Source Reduction* strategy can be found in Figure 92.

**Figure 91: Recycling and Source Reduction—Investment Phase**[99]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 873.3 | $67,474,365 | $21,640,778 |
| 2011 | 891.6 | $68,328,857 | $23,357,391 |
| 2012 | 891.6 | $68,481,445 | $24,765,015 |
| 2013 | 882.6 | $68,023,682 | $25,863,647 |
| 2014 | 867.6 | $67,138,672 | $26,699,066 |
| 2015 | 847.6 | $65,856,934 | $27,278,900 |
| 2016 | 826.9 | $64,636,230 | $27,748,108 |
| 2017 | 810.3 | $63,537,598 | $28,175,354 |
| 2018 | 795.6 | $62,622,070 | $28,598,785 |
| 2019 | 782.8 | $61,767,578 | $29,094,696 |
| 2020 | 773.1 | $61,218,262 | $29,666,901 |
| ***Average*** | ***840.3*** | ***$65,371,427*** | ***$26,626,240*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 773 jobs by 2020, and generate $65.4 million in output and $26.6 million in wages on average each year. The industry with the most significant employment gains during this time period is *Administrative and Waste Management Services.* This industry may see growth over the time period associated with new recycling facilities and collection routes being added to meet the *Zero Waste* requirements.

[99] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase of the *Recycling and Source Reduction* strategy can be found in Figure 93.

**Figure 92: Recycling and Source Reduction—Investment Phase**[100]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 873.3 | $67,474,365 | $21,640,778 |
| 2011 | 891.6 | $68,328,857 | $23,357,391 |
| 2012 | 891.6 | $68,481,445 | $24,765,015 |
| 2013 | 882.6 | $68,023,682 | $25,863,647 |
| 2014 | 867.6 | $67,138,672 | $26,699,066 |
| 2015 | 1,452.9 | $112,897,600 | $46,763,828 |
| 2016 | 1,417.5 | $110,804,966 | $47,568,185 |
| 2017 | 1,389.1 | $108,921,595 | $48,300,606 |
| 2018 | 1,364.0 | $107,352,120 | $49,026,489 |
| 2019 | 1,341.9 | $105,887,276 | $49,876,621 |
| 2020 | 1,325.3 | $104,945,591 | $50,857,544 |
| ***Average*** | ***1,154.3*** | ***$90,023,288*** | ***$37,701,743*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 1,325 jobs by 2020, and generate $90.0 million in output and $37.7 million in wages on average each year. The industry with the most significant employment gains during this time period is *Administrative and Waste Management Services.* This industry may see growth over the time period associated with new recycling facilities and collection routes being added to meet the *Zero Waste* requirements.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Recycling and Source Reduction* strategy can be found in Figure 94.

[100] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 93: Recycling and Source Reduction—Operation Phase**[101]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | -515.8 | -$39,764,404 | -$12,779,236 |
| 2011 | -527.0 | -$40,344,238 | -$13,813,019 |
| 2012 | -525.6 | -$40,252,686 | -$14,583,588 |
| 2013 | -512.6 | -$39,520,264 | -$15,064,240 |
| 2014 | -497.7 | -$38,574,219 | -$15,373,230 |
| 2015 | -485.1 | -$37,719,727 | -$15,632,629 |
| 2016 | -474.8 | -$36,987,305 | -$15,922,546 |
| 2017 | -462.7 | -$36,193,848 | -$16,078,949 |
| 2018 | -453.7 | -$35,522,461 | -$16,296,387 |
| 2019 | -449.0 | -$35,339,355 | -$16,624,451 |
| 2020 | -447.6 | -$35,278,320 | -$17,074,585 |
| ***Average*** | ***-486.5*** | ***-$37,772,439*** | ***-$15,385,714*** |

Source: REMI PI+, RESI

As shown Figure 94, the strategy will result in approximately 448 forgone jobs by 2020, approximately $37.8 million in forgone output and $15.4 million in forgone wages on average each year. The industry experiencing the greatest decline is *Administrative and Waste Management Services*. This would likely occur with the reduction from current waste management practices and purchases of landfill space within the state. The result may see a shift of these employees to recycling facilities and land acquisition to expand current recycling operations within the State.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *Recycling and Source Reduction* strategy can be found in Figure 95.

[101] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 94: Recycling and Source Reduction—Operation Phase**[102]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | -515.8 | -$39,764,404 | -$12,779,236 |
| 2011 | -527.0 | -$40,344,238 | -$13,813,019 |
| 2012 | -525.6 | -$40,252,686 | -$14,583,588 |
| 2013 | -512.6 | -$39,520,264 | -$15,064,240 |
| 2014 | -497.7 | -$38,574,219 | -$15,373,230 |
| 2015 | -831.5 | -$64,662,388 | -$26,798,793 |
| 2016 | -813.9 | -$63,406,808 | -$27,295,794 |
| 2017 | -793.2 | -$62,046,595 | -$27,563,912 |
| 2018 | -777.8 | -$60,895,647 | -$27,936,663 |
| 2019 | -769.7 | -$60,581,752 | -$28,499,058 |
| 2020 | -767.3 | -$60,477,120 | -$29,270,717 |
| ***Average*** | ***-666.6*** | ***-$51,866,011*** | ***-$21,725,295*** |

Source: REMI PI+, RESI

As shown Figure 95, the strategy will result in approximately 767 forgone jobs by 2020, approximately $51.9 million in forgone output and $21.7 million in forgone wages on average each year. The industry experiencing the greatest decline is *Administrative and Waste Management Services*. This would likely occur with the reduction from current waste management practices and purchases of landfill space within the state. The result may see a shift of these employees to recycling facilities and land acquisition to expand current recycling operations within the State.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues will increase by approximate $12,713,231 for the investment phase, and will decrease by $7,415,429 for the operation phase.

If the strategy is enhanced, the total state and local tax revenues will increase by approximately $21,793,894 during the investment phase and decrease by $12,712,164 during the operation phase.

## 3.5 Buildings

### 3.5.1 Building Codes

Given the long lifetime of buildings, updating state and local building codes on a periodic basis will provide long-term greenhouse gas emissions reductions. The statewide building code in Maryland is adopted by the Maryland Codes Administration, which is within the Department of Housing and Community Development (DHCD). The statewide building code is called the

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Maryland Building Performance Standards (MBPS) and is updated every three years following the International Codes Council (ICC) cycle.

The MBPS is based primarily on the international codes books (I-Codes) published by the ICC; the core code books adopted by Maryland are the International Building Code (IBC), the International Residential Code (IRC), and the International Energy Conservation Code (IECC). In January of each third year, the Maryland Codes Administration adopts the latest codes into the MBPS, as required by law; subsequently, the local building code authorities must adopt and implement the MBPS by July of that same year. Local code authorities may amend the MBPS to meet the specific conditions and needs of their jurisdiction – with a few exceptions. For example, the energy code (IECC) and the accessibility code (Maryland Accessibility Code or MAC) cannot be weakened. Other codes, such as the recently authorized International Green Construction Code (IgCC), are a voluntary option for local jurisdictions.

**Investment Phase**

The average annual economic impacts of the investment phase of the *Building Codes* strategy can be found in Figure 96.

**Figure 95: Building Codes—Investment Phase**[103]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 19.5 | $1,495,361 | $671,387 |
| 2011 | 23.1 | $1,739,502 | $839,233 |
| 2012 | 21.7 | $1,647,949 | $869,751 |
| 2013 | 21.4 | $1,617,432 | $915,527 |
| 2014 | 20.5 | $1,647,949 | $915,527 |
| 2015 | 18.9 | $1,525,879 | $930,786 |
| 2016 | 19.3 | $1,525,879 | $976,563 |
| 2017 | 18.8 | $1,525,879 | $976,563 |
| 2018 | 19.2 | $1,525,879 | $1,052,856 |
| 2019 | 18.3 | $1,586,914 | $1,068,115 |
| 2020 | 18.6 | $1,525,879 | $1,068,115 |
| ***Average*** | ***19.9*** | ***$1,578,591*** | ***$934,948*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 19 jobs by 2020, and generate $1.6 million in output and $0.9 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment due to this strategy are *Sales, office, and administrative occupations*, primarily due to the expectation that implementation of new building codes will

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result in the need for new training associated with repair and maintenance and new construction projects which will require building code inspectors, construction workers, site managers, architects, engineers, and other building professionals in these two industries.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Building Codes* strategy can be found in Figure 96.

**Figure 96: Building Codes—Operation Phase**[104]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 30.8 | $2,441,406 | -$1,861,572 |
| 2011 | 91.3 | $6,896,973 | -$2,506,256 |
| 2012 | 167.7 | $12,542,725 | -$2,109,528 |
| 2013 | 265.0 | $19,744,873 | -$1,098,633 |
| 2014 | 359.1 | $26,733,398 | $1,091,003 |
| 2015 | 446.4 | $33,386,230 | $3,620,148 |
| 2016 | 525.6 | $39,489,746 | $6,374,359 |
| 2017 | 587.3 | $44,311,523 | $9,071,350 |
| 2018 | 638.6 | $48,461,914 | $11,680,603 |
| 2019 | 677.7 | $51,635,742 | $14,091,492 |
| 2020 | 708.2 | $54,199,219 | $16,334,534 |
| ***Average*** | ***408.9*** | ***$30,894,886*** | ***$4,971,591*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 708 jobs by 2020, and generate $30.9 million in output and $5.0 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this strategy is *Professional, Scientific, and Technical Services.* The increased level of skilled individuals in energy efficiency code knowledge, may help to foster competition within the region and support a growing green industry.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $398,903 for the investment phase and $4,189,647 for the operation phase.

[104] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

## 3.6 Land Use

### 3.6.1 Reducing Emissions through Smart Growth and Land Use/Location Efficiency (Include Land Use Planning and Growth Boundary GHG Benefits)

This program reduces Marylanders' dependence on motor vehicle travel, especially single occupant vehicles, by developing incentives and requirements for development projects and regional land use patterns that achieve land use/location efficiency with regard to transportation. The purpose is to reduce VMT and the combustion of fossil fuels. Land use/location efficiency means that residences, jobs, shopping, schools, and recreational opportunities are in close proximity to each other and that alternative transportation modes (walking, biking and mass transit) are convenient and easily accessed. The Smart Growth development pattern, together with land use/location efficiency, results in shorter trip lengths, less need for automobile and truck travel, and greater use of alternative transportation modes.

Existing state laws and initiatives that support the P.1 strategy include the Maryland Sustainable Growth Commission, Smart Growth Subcabinet, Sustainable Communities Act of 2010, 2009 planning legislation, MDP data analysis and forecasting, and MDP indicator development.

This strategy has been identified as one that can provide greater GHG benefits if enhanced.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *Reducing Transportation Issues through Smart Growth* strategy can be found in Figure 97.

**Figure 97: Reducing Emissions through Smart Growth and Land Use/Location Efficiency (Include Land Use Planning and Growth Boundary GHG Benefits)—Investment Phase**[105]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 1,783.2 | $379,758,400 | $40,000,000 |
| 2011 | 4,443.2 | $439,290,496 | $101,600,000 |
| 2012 | 2,836.0 | $469,038,548 | $72,000,000 |
| 2013 | 2,592.8 | $478,150,758 | $70,400,000 |
| 2014 | 2,016.0 | $476,456,226 | $56,960,000 |
| 2015 | 1,588.5 | $468,789,351 | $46,784,000 |
| 2016 | 1,471.0 | $459,195,129 | $45,152,000 |
| 2017 | 1,369.3 | $449,400,783 | $43,520,000 |
| 2018 | 1,284.4 | $440,178,997 | $41,888,000 |
| 2019 | 1,208.8 | $433,341,910 | $40,800,000 |
| 2020 | 1,144.6 | $414,922,431 | $39,168,000 |
| ***Average*** | ***2,586.7*** | ***$446,229,366*** | ***$54,388,364*** |

Source: REMI PI+, RESI

As shown in the figure above, under the investment phase this strategy will maintain approximately 2,587 jobs by 2020, and generate $446.2 million in output and $54.4 million in wages on average each year. The industry that gained the most from this strategy was *Construction.* This program seeks to enable individuals within the state to pursue energy efficiency through a tax credit incentive. The current tax credit does have a sunset year, and if not expand may disinterest individuals from continuing to invest in energy efficient measures for their home or business.

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase under the enhanced scenario of the *Reducing Transportation Issues through Smart Growth* strategy can be found in Figure 98.

[105] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 98: Reducing Emissions through Smart Growth and Land Use/Location Efficiency (Include Land Use Planning and Growth Boundary GHG Benefits)—Investment Phase**[106]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 2,828.1 | $446,774,588 | $174,015,076 |
| 2011 | 3,217.6 | $516,812,348 | $213,975,528 |
| 2012 | 3,357.7 | $551,810,056 | $240,745,148 |
| 2013 | 3,355.1 | $562,530,304 | $257,496,068 |
| 2014 | 3,280.2 | $560,536,736 | $267,339,804 |
| 2015 | 3,172.1 | $551,516,884 | $272,467,868 |
| 2016 | 3,057.6 | $540,229,564 | $275,314,124 |
| 2017 | 2,947.3 | $528,706,804 | $276,989,524 |
| 2018 | 2,844.9 | $517,857,644 | $278,132,008 |
| 2019 | 2,755.0 | $509,814,012 | $279,818,128 |
| 2020 | 2,659.9 | $488,144,037 | $265,026,315 |
| ***Average*** | ***3,043.2*** | ***$524,975,725*** | ***$254,665,417*** |

Source: REMI PI+, RESI

As shown in the figure above, under the investment phase this strategy will maintain approximately 2,660 jobs by 2020, and generate $525.0 million in output and $254.7 million in wages on average each year. The industry that gained the most from this strategy was *Construction.* This program seeks to enable individuals within the state to pursue energy efficiency through a tax credit incentive. Under this scenario, RESI assumes that the tax credit is extended through 2020 to help offset costs associated with the smart growth initiatives. The continued tax credit past the sunset year does assist in smart growth initiatives, however, the tax credit does indicate that there could be a potential decline in some areas of employment specifically government and private consumption may decline of households.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Reducing Transportation Issues through Smart Growth* strategy can be found in Figure 99.

[106] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 99: Reducing Transportation Issues through Smart Growth—Operation Phase**[107]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 733.1 | $139,545,931 | $42,727,625 |
| 2011 | 824.8 | $160,052,214 | $49,769,910 |
| 2012 | 867.0 | $171,800,520 | $53,594,770 |
| 2013 | 870.3 | $174,957,962 | $54,288,564 |
| 2014 | 852.6 | $173,351,448 | $53,037,899 |
| 2015 | 825.7 | $169,266,828 | $50,646,357 |
| 2016 | 798.3 | $164,610,222 | $47,898,859 |
| 2017 | 772.3 | $159,923,499 | $45,087,497 |
| 2018 | 747.8 | $155,360,603 | $42,370,042 |
| 2019 | 727.3 | $151,908,068 | $40,056,723 |
| 2020 | 710.8 | $149,479,231 | $38,228,325 |
| ***Average*** | ***793.6*** | ***$160,932,412*** | ***$47,064,234*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 711 jobs by 2020, and generate $160.9 million in output and $47.1 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment from this strategy is *Retail Trade.* Increased savings in energy may allow smaller businesses within the region to expand operations or offer better deals to customers thus increasing their level of employment through 2020.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase under the enhanced scenario of the *Reducing Transportation Issues through Smart Growth* strategy can be found in Figure 100.

[107] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 100: Reducing Transportation Issues through Smart Growth—Operation Phase**[108]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 1,127.8 | $187,850,292 | $82,168,510 |
| 2011 | 1,268.9 | $215,454,904 | $95,711,365 |
| 2012 | 1,333.8 | $231,269,931 | $103,066,865 |
| 2013 | 1,338.9 | $235,520,334 | $104,401,085 |
| 2014 | 1,311.6 | $233,357,719 | $101,995,960 |
| 2015 | 1,270.4 | $227,859,191 | $97,396,840 |
| 2016 | 1,228.2 | $221,590,684 | $92,113,190 |
| 2017 | 1,188.1 | $215,281,633 | $86,706,725 |
| 2018 | 1,150.4 | $209,139,273 | $81,480,850 |
| 2019 | 1,118.9 | $204,491,630 | $77,032,160 |
| 2020 | 1,093.5 | $201,222,042 | $73,516,010 |
| ***Average*** | ***1,221.0*** | ***$216,639,785*** | ***$90,508,142*** |

Source: REMI PI+, RESI

As shown in the Figure 100, the strategy will maintain approximately 1,094 jobs by 2020, and generate $216.6 million in output and $90.5 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment from this strategy is *Retail Trade.* Increased savings in energy may allow smaller businesses within the region to expand operations or offer better deals to customers thus increasing their level of employment through 2020.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $123,807,254 during the investment phase and $41,269,085 during the operation phase.

If this strategy is enhanced, additional tax revenues would accumulate to approximately $160,949,430 during the investment phase and $41,433,728 during the operation phase.

### 3.6.2 Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth)

Maryland has established Priority Funding Areas to preserve existing communities, to target State resources to build on past investments, and to reduce development pressure on critical farmland and natural resource areas. By encouraging projects in already developed areas, PFAs reduce the GHG emissions associated with sprawl. Priority Funding Areas are geographic growth areas defined under Maryland law and designated by local jurisdictions to provide a map for targeting State investment in infrastructure. Maryland law directs the use of State

[108] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

funding for roads, water and sewer plants, economic development and other growth-related needs toward Priority Funding Areas, recognizing that these investments are the most important tool the State has to influence smarter, more sustainable growth and development. This strategy has been identified as one that can provide greater GHG benefits if enhanced.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth)* strategy can be found in Figure 101.

**Figure 101: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth)—Investment Phase**[109]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 2,828.1 | $376,966,059 | $146,825,220 |
| 2011 | 3,217.6 | $436,060,419 | $180,541,852 |
| 2012 | 3,357.7 | $465,589,735 | $203,128,719 |
| 2013 | 3,355.1 | $474,634,944 | $217,262,307 |
| 2014 | 3,280.2 | $472,952,871 | $225,567,960 |
| 2015 | 3,172.1 | $465,342,371 | $229,894,764 |
| 2016 | 3,057.6 | $455,818,695 | $232,296,292 |
| 2017 | 2,947.3 | $446,096,366 | $233,709,911 |
| 2018 | 2,844.9 | $436,942,387 | $234,673,882 |
| 2019 | 2,755.0 | $430,155,573 | $236,096,546 |
| 2020 | 2,659.9 | $411,871,531 | $223,615,953 |
| ***Average*** | ***3,043.2*** | ***$442,948,268*** | ***$214,873,946*** |

Source: REMI PI+, RESI

As shown in the figure above, under the investment phase this strategy will maintain approximately 2,660 jobs by 2020, and generate $442.9 million in output and $214.9 million in wages on average each year. The industry that gained the most from this strategy was *Construction.* This program seeks to decrease the issue of rural sprawl from residential construction. The increasing construction activity in areas that happen to be more urbanized have a two-fold effect. The first effect is increased employment to residential/mixed-use developments. A secondary construction impact can be attributed to the increase for transportation and regional amenities such as expanding or retrofitted septic systems.

[109] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase under the enhanced scenario of the *Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth)* strategy can be found in Figure 102.

**Figure 102: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth)—Investment Phase[110]**

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 3,181.6 | $726,008,706 | $326,278,268 |
| 2011 | 3,619.8 | $839,820,066 | $401,204,115 |
| 2012 | 3,777.4 | $896,691,341 | $451,397,153 |
| 2013 | 3,774.5 | $914,111,744 | $482,805,128 |
| 2014 | 3,690.3 | $910,872,196 | $501,262,133 |
| 2015 | 3,568.6 | $896,214,937 | $510,877,253 |
| 2016 | 3,439.8 | $877,873,042 | $516,213,983 |
| 2017 | 3,315.7 | $859,148,557 | $519,355,358 |
| 2018 | 3,200.5 | $841,518,672 | $521,497,515 |
| 2019 | 3,099.4 | $828,447,770 | $524,658,990 |
| 2020 | 2,992.4 | $793,234,059 | $496,924,340 |
| ***Average*** | ***3,423.6*** | ***$853,085,553*** | ***$477,497,657*** |

Source: REMI PI+, RESI

As shown in the figure above, under the investment phase this strategy will maintain approximately 2,992 jobs by 2020, and generate $853.1 million in output and $447.5 million in wages on average each year. The industry that gained the most from this strategy was *Construction.* This program seeks to decrease the issue of rural sprawl by incentivizing residential construction in urbanized regions. However, during the enhancement investment phase of this program, RESI saw some declines due to supply constraints. *Construction* remained the top gaining sector for this strategy.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth)* strategy can be found in Figure 103.

[110] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 103: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth)—Operation Phase[111]**

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 1,151.4 | $292,241,383 | $89,481,507 |
| 2011 | 1,295.5 | $335,186,272 | $104,229,676 |
| 2012 | 1,361.8 | $359,789,935 | $112,239,816 |
| 2013 | 1,367.0 | $366,402,348 | $113,692,782 |
| 2014 | 1,339.1 | $363,037,937 | $111,073,600 |
| 2015 | 1,297.0 | $354,483,799 | $106,065,159 |
| 2016 | 1,253.9 | $344,731,793 | $100,311,264 |
| 2017 | 1,213.0 | $334,916,712 | $94,423,624 |
| 2018 | 1,174.5 | $325,360,955 | $88,732,646 |
| 2019 | 1,142.4 | $318,130,550 | $83,888,022 |
| 2020 | 1,116.4 | $313,044,005 | $80,058,935 |
| ***Average*** | ***1,246.5*** | ***$337,029,608*** | ***$98,563,366*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 1,116 jobs by 2020, and generate $337.0 million in output and $98.6 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment from this strategy is *Construction.* Increased urbanized populations continue to require more amenities such as transportation and sewage/waste collection services. To accommodate some of these services, RESI expects that state government may make strategic investments to meet the growing population needs.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase under the enhanced scenario of the *Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth)* strategy can be found in Figure 104.

[111] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 104: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth)—Operation Phase**[112]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 1,832.7 | $348,864,828 | $123,252,765 |
| 2011 | 2,062.0 | $400,130,536 | $143,567,048 |
| 2012 | 2,167.5 | $429,501,300 | $154,600,298 |
| 2013 | 2,175.8 | $437,394,906 | $156,601,628 |
| 2014 | 2,131.4 | $433,378,621 | $152,993,940 |
| 2015 | 2,064.3 | $423,167,069 | $146,095,260 |
| 2016 | 1,995.8 | $411,525,556 | $138,169,785 |
| 2017 | 1,930.7 | $399,808,747 | $130,060,088 |
| 2018 | 1,869.5 | $388,401,507 | $122,221,275 |
| 2019 | 1,818.3 | $379,770,170 | $115,548,240 |
| 2020 | 1,777.0 | $373,698,078 | $110,274,015 |
| ***Average*** | ***1,984.1*** | ***$402,331,029*** | ***$135,762,213*** |

Source: REMI PI+, RESI

As shown in the Figure 104, the strategy will maintain approximately 1,777 jobs by 2020, and generate $402.3 million in output and $135.8 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment from this strategy is *Construction.* As the increased urban population begins to grow, RESI expects the state will invest more into amenities such as water, public transportation, and sewage/trash collection.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $96,183,876 during the investment phase and $68,925,313 during the operation phase.

If this strategy is enhanced, additional tax revenues would accumulate to approximately $125,039,038 during the investment phase and $89,602,906 during the operation phase.

## 3.7 Innovative Initiatives

### 3.7.1 Buy Local for GHG Benefits

Although farm stands and farmers markets are not new, 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 for Marylanders by helping

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agricultural producers market their products directly to supermarket, food service, institutional, and other wholesale buyers, as well as consumers.

MDA will promote the sustainable production and consumption of local agricultural goods and thereby help 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 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. By 2020, MDA aims to raise the number of farmers markets by 20 percent, establish a state farmers market association, and increase direct sales (buyer/grower) by 20 percent.

**Investment Phase**

The total economic impacts of the investment phase of the *Buy Local for GHG Benefits* strategy can be found in Figure 105.

**Figure 105: Buy Local for GHG Benefits—Investment Phase**[113]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 83.9 | $1,068,115 | $823,975 |
| 2011 | 83.8 | $1,098,633 | $953,674 |
| 2012 | 80.3 | $1,037,598 | $1,007,080 |
| 2013 | 29.7 | $396,729 | $541,687 |
| 2014 | 27.0 | $244,141 | $457,764 |
| 2015 | 26.1 | $244,141 | $434,875 |
| 2016 | 24.8 | $183,105 | $385,284 |
| 2017 | 24.0 | $122,070 | $350,952 |
| 2018 | 24.8 | $305,176 | $358,582 |
| 2019 | 23.6 | $122,070 | $339,508 |
| 2020 | 22.8 | $122,070 | $312,805 |
| ***Average*** | ***41.0*** | ***$449,441*** | ***$542,381*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 23 jobs by 2020, and generate $0.4 million in output and $0.5 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment as a result of this strategy is *Forestry, fishing, and related activities*,

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primarily due to the expectation that as popularity for buying local continues, Maryland may need to increase assistance to farmers in expanding their local farms to accommodate demand.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Buy Local for GHG Benefits* strategy can be found in Figure 106.

**Figure 106: Buy Local for GHG Benefits—Operation Phase**[114]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 6.0 | $1,190,186 | $152,588 |
| 2011 | 7.5 | $1,281,738 | $209,808 |
| 2012 | 6.0 | $1,220,703 | $198,364 |
| 2013 | 6.4 | $1,190,186 | $225,067 |
| 2014 | 6.4 | $1,159,668 | $240,326 |
| 2015 | 5.7 | $1,098,633 | $221,252 |
| 2016 | 4.2 | $1,037,598 | $205,994 |
| 2017 | 4.4 | $1,037,598 | $202,179 |
| 2018 | 5.9 | $1,159,668 | $240,326 |
| 2019 | 5.2 | $1,037,598 | $205,994 |
| 2020 | 4.6 | $1,037,598 | $198,364 |
| ***Average*** | ***5.7*** | ***$1,131,925*** | ***$209,115*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 5 jobs by 2020, and generate $1.1 million in output and $0.2 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Farming, fishing, and forestry occupations*. As buying locally continues to be encouraged, more retailers will begin to purchase Maryland-sourced goods to meet increased demand.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate approximately $412,148 for the investment phase and $269,554 for the operation phase.

### 3.7.2 Voluntary Stationary Source Reductions

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. Either companies may simply take totally voluntary action and provide a good faith estimate of potential

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reductions, which if appropriate, included in the plan as a reduction, or a company can implement an early voluntary GHG emissions reduction plan, which must be approved by MDE before January 1, 2012 and secure a formal "credit."

**Investment Phase**

The average annual economic impacts of the investment phase of the *Voluntary Stationary Source Reductions* strategy can be found in Figure 107.

**Figure 107: Voluntary Stationary Source Reductions—Investment Phase**[115]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.8 | $61,035 | $15,259 |
| 2011 | 0.7 | $30,518 | $15,259 |
| 2012 | 0.4 | $30,518 | $0 |
| 2013 | 0.3 | $30,518 | $15,259 |
| 2014 | 0.6 | $61,035 | $15,259 |
| 2015 | 0.3 | $0 | $15,259 |
| 2016 | 1.0 | $61,035 | $30,518 |
| 2017 | 0.4 | $0 | $30,518 |
| 2018 | 0.0 | $0 | $15,259 |
| 2019 | 0.7 | $61,035 | $30,518 |
| 2020 | -0.3 | $0 | $30,518 |
| ***Average*** | ***0.4*** | ***$30,518*** | ***$19,420*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will result in less than one forgone job by 2020, and generate $30,518 in output and $19,420 in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy are *Sales, office, and administrative occupations*. Some sources are likely to take advantage of voluntary early reductions and develop plans to retrofit or construct new, energy-efficient facilities. These actions will require engineers, planners, and construction workers within these two industries.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Voluntary Stationary Source Reductions* strategy can be found in Figure 108.

[115] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 108: Voluntary Stationary Source Reductions—Operation Phase**[116]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 2.0 | $183,105 | $45,776 |
| 2012 | 2.7 | $305,176 | $76,294 |
| 2013 | 3.4 | $366,211 | $122,070 |
| 2014 | 4.9 | $518,799 | $137,329 |
| 2015 | 4.2 | $488,281 | $152,588 |
| 2016 | 5.4 | $549,316 | $183,105 |
| 2017 | 5.2 | $549,316 | $213,623 |
| 2018 | 5.3 | $610,352 | $183,105 |
| 2019 | 5.4 | $671,387 | $228,882 |
| 2020 | 4.3 | $549,316 | $228,882 |
| ***Average*** | ***3.9*** | ***$435,569*** | ***$142,878*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 4 jobs by 2020, and generate $0.4 million in output and $0.1 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment from this phase of the strategy is *Construction and extraction occupations*, primarily due to the expectation that sources which pursue voluntary early reductions have successfully implemented retrofitting or construct new, energy-efficient facilities. These facilities generate operating cost savings which are passed on to a wide variety of companies and enterprises. Positive impacts occur in other industries as these cost savings allow companies and enterprises to hire additional workers (who then spend in the economy) or increase spending with other vendors.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $5,776 during the investment phase, and $6,622,774 during the operation phase.

### 3.7.3 PAYD Insurance in Maryland

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.

[116] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase**

The average annual economic impacts of the investment phase of the *PAYD Insurance in Maryland* strategy can be found in Figure 109.

**Figure 109: PAYD Insurance in Maryland—Investment Phase**[117]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.0 | $0 | $0 |
| 2020 | 0.0 | $0 | $0 |
| ***Average*** | ***0.0*** | ***$0*** | ***$0*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will have discernable impact on the economy.

**Operation Phase**

The average annual economic impacts of the operation phase of the *PAYD* strategy can be found in Figure 110.

[117] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 110: PAYD Insurance in Maryland—Operation Phase**[118]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | -0.5 | -$30,518 | -$15,259 |
| 2011 | -0.1 | -$30,518 | -$15,259 |
| 2012 | -0.5 | -$61,035 | -$15,259 |
| 2013 | -0.7 | -$61,035 | $0 |
| 2014 | 0.3 | $0 | $15,259 |
| 2015 | -0.1 | -$61,035 | $0 |
| 2016 | 0.6 | $0 | $15,259 |
| 2017 | -0.2 | $0 | $15,259 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.1 | $61,035 | $15,259 |
| 2020 | 0.6 | $61,035 | $15,259 |
| ***Average*** | ***0.0*** | ***-$11,444*** | ***$11,444*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately one job by 2020, result in approximately $11,444 in forgone output and generate $11,444 in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy are those (such as *Management, business, and financial occupations)* associated with the spending patterns of households experiencing increased income. This is due to those households taking advantage of PAYD as the policyholders tend to drive less than the average Maryland resident.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would not be impacted during the investment phase, and would decrease by $19,002 for the operation phase.

### 3.7.4 Leadership-by-Example – Local Government

Maryland county and municipal governments, together with State agencies, 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.

[118] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase**

The average annual economic impacts of the investment phase of the *Leadership-by-Example – Local Government* strategy can be found in Figure 111.

**Figure 111: Leadership-by-Example – Local Government—Investment Phase**[119]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 168.6 | $13,031,006 | $6,072,998 |
| 2011 | 172.5 | $13,244,629 | $6,637,573 |
| 2012 | 170.4 | $13,153,076 | $6,988,525 |
| 2013 | 167.2 | $12,908,936 | $7,217,407 |
| 2014 | 162.4 | $12,725,830 | $7,492,065 |
| 2015 | 157.2 | $12,512,207 | $7,720,947 |
| 2016 | 153.6 | $12,329,102 | $7,934,570 |
| 2017 | 151.0 | $12,268,066 | $8,148,193 |
| 2018 | 148.4 | $12,207,031 | $8,377,075 |
| 2019 | 145.7 | $12,207,031 | $8,544,922 |
| 2020 | 144.5 | $12,207,031 | $8,682,251 |
| ***Average*** | ***158.3*** | ***$12,617,631*** | ***$7,619,684*** |

Source: REMI PI+, RESI

As shown in the previous figure, the investment phase of this strategy's implementation will maintain approximately 145 jobs by 2020, and generate $12.6 million in output and $7.6 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment due to this strategy are *Sales, office, and administrative occupations*, primarily due to the expectation that state government must lead by example by obtaining high performance and energy-efficient buildings, among other measures. Environmental consultants will also likely be contracted to assist in the creation of GHG inventories, climate action plans and targets, and inventory and emissions tracking protocols.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Leadership-by-example – Local Government* strategy can be found in Figure 112.

[119] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 112: Leadership-by-Example – Local Government—Operation Phase**[120]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.0 | $0 | $0 |
| 2020 | 1,837.4 | $109,313,965 | $103,195,190 |
| ***Average*** | ***1,837.4*** | ***$109,313,965*** | ***$103,195,190*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 1,837 jobs by 2020, and generate $109.3 million in output and $103.2 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this strategy is *Sales, office, and administrative occupations*. Leading by example will result in higher efficiency and subsequent cost savings for local governments, which will in turn be able to support additional employment. Other industry sectors will benefit from the ongoing sustainable procurement activities of local governments.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by approximately $3,140,436 during the investment phase, and $20,478,272 for the operation phase.

### 3.7.5 Leadership-by-Example – Federal Government

Federal agencies with facilities located in Maryland are implementing suites of lead-by-example programs to improve efficiency, reduce waste, and integrate renewable energy and sustainable practices into their operations, facilities and fleets. These programs include tools to benchmark and track energy use and GHG emissions in order to report progress. 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.

[120] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase**
The average annual economic impacts of the investment phase of the *Leadership-by-Example – Federal Government* strategy can be found in Figure 113.

**Figure 113: Leadership-by-Example – Federal Government—Investment Phase**[121]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 105.9 | $8,178,711 | $3,814,697 |
| 2011 | 108.0 | $8,300,781 | $4,135,132 |
| 2012 | 106.8 | $8,239,746 | $4,394,531 |
| 2013 | 105.2 | $8,117,676 | $4,547,119 |
| 2014 | 102.5 | $8,056,641 | $4,745,483 |
| 2015 | 98.2 | $7,812,500 | $4,837,036 |
| 2016 | 96.6 | $7,751,465 | $4,989,624 |
| 2017 | 94.1 | $7,690,430 | $5,142,212 |
| 2018 | 91.9 | $7,629,395 | $5,279,541 |
| 2019 | 90.3 | $7,629,395 | $5,355,835 |
| 2020 | 88.5 | $7,507,324 | $5,416,870 |
| ***Average*** | ***98.9*** | ***$7,901,278*** | ***$4,787,098*** |

Source: REMI PI+, RESI

As shown in the previous figure, the investment phase of this strategy's implementation will maintain approximately 87 jobs by 2020, and generate $7.9 million in output and $4.8 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment from to this strategy are *Sale, office, and administrative occupations*, primarily due to the expectation that federal government must lead by example by obtaining high performance and energy-efficient buildings, among other measures. Environmental consultants will also likely be contracted to assist and advise in the planning and implementation of efficiency improvements, waste reduction, water conservation, renewable energy use, and other measures.

**Operation Phase**
The average annual economic impacts of the operation phase of the *Leadership-by-Example – Federal Government* strategy can be found in Figure 114.

[121] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 114: Leadership-by-Example – Federal Government—Operation Phase**[122]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.0 | $0 | $0 |
| 2020 | 1,258.4 | $92,102,051 | $68,771,362 |
| ***Average*** | ***1,258.4*** | ***$92,102,051*** | ***$68,771,362*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 1,258 jobs by 2020, and generate $92.1 million in output and $68.8 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this strategy is *Sales, office, and administrative occupations*, primarily due to the expectation that leading by example will result in higher efficiency and subsequent cost savings for federal governments, which will in turn be able to hire additional employees. Other industry sectors will benefit from the ongoing sustainable procurement activities of federal governments which are continuing implementation and operation of this strategy.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $1,957,467 for the investment phase and $14,969,077 for the operation phase.

### 3.7.6 Lead-by-Example: State of Maryland Initiatives and Carbon Footprint

Through lead-by-example programs, state government in Maryland aims to improve energy efficiency, reduce waste, and integrate renewable energy practices in all of its agencies' operations and facilities, as well as their purchasing practices. DGS currently manages the following lead-by-example programs:

- Maryland Green Building Council,
- Maryland Green Purchasing Committee,
- State Energy Database, and,
- Renewable Energy Portfolio.

[122] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

This strategy is one that has been identified as providing greater GHG reductions if enhanced.

**Investment Phase—Status Quo**

The average annual economic impacts of the investment phase of the *State of Maryland Initiatives to Lead by Example* strategy can be found in Figure 115.

**Figure 115: State of Maryland Initiatives to Lead by Example—Investment Phase**[123]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 87.1 | $4,913,330 | $2,006,531 |
| 2011 | 30.3 | $1,678,467 | $804,901 |
| 2012 | 47.8 | $2,655,029 | $1,239,777 |
| 2013 | 172.5 | $9,735,107 | $4,325,867 |
| 2014 | 171.1 | $9,399,414 | $4,604,340 |
| 2015 | 167.5 | $9,277,344 | $4,817,963 |
| 2016 | 163.2 | $9,033,203 | $4,951,477 |
| 2017 | 158.9 | $8,666,992 | $5,001,068 |
| 2018 | 166.9 | $9,155,273 | $5,390,167 |
| 2019 | 24.3 | $427,246 | $1,266,479 |
| 2020 | 19.9 | $122,070 | $896,454 |
| ***Average*** | ***110.0*** | ***$5,914,862*** | ***$3,209,548*** |

Source: REMI PI+, RESI

As in Figure 115, the investment phase of this strategy's implementation will maintain approximately 20 jobs by 2020, and generate $5.9 million in output and $3.2 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Construction.* Part of this strategy's implementation is to increase state building's energy efficiency. This sector may see an increase in demand to meet these specialized retrofits and assessments.

**Investment Phase—Enhancement**

The average annual economic impacts of the investment phase of the *State of Maryland Initiatives to Lead by Example* strategy can be found in Figure 116.

[123] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 116: State of Maryland Initiatives to Lead by Example—Investment Phase**[124]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 87.1 | $4,913,330 | $2,006,531 |
| 2011 | 30.3 | $1,678,467 | $804,901 |
| 2012 | 47.8 | $2,655,029 | $1,239,777 |
| 2013 | 172.5 | $9,735,107 | $4,325,867 |
| 2014 | 171.1 | $9,399,414 | $4,604,340 |
| 2015 | 228.4 | $12,650,924 | $6,569,949 |
| 2016 | 222.6 | $12,318,005 | $6,752,014 |
| 2017 | 216.7 | $11,818,626 | $6,819,639 |
| 2018 | 227.6 | $12,484,464 | $7,350,228 |
| 2019 | 33.1 | $582,608 | $1,727,018 |
| 2020 | 27.1 | $166,460 | $1,222,437 |
| ***Average*** | ***133.1*** | ***$7,127,494*** | ***$3,947,518*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 27 jobs by 2020, and generate $7.1 million in output and $3.9 million in wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Construction.* Part of this strategy's implementation is to increase state building's energy efficiency. This sector may see an increase in demand to meet these specialized retrofits and assessments.

**Operation Phase—Status Quo**

The average annual economic impacts of the operation phase of the *State of Maryland Initiatives to Lead by Example* strategy can be found in Figure 117.

[124] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 117: State of Maryland Initiatives to Lead by Example—Operation Phase**[125]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.7 | $0 | $7,629 |
| 2011 | 0.0 | -$30,518 | -$3,815 |
| 2012 | 0.1 | $0 | $0 |
| 2013 | 0.9 | -$61,035 | -$3,815 |
| 2014 | 2.8 | -$183,105 | $11,444 |
| 2015 | 1.1 | -$183,105 | -$19,073 |
| 2016 | 0.0 | -$183,105 | -$15,259 |
| 2017 | 0.8 | -$183,105 | -$3,815 |
| 2018 | 1.4 | -$122,070 | $0 |
| 2019 | -0.2 | -$183,105 | -$19,073 |
| 2020 | 0.1 | -$122,070 | -$7,629 |
| ***Average*** | ***0.7*** | ***-$113,747*** | ***-$4,855*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain less than one job by 2020, result in approximately $0.1 million in forgone output and $4,855 in forgone wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Accommodations and Food Services.* The increased income to those in the region from reduced energy consumption by larger government buildings may be an indirect impact to the households' utility bill over time.

**Operation Phase—Enhancement**

The average annual economic impacts of the operation phase of the *State of Maryland Initiatives to Lead by Example* strategy can be found in Figure 118.

[125] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 118: State of Maryland Initiatives to Lead by Example—Operation Phase**[126]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.7 | $0 | $7,629 |
| 2011 | 0.0 | -$30,518 | -$3,815 |
| 2012 | 0.1 | $0 | $0 |
| 2013 | 0.9 | -$61,035 | -$3,815 |
| 2014 | 2.8 | -$183,105 | $11,444 |
| 2015 | 1.6 | -$249,689 | -$26,009 |
| 2016 | 0.0 | -$249,689 | -$20,807 |
| 2017 | 1.1 | -$249,689 | -$5,202 |
| 2018 | 1.9 | -$166,460 | $0 |
| 2019 | -0.3 | -$249,689 | -$26,009 |
| 2020 | 0.1 | -$166,460 | -$10,404 |
| ***Average*** | ***0.8*** | ***-$146,030*** | ***-$6,999*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain less than one job by 2020, result in approximately $0.1 million in forgone output and $6,999 in forgone wages on average each year. The industry experiencing the greatest positive economic impacts in terms of employment due to this phase of the strategy is *Accommodations and Food Services.* The increased income to those in the region from reduced energy consumption by larger government buildings may be an indirect impact to the households' utility bill over time.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $1,863,783 during the investment phase and decrease by $17,999 during the operation phase.

If the strategy is enhanced, the total state and local tax revenues would increase by $2,539,828 during the investment phase and decrease by $25,713 during the operation phase.

### 3.7.7 Leadership-by-Example – Maryland University Lead-by-Example Initiatives

In Maryland, the presidents' of 23 colleges and universities—including all USM schools, Morgan, SMCM, 4 community colleges and 4 independent institutions— have signed the American College and 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. Schools are encouraged to commit to become climate neutral by a certain date, meaning GHG emissions sourced from the school be reduced or

[126] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

mitigated from a base year, with remaining emissions offset by purchasing carbon credits or other means.

**Investment Phase**

The average annual economic impacts of the investment phase of the *Leadership-by-Example – Maryland University Lead-by-Example Initiatives* strategy can be found in Figure 119.

**Figure 119: Leadership-by-Example – Maryland University Lead-by-Example Initiatives—Investment Phase**[127]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 101.9 | $7,843,018 | $3,677,368 |
| 2011 | 104.3 | $8,026,123 | $3,967,285 |
| 2012 | 102.9 | $7,934,570 | $4,226,685 |
| 2013 | 101.9 | $7,843,018 | $4,409,790 |
| 2014 | 99.1 | $7,781,982 | $4,562,378 |
| 2015 | 95.0 | $7,568,359 | $4,684,448 |
| 2016 | 93.0 | $7,446,289 | $4,791,260 |
| 2017 | 91.0 | $7,385,254 | $4,943,848 |
| 2018 | 89.4 | $7,385,254 | $5,096,436 |
| 2019 | 86.5 | $7,324,219 | $5,157,471 |
| 2020 | 85.8 | $7,263,184 | $5,249,023 |
| ***Average*** | ***95.5*** | ***$7,618,297*** | ***$4,615,090*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 86 jobs by 2020, and generate $7.6 million in output and $4.6 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment due to this strategy are *Sales, office, and administrative occupations*. Universities must lead by example by obtaining high performance and energy-efficient buildings, and fleet vehicles among other measures. Environmental consultants will likely be contracted to assist and advise in the planning and implementation of building efficiency, efficient appliance purchasing, optimized operations, waste minimization, and other measures.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Leadership-by-Example – Maryland University Lead-by-Example Initiatives* strategy can be found in Figure 120.

[127] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 120: Leadership-by-Example – Maryland University Lead-by-Example Initiatives—Operation Phase[128]**

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.0 | $0 | $0 |
| 2020 | 96.0 | $5,615,234 | $5,386,353 |
| ***Average*** | ***96.0*** | ***$5,615,234*** | ***$5,386,353*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain approximately 96 jobs by 2020, and generate $5.6 million in output and $5.4 million in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment due to this strategy are *Sales, office, and administrative occupations* and *Construction and extraction occupations*. Leading by example will result in higher efficiency and subsequent cost savings for universities within Maryland's higher education system, which will in turn be able to support additional employment. Other industry sectors will benefit from the ongoing sustainable purchasing by universities which are continuing implementation and operation of this strategy.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would accumulate to approximately $1,886,382 during the investment phase and $1,064,665 during the operation phase.

### 3.7.8 Transportation and Climate Initiative

The Transportation and Climate Initiative (TCI) is a regional effort of Maryland and 10 other Northeast and Mid-Atlantic states and Washington, D.C.[1] 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.

[128] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Investment Phase**
The average annual economic impacts of the investment phase of the *Transportation and Climate Initiative* strategy can be found in Figure 121.

**Figure 121: Transportation and Climate Initiative—Investment Phase**[129]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.0 | $0 | $0 |
| 2020 | 0.0 | $0 | $0 |
| ***Average*** | ***0.0*** | ***$0*** | ***$0*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will not have an impact on jobs, output or wages. To date, there has been no investment phase costs or benefits associated with this strategy.

**Operation Phase**
The average annual economic impacts of the operation phase of the *Transportation and Climate Initiative* strategy can be found in Figure 122.

[129] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 122: Transportation and Climate Initiative—Operation Phase**[130]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 1.4 | $87,194 | $87,194 |
| 2014 | 1.7 | $174,386 | $43,597 |
| 2015 | 0.9 | $0 | $43,597 |
| 2016 | 2.6 | $174,386 | $130,789 |
| 2017 | 1.7 | $174,386 | $174,386 |
| 2018 | 0.6 | $0 | $43,597 |
| 2019 | 0.9 | $174,386 | $87,194 |
| 2020 | 0.6 | $0 | $87,194 |
| ***Average*** | ***1.3*** | ***$98,092*** | ***$87,194*** |

Source: REMI PI+, RESI

As shown in Figure 122, the strategy will maintain approximately one job by 2020, and generate $98,092 in output and $87,194 in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment as a result of this strategy are those with goods and services demanded by new employees and households directly related to the strategic efforts of TCI to reduce GHGs in the transportation sector.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would not be impacted during the operation phase and increase by $5,867,295 for the investment phase.

### 3.8.1 Greenhouse Gas Emissions Inventory Development

Emissions inventories are essential to developing environmental policies. The quality of a state-specific inventory is vital to the process if Maryland expects to set and achieve realistic pollution reduction goals. A baseline GHG inventory will pinpoint the business sectors that contribute to Maryland's GHG emissions, identifying where priorities should be placed in the development of climate policies. It also is necessary to determine what Maryland's future GHG emissions will be through the use of a forecast and modeling. Since GHG emissions may increase in the future, Maryland can take advantage of any cost-effective opportunities for early GHG reductions that may exist.

[130] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

The GGRA identified 2006 as the base year for Maryland's process and as the year for the first compliance-quality inventory. Since Maryland GHG data existed for 2006, using 2006 as the base year for Maryland's GHG inventory made sense from a resource perspective

**Investment Phase**

The average annual economic impacts of the investment phase of the *Greenhouse Gas Emission Inventory and Development* strategy can be found in Figure 123.

**Figure 123: Greenhouse Gas Emissions Inventory Development —Investment Phase**[131]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 22.2 | $1,708,984 | $793,457 |
| 2011 | 23.2 | $1,739,502 | $854,492 |
| 2012 | 23.0 | $1,800,537 | $946,045 |
| 2013 | 22.5 | $1,739,502 | $976,563 |
| 2014 | 22.2 | $1,770,020 | $991,821 |
| 2015 | 20.9 | $1,647,949 | $1,022,339 |
| 2016 | 20.4 | $1,647,949 | $1,037,598 |
| 2017 | 20.0 | $1,647,949 | $1,083,374 |
| 2018 | 20.6 | $1,647,949 | $1,129,150 |
| 2019 | 20.0 | $1,708,984 | $1,144,409 |
| 2020 | 19.3 | $1,647,949 | $1,129,150 |
| ***Average*** | ***21.3*** | ***$1,700,661*** | ***$1,009,854*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will maintain approximately 19 jobs by 2020, and generate $1.7 million in output and $1.0 million in wages on average each year. Overall, the most significant gains for this strategy were recorded in the *Professional, scientific, and technical services* sector. The strategy's reliance on a well maintained and coordinated database would require skilled individuals within this sector to provide services.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Transportation and Climate Initiative* strategy can be found in Figure 124.

[131] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 124: Transportation and Climate Initiative—Operation Phase**[132]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.0 | $0 | $0 |
| 2020 | 0.0 | $0 | $0 |
| ***Average*** | ***0.0*** | ***$0*** | ***$0*** |

Source: REMI PI+, RESI

As shown in Figure 124, the strategy will have no discernable impact on the economy.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues would increase by $428,591 during the investment phase and have no impact during the operation phase.

## 3.8 Outreach

### 3.8.1 Outreach and Public Education

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 promote new actions and encourage continuation of existing efforts such as the educational efforts and action campaigns of State agencies, such as MDE, DNR, 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.

**Investment Phase**

The average annual economic impacts of the investment phase of the *Outreach and Public Education* strategy can be found in Figure 125.

[132] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 125: Outreach and Public Education—Investment Phase**[133]

| Year | Jobs | Output | Wages |
|---|---|---|---|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.0 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $0 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | 0.0 | $0 | $0 |
| 2017 | 0.0 | $0 | $0 |
| 2018 | 0.0 | $0 | $0 |
| 2019 | 0.0 | $0 | $0 |
| 2020 | 0.0 | $0 | $0 |
| ***Average*** | ***0.0*** | ***$0*** | ***$0*** |

Source: REMI PI+, RESI

As shown in the figure above, the investment phase of this strategy's implementation will have no discernable impact on the economy.

**Operation Phase**

The average annual economic impacts of the operation phase of the *Outreach and Public Education* strategy can be found in Figure 126.

[133] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Figure 126: Outreach and Public Education—Operation Phase**[134]

| Year | Jobs | Output | Wages |
|---|---:|---:|---:|
| 2010 | 0.0 | $0 | $0 |
| 2011 | 0.0 | $0 | $0 |
| 2012 | 0.1 | $0 | $0 |
| 2013 | 0.0 | $0 | $0 |
| 2014 | 0.0 | $30,518 | $0 |
| 2015 | 0.0 | $0 | $0 |
| 2016 | -0.1 | $0 | $0 |
| 2017 | 0.4 | $0 | $15,259 |
| 2018 | 0.4 | $0 | $0 |
| 2019 | 0.3 | $61,035 | $30,518 |
| 2020 | 0.1 | $61,035 | $15,259 |
| ***Average*** | ***0.1*** | ***$13,872*** | ***$5,549*** |

Source: REMI PI+, RESI

As shown in the figure above, the strategy will maintain less than one job by 2020, and generate $13,872 in output and $5,549 in wages on average each year. The industries experiencing the greatest positive economic impacts in terms of employment due to this strategy are primarily those industries (such as *Sales, office, and administrative occupations* and *Management, business, and financial occupations)* which will experience increased consumption of goods and services as successful outreach and education create some change in consumption behavior and spending patterns for both businesses and consumers.

**Fiscal Impacts**

As a result of the previously discussed activities contributing to the economic impacts of the strategy, the total state and local tax revenues not be impacted during the investment phase, and would increase by $6,541,298 during the operation phase.

[134] Values are adjusted for inflation Summed impacts throughout the report may not add up exactly to totals due to rounding

**Refined Economic Impact Analysis for the Greenhouse Gas Emissions Reduction Act 2012 Plan – Appendices A through B**

*Prepared for*
Maryland Department of the Environment

October 6, 2015

Regional Economic Studies Institute

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## Appendix A—Detailed Impacts

### A.1 Energy

**Figure 1: Regional Greenhouse Gas Initiative Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 2: Regional Greenhouse Gas Initiative Status Quo—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, REMI PI+

**Figure 3: Regional Greenhouse Gas Initiative Status Quo—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, REMI PI+

**Figure 4: Regional Greenhouse Gas Initiative Enhanced—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, REMI PI+

**Figure 5: Regional Greenhouse Gas Initiative Enhanced—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*** |

Sources: RESI, REMI PI+

**Figure 6: Regional Greenhouse Gas Initiative Enhanced—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*** |

Sources: RESI, REMI PI+

**Figure 7: Regional Greenhouse Initiative Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 8: Regional Greenhouse Initiative Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 9: Regional Greenhouse Initiative Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 10: Regional Greenhouse Initiative Enhanced—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 | 1,498.6 | 84.3 | 1,583.0 |
| 2015 | 1,410.1 | -19.5 | 1,390.6 |
| 2016 | 1,339.3 | -105.3 | 1,234.0 |
| 2017 | 1,314.0 | -177.0 | 1,137.1 |
| 2018 | 1,275.8 | -231.6 | 1,044.1 |
| 2019 | 1,276.0 | -271.3 | 1,004.7 |
| 2020 | 1,298.9 | -292.0 | 1,006.8 |
| ***Average*** | ***929.1*** | ***-75.3*** | ***853.8*** |

Sources: RESI, REMI PI+

**Figure 11: Regional Greenhouse Initiative Enhanced—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 | $71,283,567 | $3,835,265 | $75,118,832 |
| 2015 | $53,491,941 | $2,878,023 | $56,369,964 |
| 2016 | $39,471,728 | $2,123,694 | $41,595,422 |
| 2017 | $29,175,748 | $1,569,741 | $30,745,488 |
| 2018 | $20,010,524 | $1,076,625 | $21,087,148 |
| 2019 | $14,857,137 | $799,357 | $15,656,495 |
| 2020 | $11,973,125 | $644,189 | $12,617,314 |
| ***Average*** | ***$27,207,562*** | ***$1,463,846*** | ***$28,671,408*** |

Sources: RESI, REMI PI+

**Figure 12: Regional Greenhouse Initiative Enhanced—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 | $92,450,143 | $4,974,088 | $97,424,232 |
| 2015 | $93,188,592 | $5,013,819 | $98,202,411 |
| 2016 | $93,310,004 | $5,020,351 | $98,330,355 |
| 2017 | $96,796,621 | $5,207,942 | $102,004,563 |
| 2018 | $98,958,293 | $5,324,246 | $104,282,539 |
| 2019 | $102,546,545 | $5,517,304 | $108,063,850 |
| 2020 | $107,591,834 | $5,788,756 | $113,380,590 |
| ***Average*** | ***$66,065,221*** | ***$3,554,502*** | ***$69,619,723*** |

Sources: RESI, REMI PI+

**Figure 13: 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*** |

Sources: RESI, REMI PI+

**Figure 14: 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*** |

Sources: RESI, REMI PI+

**Figure 15: 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*** |

Sources: RESI, REMI PI+

**Figure 16: 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*** |

Sources: RESI, REMI PI+

**Figure 17: 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*** |

Sources: RESI, REMI PI+

**Figure 18: 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*** |

Sources: RESI, REMI PI+

**Figure 19: 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*** |

Sources: RESI, REMI PI+

**Figure 20: 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*** |

Sources: RESI, REMI PI+

**Figure 21: 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*** |

Sources: RESI, REMI PI+

**Figure 22: 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*** |

Sources: RESI, REMI PI+

**Figure 23: 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*** |

Sources: RESI, REMI PI+

**Figure 24: 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*** |

Sources: RESI, REMI PI+

**Figure 25: 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*** |

Sources: RESI, REMI PI+

**Figure 26: 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*** |

Sources: RESI, REMI PI+

**Figure 27: 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*** |

Sources: RESI, REMI PI+

**Figure 28: 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*** |

Sources: RESI, REMI PI+

**Figure 29: 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*** |

Sources: RESI, REMI PI+

**Figure 30: 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*** |

Sources: RESI, REMI PI+

**Figure 31: Energy Efficiency in the Residential Sector Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 32: Energy Efficiency in the Residential Sector Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 33: Energy Efficiency in the Residential Sector Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 34: Energy Efficiency in the Residential Sector Enhanced—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 | 1,563.4 | 1,447.1 | 3,010.6 |
| 2016 | 190.5 | 173.4 | 363.9 |
| 2017 | 32.3 | 27.8 | 60.1 |
| 2018 | -38.8 | -36.6 | -75.3 |
| 2019 | -52.4 | -48.4 | -100.8 |
| 2020 | -37.6 | -34.2 | -71.8 |
| ***Average*** | ***1,159.7*** | ***1,050.7*** | ***2,210.3*** |

Sources: RESI, REMI PI+

**Figure 35: Energy Efficiency in the Residential Sector Enhanced—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 | $92,270,966 | $83,597,313 | $175,868,279 |
| 2016 | $2,180,134 | $1,975,197 | $4,155,331 |
| 2017 | -$8,431,989 | -$7,639,365 | -$16,071,354 |
| 2018 | -$13,048,743 | -$11,822,136 | -$24,870,879 |
| 2019 | -$13,625,838 | -$12,344,982 | -$25,970,819 |
| 2020 | -$12,247,223 | -$11,095,960 | -$23,343,184 |
| ***Average*** | ***$67,054,751*** | ***$60,751,472*** | ***$127,806,223*** |

Sources: RESI, REMI PI+

**Figure 36: Energy Efficiency in the Residential Sector Enhanced—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 | $47,946,918 | $43,439,813 | $91,386,731 |
| 2016 | $10,892,655 | $9,868,724 | $20,761,379 |
| 2017 | $3,887,371 | $3,521,951 | $7,409,322 |
| 2018 | -$424,806 | -$384,873 | -$809,678 |
| 2019 | -$2,572,879 | -$2,331,023 | -$4,903,902 |
| 2020 | -$3,262,186 | -$2,955,534 | -$6,217,720 |
| ***Average*** | ***$31,046,993*** | ***$28,128,514*** | ***$59,175,507*** |

Sources: RESI, REMI PI+

**Figure 37: Energy Efficiency in the Residential Sector Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 38: Energy Efficiency in the Residential Sector Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 39: Energy Efficiency in the Residential Sector Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 40: Energy Efficiency in the Residential Sector Enhanced—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 | 40.2 | 77.6 |
| 2017 | 37.5 | 39.7 | 77.2 |
| 2018 | 36.7 | 39.0 | 75.8 |
| 2019 | 35.9 | 38.3 | 74.2 |
| 2020 | 37.3 | 39.3 | 76.7 |
| ***Average*** | ***43.4*** | ***45.7*** | ***89.0*** |

Sources: RESI, REMI PI+

**Figure 41: Energy Efficiency in the Residential Sector Enhanced—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 | -$2,618,938 | -$2,758,549 | -$5,377,487 |
| 2016 | -$2,648,699 | -$2,789,897 | -$5,438,595 |
| 2017 | -$2,648,699 | -$2,789,897 | -$5,438,595 |
| 2018 | -$2,678,459 | -$2,821,244 | -$5,499,703 |
| 2019 | -$2,648,699 | -$2,789,897 | -$5,438,595 |
| 2020 | -$2,589,177 | -$2,727,202 | -$5,316,380 |
| ***Average*** | ***-$2,362,168*** | ***-$2,488,092*** | ***-$4,850,260*** |

Sources: RESI, REMI PI+

**Figure 42: Energy Efficiency in the Residential Sector Enhanced—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 | $215,765 | $227,267 | $443,032 |
| 2016 | $186,004 | $195,920 | $381,924 |
| 2017 | $215,765 | $227,267 | $443,032 |
| 2018 | $193,444 | $203,756 | $397,201 |
| 2019 | $200,884 | $211,593 | $412,478 |
| 2020 | $260,406 | $274,288 | $534,693 |
| ***Average*** | ***$291,310*** | ***$306,839*** | ***$598,149*** |

Sources: RESI, REMI PI+

**Figure 43: Energy Efficiency in the Commercial and Industrial Sectors Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 44: Energy Efficiency in the Commercial and Industrial Sectors Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 45: Energy Efficiency in the Commercial and Industrial Sectors Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 46: Energy Efficiency in the Commercial and Industrial Sectors Enhanced—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 | 2,303.6 | 906.5 | 3,210.1 |
| 2016 | 4,105.1 | 1,626.6 | 5,731.7 |
| 2017 | 4,144.8 | 1,677.6 | 5,822.4 |
| 2018 | 4,155.2 | 1,701.2 | 5,856.3 |
| 2019 | 4,153.7 | 1,701.8 | 5,855.5 |
| 2020 | 4,164.9 | 1,709.9 | 5,874.8 |
| ***Average*** | ***3,046.5*** | ***1,217.0*** | ***4,263.5*** |

Sources: RESI, REMI PI+

**Figure 47: Energy Efficiency in the Commercial and Industrial Sectors Enhanced—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 | $174,093,734 | $69,537,321 | $243,631,055 |
| 2016 | $319,818,925 | $127,743,548 | $447,562,472 |
| 2017 | $324,495,543 | $129,611,504 | $454,107,047 |
| 2018 | $327,980,947 | $131,003,660 | $458,984,607 |
| 2019 | $327,980,947 | $131,003,660 | $458,984,607 |
| 2020 | $329,260,399 | $131,514,705 | $460,775,104 |
| ***Average*** | ***$235,745,906*** | ***$94,162,716*** | ***$329,908,622*** |

Sources: RESI, REMI PI+

**Figure 48: Energy Efficiency in the Commercial and Industrial Sectors Enhanced—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 | $96,620,699 | $38,592,684 | $135,213,383 |
| 2016 | $177,038,680 | $70,713,605 | $247,752,285 |
| 2017 | $187,318,416 | $74,819,584 | $262,138,001 |
| 2018 | $196,076,046 | $78,317,597 | $274,393,643 |
| 2019 | $200,962,229 | $80,269,259 | $281,231,489 |
| 2020 | $205,506,491 | $82,084,349 | $287,590,840 |
| ***Average*** | ***$132,823,410*** | ***$53,052,938*** | ***$185,876,348*** |

Sources: RESI, REMI PI+

**Figure 49: Energy Efficiency in the Commercial and Industrial Sectors Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 50: Energy Efficiency in the Commercial and Industrial Sectors Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 51: Energy Efficiency in the Commercial and Industrial Sectors Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 52: Energy Efficiency in the Commercial and Industrial Sectors Enhanced—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 | 2,093.8 | 1,846.1 | 3,939.9 |
| 2016 | 2,373.9 | 2,075.9 | 4,449.7 |
| 2017 | 2,562.4 | 2,222.4 | 4,784.8 |
| 2018 | 2,669.8 | 2,294.5 | 4,964.3 |
| 2019 | 2,694.2 | 2,296.4 | 4,990.6 |
| 2020 | 2,675.9 | 2,260.6 | 4,936.4 |
| ***Average*** | ***1,724.1*** | ***1,496.5*** | ***3,220.6*** |

Sources: RESI, REMI PI+

**Figure 53: Energy Efficiency in the Commercial and Industrial Sectors Enhanced—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 | $198,077,227 | $171,938,209 | $370,015,436 |
| 2016 | $236,383,836 | $205,189,733 | $441,573,569 |
| 2017 | $267,584,387 | $232,272,942 | $499,857,329 |
| 2018 | $293,529,761 | $254,794,466 | $548,324,226 |
| 2019 | $311,708,048 | $270,573,878 | $582,281,925 |
| 2020 | $325,821,009 | $282,824,439 | $608,645,448 |
| ***Average*** | ***$179,485,964*** | ***$155,800,319*** | ***$335,286,282*** |

Sources: RESI, REMI PI+

**Figure 54: Energy Efficiency in the Commercial and Industrial Sectors Enhanced—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 | $51,114,038 | $44,368,837 | $95,482,875 |
| 2016 | $61,087,308 | $53,025,996 | $114,113,304 |
| 2017 | $68,970,074 | $59,868,523 | $128,838,597 |
| 2018 | $75,092,852 | $65,183,316 | $140,276,167 |
| 2019 | $77,803,069 | $67,535,882 | $145,338,952 |
| 2020 | $78,860,715 | $68,453,957 | $147,314,672 |
| ***Average*** | ***$45,386,479*** | ***$39,397,108*** | ***$84,783,586*** |

Sources: RESI, REMI PI+

**Figure 55: 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*** |

Sources: RESI, REMI PI+

**Figure 56: 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*** |

Sources: RESI, REMI PI+

**Figure 57: 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*** |

Sources: RESI, REMI PI+

**Figure 58: 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*** |

Sources: RESI, REMI PI+

**Figure 59: 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*** |

Sources: RESI, REMI PI+

**Figure 60: 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*** |

Sources: RESI, REMI PI+

**Figure 61: Energy Efficiency in the Power Sector – General Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 62: Energy Efficiency in the Power Sector – General Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 63: Energy Efficiency in the Power Sector – General Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 64: Energy Efficiency in the Power Sector – General Enhanced—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 | -1,818.1 | -1,576.2 | -3,394.3 |
| 2016 | -1,914.2 | -1,657.0 | -3,571.2 |
| 2017 | -1,984.1 | -1,715.4 | -3,699.5 |
| 2018 | -2,026.1 | -1,747.4 | -3,773.5 |
| 2019 | -2,028.4 | -1,746.7 | -3,775.1 |
| 2020 | -2,020.1 | -1,736.7 | -3,756.8 |
| ***Average*** | ***-1,570.7*** | ***-1,355.9*** | ***-2,926.5*** |

Sources: RESI, REMI PI+

**Figure 65: Energy Efficiency in the Power Sector – General Enhanced—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 | -$197,351,498 | -$170,359,499 | -$367,710,997 |
| 2016 | -$208,058,203 | -$179,601,835 | -$387,660,037 |
| 2017 | -$216,564,450 | -$186,944,672 | -$403,509,122 |
| 2018 | -$223,264,351 | -$192,728,220 | -$415,992,571 |
| 2019 | -$226,417,245 | -$195,449,889 | -$421,867,135 |
| 2020 | -$228,617,703 | -$197,349,388 | -$425,967,091 |
| ***Average*** | ***-$172,794,465*** | ***-$149,161,161*** | ***-$321,955,626*** |

Sources: RESI, REMI PI+

**Figure 66: Energy Efficiency in the Power Sector – General Enhanced—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 | -$59,166,038 | -$51,073,829 | -$110,239,867 |
| 2016 | -$65,143,401 | -$56,233,660 | -$121,377,061 |
| 2017 | -$70,373,593 | -$60,748,513 | -$131,122,107 |
| 2018 | -$75,012,618 | -$64,753,053 | -$139,765,671 |
| 2019 | -$77,245,918 | -$66,680,902 | -$143,926,821 |
| 2020 | -$78,715,627 | -$67,949,597 | -$146,665,224 |
| ***Average*** | ***-$53,390,187*** | ***-$46,087,947*** | ***-$99,478,134*** |

Sources: RESI, REMI PI+

**Figure 67: Energy Efficiency in the Power Sector – General Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 68: Energy Efficiency in the Power Sector – General Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 69: Energy Efficiency in the Power Sector – General Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 70: Energy Efficiency in the Power Sector – General Enhanced—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 | 388.5 | 336.5 | 725.1 |
| 2016 | 382.1 | 331.5 | 713.6 |
| 2017 | 388.6 | 336.6 | 725.2 |
| 2018 | 387.8 | 334.9 | 722.7 |
| 2019 | 379.9 | 327.7 | 707.5 |
| 2020 | 372.3 | 320.0 | 692.3 |
| ***Average*** | ***272.0*** | ***235.1*** | ***507.2*** |

Sources: RESI, REMI PI+

**Figure 71: Energy Efficiency in the Power Sector – General Enhanced—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 | $43,097,768 | $37,249,135 | $80,346,903 |
| 2016 | $41,423,750 | $35,802,291 | $77,226,041 |
| 2017 | $42,244,347 | $36,511,528 | $78,755,875 |
| 2018 | $42,605,410 | $36,823,592 | $79,429,002 |
| 2019 | $42,474,114 | $36,710,114 | $79,184,229 |
| 2020 | $42,211,523 | $36,483,158 | $78,694,682 |
| ***Average*** | ***$30,051,637*** | ***$25,973,444*** | ***$56,025,081*** |

Sources: RESI, REMI PI+

**Figure 72: Energy Efficiency in the Power Sector – General Enhanced—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 | $12,571,550 | $10,865,513 | $23,437,063 |
| 2016 | $12,973,643 | $11,213,039 | $24,186,682 |
| 2017 | $13,843,476 | $11,964,831 | $25,808,306 |
| 2018 | $14,491,748 | $12,525,128 | $27,016,876 |
| 2019 | $14,639,455 | $12,652,791 | $27,292,246 |
| 2020 | $14,696,897 | $12,702,437 | $27,399,334 |
| ***Average*** | ***$9,431,285*** | ***$8,151,401*** | ***$17,582,686*** |

Sources: RESI, REMI PI+

**Figure 73: Maryland Renewable Energy Portfolio Standard Program Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 74: Maryland Renewable Energy Portfolio Standard Program Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 75: Maryland Renewable Energy Portfolio Standard Program Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 76: Maryland Renewable Energy Portfolio Standard Program Enhanced—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 | 5,485.9 | 5,712.0 | 11,197.9 |
| 2016 | 3,666.9 | 3,823.6 | 7,490.5 |
| 2017 | 20,386.6 | 21,229.9 | 41,616.5 |
| 2018 | 19,513.5 | 21,549.7 | 41,063.2 |
| 2019 | 8,962.1 | 9,314.1 | 18,276.2 |
| 2020 | 3,197.3 | 3,413.2 | 6,610.5 |
| ***Average*** | ***6,486.8*** | ***6,867.7*** | ***13,354.5*** |

Sources: RESI, REMI PI+

**Figure 77: Maryland Renewable Energy Portfolio Standard Program Enhanced—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 | $307,835,183 | $325,885,775 | $633,720,958 |
| 2016 | $202,997,406 | $214,900,605 | $417,898,010 |
| 2017 | $1,149,037,892 | $1,216,414,254 | $2,365,452,146 |
| 2018 | $1,100,827,152 | $1,165,376,571 | $2,266,203,722 |
| 2019 | $498,787,527 | $528,035,030 | $1,026,822,556 |
| 2020 | $162,105,184 | $171,610,578 | $333,715,761 |
| ***Average*** | ***$363,020,453*** | ***$384,306,955*** | ***$747,327,408*** |

Sources: RESI, REMI PI+

**Figure 78: Maryland Renewable Energy Portfolio Standard Program Enhanced—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 | $152,575,863 | $161,522,484 | $314,098,347 |
| 2016 | $114,664,413 | $121,388,012 | $236,052,425 |
| 2017 | $601,254,409 | $636,510,282 | $1,237,764,691 |
| 2018 | $644,174,470 | $681,947,056 | $1,326,121,526 |
| 2019 | $340,981,973 | $360,976,200 | $701,958,172 |
| 2020 | $157,675,956 | $166,921,632 | $324,597,587 |
| ***Average*** | ***$206,274,141*** | ***$218,369,478*** | ***$424,643,619*** |

Sources: RESI, REMI PI+

**Figure 79: Maryland Renewable Energy Portfolio Standard Program Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 80: Maryland Renewable Energy Portfolio Standard Program Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 81: Maryland Renewable Energy Portfolio Standard Program Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 82: Maryland Renewable Energy Portfolio Standard Program Enhanced—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 | -656.2 | -570.8 | -1,227.0 |
| 2016 | -702.8 | -609.4 | -1,312.2 |
| 2017 | -1,000.4 | -871.4 | -1,871.8 |
| 2018 | -1,346.3 | -1,174.7 | -2,521.0 |
| 2019 | -1,580.4 | -1,379.5 | -2,959.9 |
| 2020 | -1,733.4 | -1,511.2 | -3,244.6 |
| ***Average*** | ***-831.2*** | ***-724.7*** | ***-1,555.9*** |

Sources: RESI, REMI PI+

**Figure 83: Maryland Renewable Energy Portfolio Standard Program Enhanced—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 | -$69,690,047 | -$60,757,913 | -$130,447,959 |
| 2016 | -$75,424,887 | -$65,757,722 | -$141,182,609 |
| 2017 | -$105,910,090 | -$92,335,653 | -$198,245,744 |
| 2018 | -$141,392,318 | -$123,270,144 | -$264,662,462 |
| 2019 | -$166,880,497 | -$145,491,517 | -$312,372,014 |
| 2020 | -$185,460,038 | -$161,689,729 | -$347,149,767 |
| ***Average*** | ***-$87,496,351*** | ***-$76,281,992*** | ***-$163,778,343*** |

Sources: RESI, REMI PI+

**Figure 84: Maryland Renewable Energy Portfolio Standard Program Enhanced—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 | -$14,932,384 | -$13,018,508 | -$27,950,892 |
| 2016 | -$17,204,521 | -$14,999,427 | -$32,203,948 |
| 2017 | -$27,751,932 | -$24,194,982 | -$51,946,914 |
| 2018 | -$40,873,313 | -$35,634,603 | -$76,507,917 |
| 2019 | -$50,892,515 | -$44,369,650 | -$95,262,165 |
| 2020 | -$58,362,899 | -$50,882,559 | -$109,245,458 |
| ***Average*** | ***-$23,446,308*** | ***-$20,441,208*** | ***-$43,887,516*** |

Sources: RESI, REMI PI+

**Figure 85: 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 | -114.8 | -215.4 | -330.3 |
| 2016 | -144.4 | -211.1 | -355.5 |
| 2017 | -108.2 | -176.8 | -285.0 |
| 2018 | -94.7 | -150.1 | -244.8 |
| 2019 | -56.4 | -114.3 | -170.7 |
| 2020 | -23.3 | -83.7 | -107.0 |
| ***Average*** | ***-20.4*** | ***-115.7*** | ***-136.1*** |

Sources: RESI, REMI PI+

**Figure 86: 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 | -$2,194,968 | -$13,940,774 | -$16,135,742 |
| 2016 | -$2,522,443 | -$16,020,647 | -$18,543,091 |
| 2017 | -$1,849,792 | -$11,748,475 | -$13,598,267 |
| 2018 | -$1,531,167 | -$9,724,814 | -$11,255,981 |
| 2019 | -$849,665 | -$5,396,429 | -$6,246,094 |
| 2020 | -$274,371 | -$1,742,597 | -$2,016,968 |
| ***Average*** | ***-$575,356*** | ***-$3,654,225*** | ***-$4,229,581*** |

Sources: RESI, REMI PI+

**Figure 87: 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 | -$606,271 | -$3,850,577 | -$4,456,848 |
| 2016 | -$958,086 | -$6,085,035 | -$7,043,121 |
| 2017 | -$763,371 | -$4,848,354 | -$5,611,725 |
| 2018 | -$734,606 | -$4,665,662 | -$5,400,269 |
| 2019 | -$433,683 | -$2,754,427 | -$3,188,110 |
| 2020 | -$146,036 | -$927,511 | -$1,073,547 |
| ***Average*** | ***-$44,464*** | ***-$282,401*** | ***-$326,865*** |

Sources: RESI, REMI PI+

**Figure 88: 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 | 25.7 | 93.5 | 119.2 |
| 2016 | 31.4 | 96.9 | 128.3 |
| 2017 | 34.7 | 98.3 | 133.0 |
| 2018 | 34.8 | 97.2 | 132.0 |
| 2019 | 31.8 | 93.7 | 125.5 |
| 2020 | 28.2 | 89.4 | 117.6 |
| ***Average*** | ***11.2*** | ***82.3*** | ***93.5*** |

Sources: RESI, REMI PI+

**Figure 89: 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 | $1,136,000 | $7,871,080 | $9,007,080 |
| 2016 | $1,351,696 | $9,365,589 | $10,717,285 |
| 2017 | $1,531,443 | $10,611,013 | $12,142,456 |
| 2018 | $1,660,861 | $11,507,718 | $13,168,579 |
| 2019 | $1,739,950 | $12,055,705 | $13,795,654 |
| 2020 | $1,790,279 | $12,404,424 | $14,194,702 |
| ***Average*** | ***$904,126*** | ***$6,264,476*** | ***$7,168,601*** |

Sources: RESI, REMI PI+

**Figure 90: 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 | -$209,253 | -$1,449,866 | -$1,659,119 |
| 2016 | -$172,326 | -$1,194,007 | -$1,366,333 |
| 2017 | -$147,708 | -$1,023,435 | -$1,171,143 |
| 2018 | -$143,605 | -$995,006 | -$1,138,611 |
| 2019 | -$164,120 | -$1,137,149 | -$1,301,270 |
| 2020 | -$198,996 | -$1,378,794 | -$1,577,789 |
| ***Average*** | ***-$264,237*** | ***-$1,830,836*** | ***-$2,095,073*** |

Sources: RESI, REMI PI+

**Figure 91: 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*** |

Sources: RESI, REMI PI+

**Figure 92: 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*** |

Sources: RESI, REMI PI+

[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 93: Offshore Wind Initiatives to Support Renewable Energy Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 94: 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*** |

Sources: RESI, REMI PI+

**Figure 95: 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*** |

Sources: RESI, REMI PI+

**Figure 96: Offshore Wind Initiatives to Support Renewable Energy Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 97: 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*** |

Sources: RESI, REMI PI+

**Figure 98: 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*** |

Sources: RESI, REMI PI+

**Figure 99: 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*** |

Sources: RESI, REMI PI+

**Figure 100: 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*** |

Sources: RESI, REMI PI+

**Figure 101: 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*** |

Sources: RESI, REMI PI+

**Figure 102: 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*** |

Sources: RESI, REMI PI+

**Figure 103: BeSMART Status Quo—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 0.0 | 0.0 |
| 2011 | 499.6 | 467.2 | 966.9 |
| 2012 | 1,298.8 | 1,216.3 | 2,515.1 |
| 2013 | 1,181.9 | 1,106.5 | 2,288.5 |
| 2014 | 1,419.6 | 1,330.4 | 2,750.0 |
| 2015 | 3,722.3 | 3,500.2 | 7,222.5 |
| 2016 | 1,707.1 | 1,599.2 | 3,306.3 |
| 2017 | 1,653.0 | 1,549.1 | 3,202.0 |
| 2018 | 470.0 | 432.5 | 902.5 |
| 2019 | -144.8 | -146.6 | -291.4 |
| 2020 | 357.8 | 331.1 | 689.0 |
| ***Average*** | ***1,105.9*** | ***1,035.1*** | ***2,141.0*** |

Sources: RESI, REMI PI+

**Figure 104: BeSMART Status Quo—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $25,647,660 | $24,004,440 | $49,652,100 |
| 2012 | $67,169,440 | $62,865,960 | $130,035,400 |
| 2013 | $62,125,032 | $58,144,743 | $120,269,775 |
| 2014 | $75,004,035 | $70,198,601 | $145,202,637 |
| 2015 | $196,605,786 | $184,009,448 | $380,615,234 |
| 2016 | $92,060,439 | $86,162,218 | $178,222,656 |
| 2017 | $88,623,936 | $82,945,888 | $171,569,824 |
| 2018 | $24,339,267 | $22,779,874 | $47,119,141 |
| 2019 | -$10,404,091 | -$9,737,511 | -$20,141,602 |
| 2020 | $16,236,687 | $15,196,419 | $31,433,105 |
| ***Average*** | ***$57,946,199*** | ***$54,233,644*** | ***$112,179,843*** |

Sources: RESI, REMI PI+

**Figure 105: BeSMART Status Quo—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $10,634,636 | $9,953,285 | $20,587,921 |
| 2012 | $29,038,842 | $27,178,352 | $56,217,194 |
| 2013 | $28,904,850 | $27,052,945 | $55,957,794 |
| 2014 | $36,282,296 | $33,957,725 | $70,240,021 |
| 2015 | $94,143,227 | $88,111,564 | $182,254,791 |
| 2016 | $51,190,885 | $47,911,136 | $99,102,020 |
| 2017 | $50,796,790 | $47,542,290 | $98,339,081 |
| 2018 | $19,878,119 | $18,604,547 | $38,482,666 |
| 2019 | $614,787 | $575,398 | $1,190,186 |
| 2020 | $12,120,372 | $11,343,831 | $23,464,203 |
| ***Average*** | ***$30,327,709*** | ***$28,384,643*** | ***$58,712,352*** |

Sources: RESI, REMI PI+

**Figure 106: BeSMART Enhanced—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 0.0 | 0.0 |
| 2011 | 499.6 | 467.2 | 966.9 |
| 2012 | 1,298.8 | 1,216.3 | 2,515.1 |
| 2013 | 1,181.9 | 1,106.5 | 2,288.5 |
| 2014 | 2,534.7 | 2,379.4 | 4,914.2 |
| 2015 | 6,717.4 | 6,320.2 | 13,037.6 |
| 2016 | 3,113.3 | 2,918.7 | 6,032.0 |
| 2017 | 3,023.7 | 2,835.9 | 5,859.6 |
| 2018 | 895.9 | 827.2 | 1,723.1 |
| 2019 | -215.7 | -220.1 | -435.8 |
| 2020 | 684.9 | 635.5 | 1,320.4 |
| ***Average*** | ***1,794.0*** | ***1,680.6*** | ***3,474.7*** |

Sources: RESI, REMI PI+

**Figure 107: BeSMART Enhanced—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $0 | $0 | $0 |
| 2011 | $25,636,390 | $24,015,709 | $49,652,100 |
| 2012 | $67,139,926 | $62,895,474 | $130,035,400 |
| 2013 | $62,097,735 | $58,172,041 | $120,269,775 |
| 2014 | $133,082,332 | $124,669,133 | $257,751,465 |
| 2015 | $354,560,576 | $332,145,967 | $686,706,543 |
| 2016 | $168,062,532 | $157,437,956 | $325,500,488 |
| 2017 | $162,610,663 | $152,330,743 | $314,941,406 |
| 2018 | $47,049,946 | $44,075,543 | $91,125,488 |
| 2019 | -$15,693,820 | -$14,701,688 | -$30,395,508 |
| 2020 | $31,986,400 | $29,964,284 | $61,950,684 |
| ***Average*** | ***$94,230,244*** | ***$88,273,197*** | ***$182,503,440*** |

Sources: RESI, REMI PI+

**Figure 108: BeSMART Enhanced—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $0 | $0 | $0 |
| 2011 | $10,629,963 | $9,957,958 | $20,587,921 |
| 2012 | $29,026,082 | $27,191,111 | $56,217,194 |
| 2013 | $28,892,149 | $27,065,645 | $55,957,794 |
| 2014 | $62,304,543 | $58,365,775 | $120,670,319 |
| 2015 | $168,285,098 | $157,646,451 | $325,931,549 |
| 2016 | $92,301,641 | $86,466,517 | $178,768,158 |
| 2017 | $92,398,152 | $86,556,926 | $178,955,078 |
| 2018 | $37,266,913 | $34,910,974 | $72,177,887 |
| 2019 | $2,792,901 | $2,616,340 | $5,409,241 |
| 2020 | $23,619,514 | $22,126,336 | $45,745,850 |
| ***Average*** | ***$49,774,269*** | ***$46,627,639*** | ***$96,401,908*** |

Sources: RESI, REMI PI+

**Figure 109: BeSMART Status Quo—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 0.0 | 0.0 |
| 2011 | 0.0 | 0.1 | 0.1 |
| 2012 | 0.0 | -0.1 | -0.1 |
| 2013 | 0.2 | 0.2 | 0.5 |
| 2014 | 0.3 | 0.2 | 0.5 |
| 2015 | 0.3 | 0.2 | 0.5 |
| 2016 | 0.3 | 0.3 | 0.6 |
| 2017 | 0.2 | 0.2 | 0.5 |
| 2018 | 0.8 | 0.5 | 1.3 |
| 2019 | 1.0 | 0.8 | 1.8 |
| 2020 | 0.6 | 0.6 | 1.2 |
| ***Average*** | ***0.3*** | ***0.3*** | ***0.6*** |

Sources: RESI, REMI PI+

**Figure 110: BeSMART Status Quo—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $0 | $0 | $0 |
| 2013 | $16,809 | $13,709 | $30,518 |
| 2014 | $33,618 | $27,418 | $61,035 |
| 2015 | $0 | $0 | $0 |
| 2016 | $0 | $0 | $0 |
| 2017 | $0 | $0 | $0 |
| 2018 | $67,235 | $54,835 | $122,070 |
| 2019 | $33,618 | $27,418 | $61,035 |
| 2020 | $33,618 | $27,418 | $61,035 |
| ***Average*** | ***$16,809*** | ***$13,709*** | ***$30,518*** |

Sources: RESI, REMI PI+

**Figure 111: BeSMART Status Quo—Operation Phase, Wages Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | -$2,101 | -$1,714 | -$3,815 |
| 2012 | $0 | $0 | $0 |
| 2013 | $4,202 | $3,427 | $7,629 |
| 2014 | $0 | $0 | $0 |
| 2015 | $10,505 | $8,568 | $19,073 |
| 2016 | $10,505 | $8,568 | $19,073 |
| 2017 | $8,404 | $6,854 | $15,259 |
| 2018 | $18,910 | $15,422 | $34,332 |
| 2019 | $27,314 | $22,277 | $49,591 |
| 2020 | $14,708 | $11,995 | $26,703 |
| ***Average*** | ***$8,404*** | ***$6,854*** | ***$15,259*** |

Sources: RESI, REMI PI+

**Figure 112: BeSMART Enhanced—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 0.0 | 0.0 |
| 2011 | 0.0 | 0.1 | 0.1 |
| 2012 | 0.0 | 0.0 | 0.0 |
| 2013 | 0.5 | 0.4 | 0.9 |
| 2014 | 0.5 | 0.4 | 1.0 |
| 2015 | 0.5 | 0.2 | 0.7 |
| 2016 | 0.5 | 0.6 | 1.2 |
| 2017 | 0.5 | 0.5 | 1.0 |
| 2018 | 1.1 | 1.0 | 2.1 |
| 2019 | 1.3 | 1.1 | 2.4 |
| 2020 | 1.1 | 1.0 | 2.1 |
| ***Average*** | ***0.6*** | ***0.5*** | ***1.0*** |

Sources: RESI, REMI PI+

**Figure 113: BeSMART Enhanced—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $0 | $0 | $0 |
| 2013 | $16,298 | $14,220 | $30,518 |
| 2014 | $32,596 | $28,440 | $61,035 |
| 2015 | $0 | $0 | $0 |
| 2016 | $32,596 | $28,440 | $61,035 |
| 2017 | $32,596 | $28,440 | $61,035 |
| 2018 | $97,787 | $85,319 | $183,105 |
| 2019 | $65,191 | $56,879 | $122,070 |
| 2020 | $65,191 | $56,879 | $122,070 |
| ***Average*** | ***$31,114*** | ***$27,147*** | ***$58,261*** |

Sources: RESI, REMI PI+

**Figure 114: BeSMART Enhanced—Operation Phase, Wages Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | -$2,037 | -$1,777 | -$3,815 |
| 2012 | $0 | $0 | $0 |
| 2013 | $8,149 | $7,110 | $15,259 |
| 2014 | $8,149 | $7,110 | $15,259 |
| 2015 | $10,186 | $8,887 | $19,073 |
| 2016 | $16,298 | $14,220 | $30,518 |
| 2017 | $16,298 | $14,220 | $30,518 |
| 2018 | $28,521 | $24,885 | $53,406 |
| 2019 | $36,670 | $31,995 | $68,665 |
| 2020 | $30,558 | $26,662 | $57,220 |
| ***Average*** | ***$13,890*** | ***$12,119*** | ***$26,009*** |

Sources: RESI, REMI PI+

**Figure 115: Weatherization and Energy Efficiency for Low-Income Houses Status Quo—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 348.3 | 337.1 | 685.4 |
| 2011 | 814.8 | 787.4 | 1,602.1 |
| 2012 | 911.7 | 878.9 | 1,790.5 |
| 2013 | 428.3 | 409.0 | 837.2 |
| 2014 | 754.2 | 725.1 | 1,479.3 |
| 2015 | 912.1 | 877.6 | 1,789.6 |
| 2016 | 916.0 | 880.6 | 1,796.6 |
| 2017 | 635.0 | 607.1 | 1,242.1 |
| 2018 | 110.5 | 98.1 | 208.6 |
| 2019 | 83.3 | 73.8 | 157.1 |
| 2020 | 72.9 | 64.7 | 137.6 |
| ***Average*** | ***544.3*** | ***521.7*** | ***1,066.0*** |

Sources: RESI, REMI PI+

**Figure 116: Weatherization and Energy Efficiency for Low-Income Houses Status Quo—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $7,665,990 | $7,348,658 | $15,014,648 |
| 2011 | $18,510,562 | $17,744,321 | $36,254,883 |
| 2012 | $21,642,400 | $20,746,516 | $42,388,916 |
| 2013 | $11,015,966 | $10,559,962 | $21,575,928 |
| 2014 | $18,198,936 | $17,445,595 | $35,644,531 |
| 2015 | $22,156,582 | $21,239,414 | $43,395,996 |
| 2016 | $22,624,020 | $21,687,503 | $44,311,523 |
| 2017 | $15,768,257 | $15,115,533 | $30,883,789 |
| 2018 | $1,994,404 | $1,911,846 | $3,906,250 |
| 2019 | $93,488 | $89,618 | $183,105 |
| 2020 | -$654,414 | -$627,324 | -$1,281,738 |
| ***Average*** | ***$12,637,836*** | ***$12,114,695*** | ***$24,752,530*** |

Sources: RESI, REMI PI+

**Figure 117: Weatherization and Energy Efficiency for Low-Income Houses Status Quo—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $4,074,505 | $3,905,842 | $7,980,347 |
| 2011 | $10,046,031 | $9,630,177 | $19,676,208 |
| 2012 | $12,340,375 | $11,829,547 | $24,169,922 |
| 2013 | $7,239,453 | $6,939,777 | $14,179,230 |
| 2014 | $11,202,941 | $10,739,198 | $21,942,139 |
| 2015 | $13,787,486 | $13,216,756 | $27,004,242 |
| 2016 | $14,527,597 | $13,926,230 | $28,453,827 |
| 2017 | $10,903,002 | $10,451,674 | $21,354,675 |
| 2018 | $2,678,033 | $2,567,176 | $5,245,209 |
| 2019 | $880,342 | $843,901 | $1,724,243 |
| 2020 | -$185,028 | -$177,369 | -$362,396 |
| ***Average*** | ***$7,954,067*** | ***$7,624,810*** | ***$15,578,877*** |

Sources: RESI, REMI PI+

**Figure 118: Weatherization and Energy Efficiency for Low-Income Houses Enhanced—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 348.3 | 337.1 | 685.4 |
| 2011 | 814.8 | 787.4 | 1,602.1 |
| 2012 | 911.7 | 878.9 | 1,790.5 |
| 2013 | 428.3 | 409.0 | 837.2 |
| 2014 | 1,483.2 | 1,432.0 | 2,915.2 |
| 2015 | 1,821.4 | 1,756.9 | 3,578.4 |
| 2016 | 1,837.5 | 1,769.8 | 3,607.3 |
| 2017 | 1,276.2 | 1,222.5 | 2,498.8 |
| 2018 | 222.2 | 200.0 | 422.2 |
| 2019 | 163.9 | 147.0 | 310.9 |
| 2020 | 137.8 | 124.1 | 261.9 |
| ***Average*** | ***858.7*** | ***824.0*** | ***1,682.7*** |

Sources: RESI, REMI PI+

**Figure 119: Weatherization and Energy Efficiency for Low-Income Houses Enhanced—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $7,661,781 | $7,352,868 | $15,014,648 |
| 2011 | $18,500,397 | $17,754,486 | $36,254,883 |
| 2012 | $21,630,515 | $20,758,401 | $42,388,916 |
| 2013 | $11,009,917 | $10,566,011 | $21,575,928 |
| 2014 | $35,443,522 | $34,014,486 | $69,458,008 |
| 2015 | $44,911,739 | $43,100,957 | $88,012,695 |
| 2016 | $46,469,011 | $44,595,442 | $91,064,453 |
| 2017 | $32,858,450 | $31,533,640 | $64,392,090 |
| 2018 | $5,045,563 | $4,842,132 | $9,887,695 |
| 2019 | $1,027,800 | $986,360 | $2,014,160 |
| 2020 | -$809,782 | -$777,132 | -$1,586,914 |
| ***Average*** | ***$20,340,810*** | ***$19,520,695*** | ***$39,861,506*** |

Sources: RESI, REMI PI+

**Figure 120: Weatherization and Energy Efficiency for Low-Income Houses Enhanced—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $4,072,268 | $3,908,079 | $7,980,347 |
| 2011 | $10,040,514 | $9,635,694 | $19,676,208 |
| 2012 | $12,333,598 | $11,836,324 | $24,169,922 |
| 2013 | $7,235,477 | $6,943,752 | $14,179,230 |
| 2014 | $20,657,220 | $19,824,348 | $40,481,567 |
| 2015 | $27,121,847 | $26,028,330 | $53,150,177 |
| 2016 | $29,356,533 | $28,172,916 | $57,529,449 |
| 2017 | $22,551,252 | $21,642,015 | $44,193,268 |
| 2018 | $6,266,075 | $6,013,435 | $12,279,510 |
| 2019 | $2,705,761 | $2,596,668 | $5,302,429 |
| 2020 | $537,259 | $515,597 | $1,052,856 |
| ***Average*** | ***$12,988,891*** | ***$12,465,196*** | ***$25,454,088*** |

Sources: RESI, REMI PI+

**Figure 121: Weatherization and Energy Efficiency for Low-Income Houses Status Quo—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 1.7 | 1.9 | 3.6 |
| 2011 | 2.0 | 2.0 | 3.9 |
| 2012 | 1.4 | 1.4 | 2.8 |
| 2013 | 2.2 | 2.1 | 4.2 |
| 2014 | 1.7 | 1.6 | 3.3 |
| 2015 | 1.5 | 1.5 | 3.0 |
| 2016 | 1.1 | 1.2 | 2.3 |
| 2017 | 1.5 | 1.4 | 2.9 |
| 2018 | 1.8 | 1.8 | 3.6 |
| 2019 | 2.4 | 2.4 | 4.8 |
| 2020 | 1.8 | 1.9 | 3.7 |
| ***Average*** | ***1.7*** | ***1.7*** | ***3.5*** |

Sources: RESI, REMI PI+

**Figure 122: Weatherization and Energy Efficiency for Low-Income Houses Status Quo—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $15,236 | $15,282 | $30,518 |
| 2011 | $15,236 | $15,282 | $30,518 |
| 2012 | -$15,236 | -$15,282 | -$30,518 |
| 2013 | $15,236 | $15,282 | $30,518 |
| 2014 | $0 | $0 | $0 |
| 2015 | -$30,472 | -$30,564 | -$61,035 |
| 2016 | -$30,472 | -$30,564 | -$61,035 |
| 2017 | -$30,472 | -$30,564 | -$61,035 |
| 2018 | $30,472 | $30,564 | $61,035 |
| 2019 | $0 | $0 | $0 |
| 2020 | $0 | $0 | $0 |
| ***Average*** | ***-$2,770*** | ***-$2,779*** | ***-$5,549*** |

Sources: RESI, REMI PI+

**Figure 123: Weatherization and Energy Efficiency for Low-Income Houses Status Quo—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $24,758 | $24,833 | $49,591 |
| 2011 | $26,663 | $26,743 | $53,406 |
| 2012 | $19,045 | $19,102 | $38,147 |
| 2013 | $30,472 | $30,564 | $61,035 |
| 2014 | $24,758 | $24,833 | $49,591 |
| 2015 | $24,758 | $24,833 | $49,591 |
| 2016 | $28,567 | $28,653 | $57,220 |
| 2017 | $24,758 | $24,833 | $49,591 |
| 2018 | $36,185 | $36,294 | $72,479 |
| 2019 | $47,612 | $47,755 | $95,367 |
| 2020 | $36,185 | $36,294 | $72,479 |
| ***Average*** | ***$29,433*** | ***$29,522*** | ***$58,954*** |

Sources: RESI, REMI PI+

**Figure 124: Weatherization and Energy Efficiency for Low-Income Houses Enhanced—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 1.7 | 1.9 | 3.6 |
| 2011 | 2.0 | 2.0 | 3.9 |
| 2012 | 1.4 | 1.4 | 2.8 |
| 2013 | 2.2 | 2.1 | 4.2 |
| 2014 | 3.5 | 3.5 | 7.1 |
| 2015 | 3.2 | 3.1 | 6.2 |
| 2016 | 2.5 | 2.6 | 5.1 |
| 2017 | 2.9 | 2.7 | 5.6 |
| 2018 | 3.0 | 2.8 | 5.7 |
| 2019 | 3.1 | 3.1 | 6.2 |
| 2020 | 3.1 | 2.8 | 5.9 |
| ***Average*** | ***2.6*** | ***2.5*** | ***5.1*** |

Sources: RESI, REMI PI+

**Figure 125: Weatherization and Energy Efficiency for Low-Income Houses Enhanced—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $15,391 | $15,127 | $30,518 |
| 2011 | $15,391 | $15,127 | $30,518 |
| 2012 | -$15,391 | -$15,127 | -$30,518 |
| 2013 | $15,391 | $15,127 | $30,518 |
| 2014 | $0 | $0 | $0 |
| 2015 | -$30,782 | -$30,253 | -$61,035 |
| 2016 | -$61,564 | -$60,506 | -$122,070 |
| 2017 | -$61,564 | -$60,506 | -$122,070 |
| 2018 | -$30,782 | -$30,253 | -$61,035 |
| 2019 | -$61,564 | -$60,506 | -$122,070 |
| 2020 | -$61,564 | -$60,506 | -$122,070 |
| ***Average*** | ***-$25,185*** | ***-$24,753*** | ***-$49,938*** |

Sources: RESI, REMI PI+

**Figure 126: Weatherization and Energy Efficiency for Low-Income Houses Enhanced—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $25,010 | $24,581 | $49,591 |
| 2011 | $26,934 | $26,471 | $53,406 |
| 2012 | $19,239 | $18,908 | $38,147 |
| 2013 | $30,782 | $30,253 | $61,035 |
| 2014 | $59,640 | $58,615 | $118,256 |
| 2015 | $50,021 | $49,161 | $99,182 |
| 2016 | $42,325 | $41,598 | $83,923 |
| 2017 | $46,173 | $45,380 | $91,553 |
| 2018 | $50,021 | $49,161 | $99,182 |
| 2019 | $55,793 | $54,834 | $110,626 |
| 2020 | $53,869 | $52,943 | $106,812 |
| ***Average*** | ***$41,801*** | ***$41,082*** | ***$82,883*** |

Sources: RESI, REMI PI+

**Figure 127: GHG Prevention of Significant Deterioration Permitting 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*** |

Sources: RESI, REMI PI+

**Figure 128: GHG Prevention of Significant Deterioration Permitting 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*** |

Sources: RESI, REMI PI+

**Figure 129: GHG Prevention of Significant Deterioration Permitting 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*** |

Sources: RESI, REMI PI+

**Figure 130: GHG Prevention of Significant Deterioration Permitting 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*** |

Sources: RESI, REMI PI+

**Figure 131: GHG Prevention of Significant Deterioration Permitting 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*** |

Sources: RESI, REMI PI+

**Figure 132: GHG Prevention of Significant Deterioration Permitting 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*** |

Sources: RESI, REMI PI+

## A.2 Transportation

**Figure 133: Transportation Technology Initiatives, Status Quo—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 247.3 | 270.3 | 517.6 |
| 2011 | 245.4 | 302.6 | 548.0 |
| 2012 | 240.2 | 315.2 | 555.4 |
| 2013 | 235.1 | 312.6 | 547.7 |
| 2014 | 230.0 | 302.7 | 532.7 |
| 2015 | 362.2 | 375.4 | 737.6 |
| 2016 | 355.4 | 371.9 | 727.3 |
| 2017 | 349.1 | 362.6 | 711.7 |
| 2018 | 343.2 | 349.3 | 692.5 |
| 2019 | 336.8 | 337.0 | 673.8 |
| 2020 | 330.2 | 325.0 | 655.2 |
| ***Average*** | ***297.7*** | ***329.5*** | ***627.2*** |

Sources: RESI, REMI PI+

**Figure 134: Transportation Technology Initiatives, Status Quo—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $33,861,075 | $31,984,775 | $65,845,850 |
| 2011 | $33,869,600 | $36,265,900 | $70,135,500 |
| 2012 | $33,870,800 | $38,437,900 | $72,308,700 |
| 2013 | $33,868,450 | $38,619,300 | $72,487,750 |
| 2014 | $33,868,600 | $37,779,775 | $71,648,375 |
| 2015 | $48,810,475 | $48,331,950 | $97,142,425 |
| 2016 | $48,811,675 | $48,358,400 | $97,170,075 |
| 2017 | $48,813,900 | $47,493,075 | $96,306,975 |
| 2018 | $48,817,350 | $45,980,150 | $94,797,500 |
| 2019 | $48,816,250 | $44,617,375 | $93,433,625 |
| 2020 | $48,815,625 | $43,313,675 | $92,129,300 |
| ***Average*** | ***$42,020,346*** | ***$41,925,661*** | ***$83,946,007*** |

Sources: RESI, REMI PI+

**Figure 135: Transportation Technology Initiatives, Status Quo—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $15,278,276 | $10,018,324 | $25,296,600 |
| 2011 | $15,816,456 | $12,989,119 | $28,805,575 |
| 2012 | $16,146,135 | $15,071,190 | $31,217,325 |
| 2013 | $16,457,136 | $16,177,789 | $32,634,925 |
| 2014 | $16,745,708 | $16,607,167 | $33,352,875 |
| 2015 | $24,780,045 | $19,577,605 | $44,357,650 |
| 2016 | $25,280,921 | $20,778,354 | $46,059,275 |
| 2017 | $25,814,223 | $21,284,927 | $47,099,150 |
| 2018 | $26,392,854 | $21,238,821 | $47,631,675 |
| 2019 | $26,932,728 | $21,086,597 | $48,019,325 |
| 2020 | $27,447,197 | $20,808,453 | $48,255,650 |
| ***Average*** | ***$21,553,789*** | ***$17,785,304*** | ***$39,339,093*** |

Sources: RESI, REMI PI+

**Figure 136: Transportation Technology Initiatives, Enhanced—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 272.0 | 297.4 | 569.4 |
| 2011 | 269.9 | 332.8 | 602.8 |
| 2012 | 264.2 | 346.7 | 610.9 |
| 2013 | 258.6 | 343.9 | 602.5 |
| 2014 | 253.0 | 333.0 | 586.0 |
| 2015 | 398.4 | 413.0 | 811.3 |
| 2016 | 390.9 | 409.1 | 800.0 |
| 2017 | 384.0 | 398.9 | 782.8 |
| 2018 | 377.5 | 384.2 | 761.7 |
| 2019 | 370.5 | 370.7 | 741.1 |
| 2020 | 363.2 | 357.5 | 720.7 |
| ***Average*** | ***327.5*** | ***362.5*** | ***689.9*** |

Sources: RESI, REMI PI+

**Figure 137: Transportation Technology Initiatives, Enhanced—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $37,247,183 | $35,183,253 | $72,430,435 |
| 2011 | $37,256,560 | $39,892,490 | $77,149,050 |
| 2012 | $37,257,880 | $42,281,690 | $79,539,570 |
| 2013 | $37,255,295 | $42,481,230 | $79,736,525 |
| 2014 | $37,255,460 | $41,557,753 | $78,813,213 |
| 2015 | $53,691,523 | $53,165,145 | $106,856,668 |
| 2016 | $53,692,843 | $53,194,240 | $106,887,083 |
| 2017 | $53,695,290 | $52,242,383 | $105,937,673 |
| 2018 | $53,699,085 | $50,578,165 | $104,277,250 |
| 2019 | $53,697,875 | $49,079,113 | $102,776,988 |
| 2020 | $53,697,188 | $47,645,043 | $101,342,230 |
| ***Average*** | ***$46,222,380*** | ***$46,118,228*** | ***$92,340,608*** |

Sources: RESI, REMI PI+

**Figure 138: Transportation Technology Initiatives, Enhanced—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $16,806,103 | $11,020,157 | $27,826,260 |
| 2011 | $17,398,102 | $14,288,031 | $31,686,133 |
| 2012 | $17,760,748 | $16,578,309 | $34,339,058 |
| 2013 | $18,102,850 | $17,795,568 | $35,898,418 |
| 2014 | $18,420,279 | $18,267,883 | $36,688,163 |
| 2015 | $27,258,050 | $21,535,365 | $48,793,415 |
| 2016 | $27,809,013 | $22,856,190 | $50,665,203 |
| 2017 | $28,395,645 | $23,413,420 | $51,809,065 |
| 2018 | $29,032,139 | $23,362,704 | $52,394,843 |
| 2019 | $29,626,001 | $23,195,257 | $52,821,258 |
| 2020 | $30,191,916 | $22,889,299 | $53,081,215 |
| ***Average*** | ***$23,709,168*** | ***$19,563,835*** | ***$43,273,003*** |

Sources: RESI, REMI PI+

**Figure 139: Transportation Technology Initiatives, Status Quo—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 0.0 | 0.0 |
| 2011 | 0.0 | 0.0 | 0.0 |
| 2012 | 236.2 | 221.0 | 457.2 |
| 2013 | 243.4 | 227.5 | 470.9 |
| 2014 | 236.9 | 221.4 | 458.3 |
| 2015 | 224.3 | 211.0 | 434.9 |
| 2016 | 212.8 | 200.9 | 413.6 |
| 2017 | 203.0 | 191.5 | 394.6 |
| 2018 | 200.9 | 189.7 | 390.2 |
| 2019 | 197.6 | 186.8 | 384.8 |
| 2020 | 193.3 | 182.5 | 375.8 |
| ***Average*** | ***177.1*** | ***166.6*** | ***343.7*** |

Sources: RESI, REMI PI+

**Figure 140: Transportation Technology Initiatives, Status Quo—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $12,399,804 | $11,660,256 | $24,060,060 |
| 2013 | $12,682,904 | $11,926,472 | $24,609,377 |
| 2014 | $12,229,942 | $11,500,524 | $23,730,469 |
| 2015 | $11,437,261 | $10,755,122 | $22,192,384 |
| 2016 | $10,644,581 | $10,009,717 | $20,654,298 |
| 2017 | $9,965,138 | $9,370,800 | $19,335,938 |
| 2018 | $9,851,900 | $9,264,312 | $19,116,212 |
| 2019 | $9,398,938 | $8,838,367 | $18,237,305 |
| 2020 | $8,945,978 | $8,412,422 | $17,358,397 |
| ***Average*** | ***$8,868,768*** | ***$8,339,818*** | ***$17,208,585*** |

Sources: RESI, REMI PI+

**Figure 141: Transportation Technology Initiatives, Status Quo—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $5,336,446 | $5,018,170 | $10,354,615 |
| 2013 | $5,952,190 | $5,597,190 | $11,549,376 |
| 2014 | $6,235,290 | $5,863,403 | $12,098,693 |
| 2015 | $6,298,988 | $5,923,303 | $12,222,292 |
| 2016 | $6,298,988 | $5,923,303 | $12,222,292 |
| 2017 | $6,277,756 | $5,903,338 | $12,181,090 |
| 2018 | $6,383,916 | $6,003,169 | $12,387,085 |
| 2019 | $6,490,080 | $6,102,997 | $12,593,077 |
| 2020 | $6,553,778 | $6,162,898 | $12,716,676 |
| ***Average*** | ***$5,075,221*** | ***$4,772,525*** | ***$9,847,745*** |

Sources: RESI, REMI PI+

**Figure 142: Transportation Technology Initiatives, Enhanced—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 0.0 | 0.0 |
| 2011 | 0.0 | 0.0 | 0.0 |
| 2012 | 259.8 | 243.1 | 502.9 |
| 2013 | 267.7 | 250.3 | 518.0 |
| 2014 | 260.6 | 243.5 | 504.1 |
| 2015 | 246.7 | 232.1 | 478.4 |
| 2016 | 234.0 | 221.0 | 455.0 |
| 2017 | 223.3 | 210.7 | 434.0 |
| 2018 | 221.0 | 208.7 | 429.3 |
| 2019 | 217.4 | 205.5 | 423.3 |
| 2020 | 212.7 | 200.8 | 413.4 |
| ***Average*** | ***238.1*** | ***224.0*** | ***462.0*** |

Sources: RESI, REMI PI+

**Figure 143: Transportation Technology Initiatives, Enhanced—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $13,639,784 | $12,826,282 | $26,466,066 |
| 2013 | $13,951,195 | $13,119,120 | $27,070,314 |
| 2014 | $13,452,936 | $12,650,576 | $26,103,516 |
| 2015 | $12,580,987 | $11,830,635 | $24,411,622 |
| 2016 | $11,709,039 | $11,010,689 | $22,719,728 |
| 2017 | $10,961,652 | $10,307,880 | $21,269,532 |
| 2018 | $10,837,090 | $10,190,743 | $21,027,834 |
| 2019 | $10,338,831 | $9,722,204 | $20,061,035 |
| 2020 | $9,840,576 | $9,253,665 | $19,094,237 |
| ***Average*** | ***$11,923,566*** | ***$11,212,421*** | ***$23,135,987*** |

Sources: RESI, REMI PI+

**Figure 144: Transportation Technology Initiatives, Enhanced—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $5,870,090 | $5,519,987 | $11,390,077 |
| 2013 | $6,547,409 | $6,156,909 | $12,704,314 |
| 2014 | $6,858,819 | $6,449,743 | $13,308,562 |
| 2015 | $6,928,887 | $6,515,634 | $13,444,521 |
| 2016 | $6,928,887 | $6,515,634 | $13,444,521 |
| 2017 | $6,905,531 | $6,493,671 | $13,399,199 |
| 2018 | $7,022,308 | $6,603,486 | $13,625,794 |
| 2019 | $7,139,088 | $6,713,297 | $13,852,385 |
| 2020 | $7,209,156 | $6,779,187 | $13,988,344 |
| ***Average*** | ***$6,823,353*** | ***$6,416,394*** | ***$13,239,746*** |

Sources: RESI, REMI PI+

**Figure 145: Public Transportation Initiatives, Status Quo—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 533.2 | 335.5 | 868.7 |
| 2011 | 529.5 | 374.1 | 903.6 |
| 2012 | 518.8 | 386.7 | 905.5 |
| 2013 | 508.3 | 379.4 | 887.6 |
| 2014 | 497.8 | 363.2 | 861.0 |
| 2015 | 459.7 | 356.9 | 816.6 |
| 2016 | 451.2 | 338.6 | 789.8 |
| 2017 | 443.3 | 321.3 | 764.6 |
| 2018 | 435.9 | 305.2 | 741.1 |
| 2019 | 427.9 | 292.9 | 720.8 |
| 2020 | 419.6 | 282.6 | 702.2 |
| ***Average*** | ***475.0*** | ***339.7*** | ***814.7*** |

Sources: RESI, REMI PI+

**Figure 146: Public Transportation Initiatives, Status Quo—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $63,794,900 | $41,749,550 | $105,544,450 |
| 2011 | $63,797,325 | $46,893,175 | $110,690,500 |
| 2012 | $63,797,550 | $49,211,350 | $113,008,900 |
| 2013 | $63,796,275 | $48,909,675 | $112,705,950 |
| 2014 | $63,794,950 | $47,369,175 | $111,164,125 |
| 2015 | $59,418,525 | $46,744,875 | $106,163,400 |
| 2016 | $59,416,700 | $44,675,425 | $104,092,125 |
| 2017 | $59,414,850 | $42,625,600 | $102,040,450 |
| 2018 | $59,413,100 | $40,631,975 | $100,045,075 |
| 2019 | $59,410,375 | $39,210,475 | $98,620,850 |
| 2020 | $59,407,850 | $38,070,500 | $97,478,350 |
| ***Average*** | ***$61,405,673*** | ***$44,190,161*** | ***$105,595,834*** |

Sources: RESI, REMI PI+

**Figure 147: Public Transportation Initiatives, Status Quo—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $28,565,873 | $11,368,277 | $39,934,150 |
| 2011 | $29,685,166 | $15,567,484 | $45,252,650 |
| 2012 | $30,422,021 | $18,600,379 | $49,022,400 |
| 2013 | $31,127,513 | $20,256,712 | $51,384,225 |
| 2014 | $31,788,852 | $20,958,623 | $52,747,475 |
| 2015 | $30,265,224 | $21,627,101 | $51,892,325 |
| 2016 | $30,900,947 | $21,267,028 | $52,167,975 |
| 2017 | $31,576,198 | $20,697,052 | $52,273,250 |
| 2018 | $32,306,848 | $19,969,152 | $52,276,000 |
| 2019 | $32,993,083 | $19,443,167 | $52,436,250 |
| 2020 | $33,648,448 | $18,994,152 | $52,642,600 |
| ***Average*** | ***$31,207,288*** | ***$18,977,193*** | ***$50,184,482*** |

Sources: RESI, REMI PI+

**Figure 148: Public Transportation Initiatives, Enhanced—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | 1,066.4 | 671.1 | 1,737.5 |
| 2011 | 1,059.0 | 748.2 | 1,807.2 |
| 2012 | 1,037.7 | 773.3 | 1,811.0 |
| 2013 | 1,016.6 | 758.7 | 1,775.3 |
| 2014 | 995.5 | 726.5 | 1,722.0 |
| 2015 | 919.4 | 713.8 | 1,633.2 |
| 2016 | 902.4 | 677.2 | 1,579.6 |
| 2017 | 886.6 | 642.7 | 1,529.2 |
| 2018 | 871.8 | 610.3 | 1,482.1 |
| 2019 | 855.8 | 585.9 | 1,441.7 |
| 2020 | 839.2 | 565.3 | 1,404.5 |
| ***Average*** | ***950.0*** | ***679.4*** | ***1,629.4*** |

Sources: RESI, REMI PI+

**Figure 149: Public Transportation Initiatives, Enhanced—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $127,589,800 | $83,499,100 | $211,088,900 |
| 2011 | $127,594,650 | $93,786,350 | $221,381,000 |
| 2012 | $127,595,100 | $98,422,700 | $226,017,800 |
| 2013 | $127,592,550 | $97,819,350 | $225,411,900 |
| 2014 | $127,589,900 | $94,738,350 | $222,328,250 |
| 2015 | $118,837,050 | $93,489,750 | $212,326,800 |
| 2016 | $118,833,400 | $89,350,850 | $208,184,250 |
| 2017 | $118,829,700 | $85,251,200 | $204,080,900 |
| 2018 | $118,826,200 | $81,263,950 | $200,090,150 |
| 2019 | $118,820,750 | $78,420,950 | $197,241,700 |
| 2020 | $118,815,700 | $76,141,000 | $194,956,700 |
| ***Average*** | ***$118,827,133*** | ***$83,986,283*** | ***$211,191,668*** |

Sources: RESI, REMI PI+

**Figure 150: Public Transportation Initiatives, Enhanced—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $57,131,746 | $22,736,554 | $79,868,300 |
| 2011 | $59,370,332 | $31,134,968 | $90,505,300 |
| 2012 | $60,844,041 | $37,200,759 | $98,044,800 |
| 2013 | $62,255,026 | $40,513,424 | $102,768,450 |
| 2014 | $63,577,703 | $41,917,247 | $105,494,950 |
| 2015 | $60,530,447 | $43,254,203 | $103,784,650 |
| 2016 | $61,801,894 | $42,534,056 | $104,335,950 |
| 2017 | $63,152,397 | $41,394,103 | $104,546,500 |
| 2018 | $64,613,695 | $39,938,305 | $104,552,000 |
| 2019 | $65,986,166 | $38,886,334 | $104,872,500 |
| 2020 | $67,296,897 | $37,988,303 | $105,285,200 |
| ***Average*** | ***$63,896,916*** | ***$40,665,884*** | ***$100,368,964*** |

Sources: RESI, REMI PI+

**Figure 151: Public Transportation Initiatives, Status Quo—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 | 26.7 | 26.1 | 52.9 |
| 2018 | 56.8 | 55.2 | 112.3 |
| 2019 | 85.5 | 83.0 | 168.5 |
| 2020 | 113.9 | 110.7 | 224.7 |
| ***Average*** | ***56.6*** | ***55.0*** | ***139.6*** |

Sources: RESI, REMI PI+

**Figure 152: Public Transportation Initiatives, Status Quo—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 | $489,599 | $477,198 | $966,796 |
| 2018 | $1,101,599 | $1,073,695 | $2,175,293 |
| 2019 | $1,713,599 | $1,670,191 | $3,383,788 |
| 2020 | $2,203,197 | $2,147,387 | $4,350,587 |
| ***Average*** | ***$1,101,599*** | ***$1,073,694*** | ***$2,719,116*** |

Sources: RESI, REMI PI+

**Figure 153: Public Transportation Initiatives, Status Quo—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 | $309,824 | $301,976 | $611,800 |
| 2018 | $734,400 | $715,796 | $1,450,196 |
| 2019 | $1,197,225 | $1,166,897 | $2,364,120 |
| 2020 | $1,705,948 | $1,662,735 | $3,368,683 |
| ***Average*** | ***$789,479*** | ***$769,481*** | ***$1,948,700*** |

Sources: RESI, REMI PI+

**Figure 154: Public Transportation Initiatives, Enhanced—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 | 53.5 | 52.3 | 105.7 |
| 2018 | 113.7 | 110.5 | 224.5 |
| 2019 | 171.1 | 165.9 | 337.0 |
| 2020 | 227.7 | 221.4 | 449.5 |
| ***Average*** | ***113.2*** | ***110.0*** | ***279.2*** |

Sources: RESI, REMI PI+

**Figure 155: Public Transportation Initiatives, Enhanced—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 | $979,197 | $954,396 | $1,933,593 |
| 2018 | $2,203,197 | $2,147,389 | $4,350,587 |
| 2019 | $3,427,198 | $3,340,383 | $6,767,577 |
| 2020 | $4,406,395 | $4,294,774 | $8,701,173 |
| ***Average*** | ***$2,203,197*** | ***$2,147,388*** | ***$5,438,232*** |

Sources: RESI, REMI PI+

**Figure 156: Public Transportation Initiatives, Enhanced—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 | $619,649 | $603,951 | $1,223,600 |
| 2018 | $1,468,800 | $1,431,591 | $2,900,391 |
| 2019 | $2,394,450 | $2,333,794 | $4,728,240 |
| 2020 | $3,411,896 | $3,325,469 | $6,737,366 |
| ***Average*** | ***$1,578,959*** | ***$1,538,961*** | ***$3,897,399*** |

Sources: RESI, REMI PI+

**Figure 157: Intercity Transportation Initiatives Status Quo—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 76.9 | 48.3 | 125.2 |
| 2011 | 76.4 | 53.8 | 130.2 |
| 2012 | 74.9 | 55.6 | 130.5 |
| 2013 | 73.3 | 54.6 | 127.9 |
| 2014 | 71.8 | 52.2 | 124.1 |
| 2015 | 73.2 | 53.0 | 126.2 |
| 2016 | 71.8 | 50.5 | 122.3 |
| 2017 | 70.5 | 48.0 | 118.6 |
| 2018 | 69.4 | 45.7 | 115.0 |
| 2019 | 68.1 | 43.8 | 111.9 |
| 2020 | 57.4 | 34.0 | 91.4 |
| ***Average*** | ***71.2*** | ***49.0*** | ***120.3*** |

Sources: RESI, REMI PI+

**Figure 158: Intercity Transportation Initiatives Status Quo—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $9,184,500 | $6,006,750 | $15,191,250 |
| 2011 | $9,184,750 | $6,748,250 | $15,933,000 |
| 2012 | $9,184,750 | $7,083,000 | $16,267,750 |
| 2013 | $9,184,750 | $7,039,250 | $16,224,000 |
| 2014 | $9,184,500 | $6,816,750 | $16,001,250 |
| 2015 | $9,968,500 | $6,916,750 | $16,885,250 |
| 2016 | $9,968,750 | $6,641,000 | $16,609,750 |
| 2017 | $9,969,750 | $6,347,250 | $16,317,000 |
| 2018 | $9,970,500 | $6,052,750 | $16,023,250 |
| 2019 | $9,970,250 | $5,835,500 | $15,805,750 |
| 2020 | $8,047,000 | $4,549,250 | $12,596,250 |
| ***Average*** | ***$9,438,000*** | ***$6,366,955*** | ***$15,804,955*** |

Sources: RESI, REMI PI+

**Figure 159: Intercity Transportation Initiatives Status Quo—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $4,112,060 | $1,632,440 | $5,744,500 |
| 2011 | $4,273,508 | $2,236,742 | $6,510,250 |
| 2012 | $4,379,894 | $2,673,356 | $7,053,250 |
| 2013 | $4,481,803 | $2,911,447 | $7,393,250 |
| 2014 | $4,577,343 | $3,011,907 | $7,589,250 |
| 2015 | $5,056,758 | $3,221,242 | $8,278,000 |
| 2016 | $5,158,044 | $3,236,956 | $8,395,000 |
| 2017 | $5,265,911 | $3,206,089 | $8,472,000 |
| 2018 | $5,383,036 | $3,140,464 | $8,523,500 |
| 2019 | $5,492,137 | $3,097,113 | $8,589,250 |
| 2020 | $4,565,525 | $2,515,225 | $7,080,750 |
| ***Average*** | ***$4,795,093*** | ***$2,807,544*** | ***$7,602,636*** |

Sources: RESI, REMI PI+

**Figure 160: Intercity Transportation Initiatives Enhancement—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | 96.2 | 60.3 | 156.5 |
| 2011 | 95.5 | 67.3 | 162.8 |
| 2012 | 93.6 | 69.5 | 163.1 |
| 2013 | 91.7 | 68.2 | 159.9 |
| 2014 | 89.8 | 65.3 | 155.1 |
| 2015 | 91.5 | 66.2 | 157.7 |
| 2016 | 89.8 | 63.1 | 152.9 |
| 2017 | 88.2 | 60.0 | 148.2 |
| 2018 | 86.7 | 57.1 | 143.8 |
| 2019 | 85.1 | 54.8 | 139.8 |
| 2020 | 71.7 | 42.5 | 114.2 |
| ***Average*** | ***89.1*** | ***61.3*** | ***150.4*** |

Sources: RESI, REMI PI+

**Figure 161: Intercity Transportation Initiatives Enhancement—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $11,480,625 | $7,508,438 | $18,989,063 |
| 2011 | $11,480,938 | $8,435,313 | $19,916,250 |
| 2012 | $11,480,938 | $8,853,750 | $20,334,688 |
| 2013 | $11,480,938 | $8,799,063 | $20,280,000 |
| 2014 | $11,480,625 | $8,520,938 | $20,001,563 |
| 2015 | $12,460,625 | $8,645,938 | $21,106,563 |
| 2016 | $12,460,938 | $8,301,250 | $20,762,188 |
| 2017 | $12,462,188 | $7,934,063 | $20,396,250 |
| 2018 | $12,463,125 | $7,565,938 | $20,029,063 |
| 2019 | $12,462,813 | $7,294,375 | $19,757,188 |
| 2020 | $10,058,750 | $5,686,563 | $15,745,313 |
| ***Average*** | ***$11,797,500*** | ***$7,958,693*** | ***$19,756,193*** |

Sources: RESI, REMI PI+

**Figure 162: Intercity Transportation Initiatives Enhancement —Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $5,140,075 | $2,040,550 | $7,180,625 |
| 2011 | $5,341,885 | $2,795,928 | $8,137,813 |
| 2012 | $5,474,868 | $3,341,695 | $8,816,563 |
| 2013 | $5,602,254 | $3,639,309 | $9,241,563 |
| 2014 | $5,721,679 | $3,764,883 | $9,486,563 |
| 2015 | $6,320,947 | $4,026,553 | $10,347,500 |
| 2016 | $6,447,554 | $4,046,196 | $10,493,750 |
| 2017 | $6,582,389 | $4,007,611 | $10,590,000 |
| 2018 | $6,728,795 | $3,925,580 | $10,654,375 |
| 2019 | $6,865,172 | $3,871,391 | $10,736,563 |
| 2020 | $5,706,907 | $3,144,031 | $8,850,938 |
| ***Average*** | ***$5,993,866*** | ***$3,509,430*** | ***$9,503,295*** |

Sources: RESI, REMI PI+

**Figure 163: Intercity Transportation Initiatives Status Quo—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 0.0 | 0.0 |
| 2011 | 0.0 | 0.0 | 0.0 |
| 2012 | 4.1 | 3.8 | 7.9 |
| 2013 | 4.9 | 4.5 | 9.4 |
| 2014 | 4.1 | 4.0 | 8.1 |
| 2015 | 4.5 | 4.3 | 8.8 |
| 2016 | 4.1 | 4.1 | 8.3 |
| 2017 | 4.9 | 4.9 | 9.7 |
| 2018 | 5.0 | 5.0 | 10.1 |
| 2019 | 5.4 | 5.2 | 10.6 |
| 2020 | 5.2 | 4.9 | 10.1 |
| ***Average*** | ***4.7*** | ***4.5*** | ***9.2*** |

Sources: RESI, REMI PI+

**Figure 164: Intercity Transportation Initiatives Status Quo—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $56,059 | $53,804 | $109,863 |
| 2013 | $84,089 | $80,707 | $164,795 |
| 2014 | $56,059 | $53,804 | $109,863 |
| 2015 | $56,059 | $53,804 | $109,863 |
| 2016 | $56,059 | $53,804 | $109,863 |
| 2017 | $112,117 | $107,609 | $219,726 |
| 2018 | $168,176 | $161,413 | $329,589 |
| 2019 | $112,117 | $107,609 | $219,726 |
| 2020 | $112,117 | $107,609 | $219,726 |
| ***Average*** | ***$90,317*** | ***$86,685*** | ***$177,002*** |

Sources: RESI, REMI PI+

**Figure 165: Intercity Transportation Initiatives Status Quo—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $49,052 | $47,079 | $96,131 |
| 2013 | $66,569 | $63,893 | $130,462 |
| 2014 | $66,569 | $63,893 | $130,462 |
| 2015 | $80,584 | $77,344 | $157,928 |
| 2016 | $84,089 | $80,707 | $164,795 |
| 2017 | $94,599 | $90,796 | $185,395 |
| 2018 | $115,621 | $110,972 | $226,593 |
| 2019 | $126,131 | $121,061 | $247,192 |
| 2020 | $105,109 | $100,883 | $205,994 |
| ***Average*** | ***$87,592*** | ***$84,070*** | ***$171,661*** |

Sources: RESI, REMI PI+

**Figure 166: Intercity Transportation Initiatives Enhanced—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 0.0 | 0.0 |
| 2011 | 0.0 | 0.0 | 0.0 |
| 2012 | 5.2 | 4.7 | 9.9 |
| 2013 | 6.1 | 5.6 | 11.7 |
| 2014 | 5.2 | 5.0 | 10.1 |
| 2015 | 5.6 | 5.4 | 11.0 |
| 2016 | 5.2 | 5.2 | 10.4 |
| 2017 | 6.1 | 6.1 | 12.2 |
| 2018 | 6.3 | 6.3 | 12.6 |
| 2019 | 6.8 | 6.5 | 13.3 |
| 2020 | 6.5 | 6.1 | 12.6 |
| ***Average*** | ***5.9*** | ***5.7*** | ***11.5*** |

Sources: RESI, REMI PI+

**Figure 167: Intercity Transportation Initiatives Enhanced —Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $70,074 | $67,255 | $137,329 |
| 2013 | $105,111 | $100,883 | $205,994 |
| 2014 | $70,074 | $67,255 | $137,329 |
| 2015 | $70,074 | $67,255 | $137,329 |
| 2016 | $70,074 | $67,255 | $137,329 |
| 2017 | $140,146 | $134,512 | $274,658 |
| 2018 | $210,220 | $201,767 | $411,986 |
| 2019 | $140,146 | $134,512 | $274,658 |
| 2020 | $140,146 | $134,512 | $274,658 |
| ***Average*** | ***$112,896*** | ***$108,356*** | ***$221,252*** |

Sources: RESI, REMI PI+

**Figure 168: Intercity Transportation Initiatives Enhancement—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $61,315 | $58,849 | $120,164 |
| 2013 | $83,212 | $79,866 | $163,078 |
| 2014 | $83,212 | $79,866 | $163,078 |
| 2015 | $100,730 | $96,680 | $197,411 |
| 2016 | $105,111 | $100,883 | $205,994 |
| 2017 | $118,249 | $113,495 | $231,743 |
| 2018 | $144,527 | $138,715 | $283,241 |
| 2019 | $157,664 | $151,326 | $308,990 |
| 2020 | $131,387 | $126,104 | $257,492 |
| ***Average*** | ***$109,490*** | ***$105,087*** | ***$214,577*** |

Sources: RESI, REMI PI+

**Figure 169: Pricing Initiatives Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 170: Pricing Initiatives Status Quo —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*** |

Sources: RESI, REMI PI+

**Figure 171: Pricing Initiatives Status Quo —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*** |

Sources: RESI, REMI PI+

**Figure 172: Pricing Initiatives Enhancement—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 1,080.7 | 793.9 | 1,874.6 |
| 2011 | 1,073.2 | 886.4 | 1,959.6 |
| 2012 | 1,051.6 | 918.3 | 1,969.9 |
| 2013 | 1,030.2 | 904.1 | 1,934.3 |
| 2014 | 1,008.8 | 868.7 | 1,877.5 |
| 2015 | 79.6 | 171.7 | 251.4 |
| 2016 | 78.2 | 51.3 | 129.5 |
| 2017 | 76.8 | -16.4 | 60.4 |
| 2018 | 75.5 | -43.3 | 32.2 |
| 2019 | 74.1 | -48.9 | 25.3 |
| 2020 | 72.7 | -41.2 | 31.5 |
| ***Average*** | ***518.3*** | ***404.1*** | ***922.4*** |

Sources: RESI, REMI PI+

**Figure 173: Pricing Initiatives Enhancement—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $129,229,750 | $97,631,250 | $226,861,000 |
| 2011 | $129,234,250 | $109,969,250 | $239,203,500 |
| 2012 | $129,234,250 | $115,762,500 | $244,996,750 |
| 2013 | $129,231,250 | $115,448,250 | $244,679,500 |
| 2014 | $129,228,250 | $112,182,500 | $241,410,750 |
| 2015 | $10,224,750 | $20,217,250 | $30,442,000 |
| 2016 | $10,224,250 | $3,404,250 | $13,628,500 |
| 2017 | $10,223,750 | -$6,357,500 | $3,866,250 |
| 2018 | $10,223,750 | -$10,483,250 | -$259,500 |
| 2019 | $10,223,250 | -$11,493,500 | -$1,270,250 |
| 2020 | $10,222,750 | -$10,523,750 | -$301,000 |
| ***Average*** | ***$64,318,205*** | ***$48,705,205*** | ***$113,023,409*** |

Sources: RESI, REMI PI+

**Figure 174: Pricing Initiatives Enhancement—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $57,863,600 | $27,404,650 | $85,268,250 |
| 2011 | $60,131,294 | $36,831,456 | $96,962,750 |
| 2012 | $61,624,275 | $43,523,475 | $105,147,750 |
| 2013 | $63,053,719 | $47,069,531 | $110,123,250 |
| 2014 | $64,393,657 | $48,449,343 | $112,843,000 |
| 2015 | $5,210,620 | $21,714,630 | $26,925,250 |
| 2016 | $5,320,765 | $9,653,985 | $14,974,750 |
| 2017 | $5,437,748 | $1,368,252 | $6,806,000 |
| 2018 | $5,564,267 | -$3,702,767 | $1,861,500 |
| 2019 | $5,683,229 | -$6,607,729 | -$924,500 |
| 2020 | $5,796,890 | -$7,859,890 | -$2,063,000 |
| ***Average*** | ***$30,916,370*** | ***$19,804,085*** | ***$50,720,455*** |

Sources: RESI, REMI PI+

**Figure 175: Pricing Initiatives Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 176: Pricing Initiatives Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 177: Pricing Initiatives Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 178: Pricing Initiatives Enhancement—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 0.0 | 0.0 |
| 2011 | 0.0 | 0.0 | 0.0 |
| 2012 | 190.3 | 185.3 | 375.6 |
| 2013 | 194.0 | 188.7 | 382.7 |
| 2014 | 195.4 | 189.9 | 385.4 |
| 2015 | 194.9 | 189.5 | 384.4 |
| 2016 | 193.1 | 187.9 | 381.1 |
| 2017 | 192.4 | 187.0 | 379.4 |
| 2018 | 191.4 | 186.3 | 377.7 |
| 2019 | 190.2 | 185.1 | 375.3 |
| 2020 | 189.3 | 184.3 | 373.5 |
| ***Average*** | ***157.4*** | ***153.1*** | ***379.4*** |

Sources: RESI, REMI PI+

**Figure 179: Pricing Initiatives Enhancement—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $3,675,466 | $3,575,510 | $7,250,977 |
| 2013 | $3,849,494 | $3,744,805 | $7,594,299 |
| 2014 | $3,884,300 | $3,778,664 | $7,662,964 |
| 2015 | $3,772,922 | $3,670,316 | $7,443,237 |
| 2016 | $3,591,933 | $3,494,249 | $7,086,182 |
| 2017 | $3,452,711 | $3,358,813 | $6,811,524 |
| 2018 | $3,327,411 | $3,236,920 | $6,564,331 |
| 2019 | $3,146,422 | $3,060,854 | $6,207,275 |
| 2020 | $3,021,122 | $2,938,961 | $5,960,083 |
| ***Average*** | ***$3,524,642*** | ***$3,428,788*** | ***$6,953,430*** |

Sources: RESI, REMI PI+

**Figure 180: Pricing Initiatives Enhancement—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $0 | $0 | $0 |
| 2011 | $0 | $0 | $0 |
| 2012 | $2,253,659 | $2,192,370 | $4,446,030 |
| 2013 | $2,675,677 | $2,602,911 | $5,278,587 |
| 2014 | $2,987,186 | $2,905,949 | $5,893,135 |
| 2015 | $3,196,020 | $3,109,103 | $6,305,122 |
| 2016 | $3,332,632 | $3,241,999 | $6,574,631 |
| 2017 | $3,447,490 | $3,353,734 | $6,801,224 |
| 2018 | $3,531,893 | $3,435,842 | $6,967,735 |
| 2019 | $3,601,504 | $3,503,560 | $7,105,064 |
| 2020 | $3,672,856 | $3,572,971 | $7,245,827 |
| ***Average*** | ***$2,608,993*** | ***$2,538,040*** | ***$6,290,817*** |

Sources: RESI, REMI PI+

**Figure 181: Bike and Pedestrian Initiatives Status Quo—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | 181.5 | 166.2 | 347.4 |
| 2011 | 296.2 | 272.8 | 568.9 |
| 2012 | 967.4 | 902.7 | 1,870.4 |
| 2013 | 680.2 | 637.2 | 1,317.2 |
| 2014 | 634.5 | 594.7 | 1,229.2 |
| 2015 | 609.1 | 572.0 | 1,181.2 |
| 2016 | 584.3 | 549.5 | 1,133.8 |
| 2017 | 568.4 | 534.8 | 1,103.2 |
| 2018 | 556.2 | 523.8 | 1,079.8 |
| 2019 | 544.0 | 512.6 | 1,056.6 |
| 2020 | 535.9 | 505.3 | 1,041.1 |
| ***Average*** | ***559.8*** | ***524.7*** | ***1,084.4*** |

Sources: RESI, REMI PI+

**Figure 182: Bike and Pedestrian Initiatives Status Quo—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $31,260,263 | $29,303,180 | $60,563,443 |
| 2011 | $47,156,603 | $44,204,308 | $91,360,906 |
| 2012 | $146,793,941 | $137,603,729 | $284,397,672 |
| 2013 | $99,941,572 | $93,684,614 | $193,626,186 |
| 2014 | $35,611,830 | $33,382,310 | $68,994,140 |
| 2015 | $33,853,921 | $31,734,457 | $65,588,378 |
| 2016 | $32,209,427 | $30,192,917 | $62,402,344 |
| 2017 | $31,018,585 | $29,076,629 | $60,095,214 |
| 2018 | $30,111,277 | $28,226,126 | $58,337,402 |
| 2019 | $29,203,969 | $27,375,620 | $56,579,589 |
| 2020 | $28,636,902 | $26,844,055 | $55,480,957 |
| ***Average*** | ***$49,618,026*** | ***$46,511,632*** | ***$96,129,658*** |

Sources: RESI, REMI PI+

**Figure 183: Bike and Pedestrian Initiatives Status Quo—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $5,170,552 | $4,846,844 | $10,017,395 |
| 2011 | $7,649,783 | $7,170,860 | $14,820,645 |
| 2012 | $23,867,179 | $22,372,946 | $46,240,126 |
| 2013 | $17,895,813 | $16,775,424 | $34,671,237 |
| 2014 | $17,589,721 | $16,488,495 | $34,078,217 |
| 2015 | $17,685,414 | $16,578,198 | $34,263,610 |
| 2016 | $17,685,414 | $16,578,198 | $34,263,610 |
| 2017 | $17,777,561 | $16,664,576 | $34,442,138 |
| 2018 | $17,880,343 | $16,760,923 | $34,641,266 |
| 2019 | $18,004,388 | $16,877,203 | $34,881,592 |
| 2020 | $18,234,760 | $17,093,151 | $35,327,911 |
| ***Average*** | ***$16,312,812*** | ***$15,291,529*** | ***$31,604,341*** |

Sources: RESI, REMI PI+

**Figure 184: Bike and Pedestrian Initiatives Enhancement—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | 181.5 | 166.2 | 347.4 |
| 2011 | 296.2 | 272.8 | 568.9 |
| 2012 | 967.4 | 902.7 | 1,870.4 |
| 2013 | 680.2 | 637.2 | 1,317.2 |
| 2014 | 654.7 | 613.6 | 1,268.3 |
| 2015 | 1,616.7 | 1,518.3 | 3,135.0 |
| 2016 | 1,554.9 | 1,462.5 | 3,017.4 |
| 2017 | 1,509.6 | 1,420.5 | 2,930.1 |
| 2018 | 1,472.4 | 1,386.9 | 2,859.3 |
| 2019 | 1,437.9 | 1,355.7 | 2,793.6 |
| 2020 | 1,413.9 | 1,334.1 | 2,747.7 |
| ***Average*** | ***1,071.4*** | ***1,006.4*** | ***2,077.8*** |

Sources: RESI, REMI PI+

**Figure 185: Bike and Pedestrian Initiatives Enhancement—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $31,260,263 | $29,303,180 | $60,563,443 |
| 2011 | $47,156,603 | $44,204,308 | $91,360,906 |
| 2012 | $146,793,941 | $137,603,729 | $284,397,672 |
| 2013 | $99,941,572 | $93,684,614 | $193,626,186 |
| 2014 | $95,530,149 | $89,549,374 | $185,079,518 |
| 2015 | $233,683,164 | $219,063,421 | $452,746,585 |
| 2016 | $222,625,603 | $208,697,642 | $431,323,246 |
| 2017 | $213,779,553 | $200,405,018 | $414,184,571 |
| 2018 | $206,899,290 | $193,955,206 | $400,854,496 |
| 2019 | $200,510,474 | $187,966,085 | $388,476,566 |
| 2020 | $196,333,176 | $184,050,126 | $380,383,302 |
| ***Average*** | ***$154,046,708*** | ***$144,407,519*** | ***$298,454,226*** |

Sources: RESI, REMI PI+

**Figure 186: Bike and Pedestrian Initiatives Enhancement—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $5,170,552 | $4,846,844 | $10,017,395 |
| 2011 | $7,649,783 | $7,170,860 | $14,820,645 |
| 2012 | $23,867,179 | $22,372,946 | $46,240,126 |
| 2013 | $17,895,813 | $16,775,424 | $34,671,237 |
| 2014 | $18,148,125 | $17,011,940 | $35,160,065 |
| 2015 | $46,953,294 | $44,015,790 | $90,969,087 |
| 2016 | $47,035,989 | $44,093,313 | $91,129,302 |
| 2017 | $47,130,498 | $44,181,909 | $91,312,407 |
| 2018 | $47,331,330 | $44,370,177 | $91,701,507 |
| 2019 | $47,579,418 | $44,602,743 | $92,182,158 |
| 2020 | $48,116,937 | $45,106,635 | $93,223,572 |
| ***Average*** | ***$32,443,538*** | ***$30,413,507*** | ***$62,857,046*** |

Sources: RESI, REMI PI+

**Figure 187: Bike and Pedestrian Initiatives Status Quo—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 | 0.6 | 0.3 | 0.9 |
| 2014 | 0.0 | 0.0 | 0.2 |
| 2015 | 0.0 | 0.0 | 0.0 |
| 2016 | -0.5 | 0.0 | -0.5 |
| 2017 | 0.4 | 0.2 | 0.5 |
| 2018 | 0.0 | 0.0 | 0.0 |
| 2019 | 0.4 | 0.2 | 0.7 |
| 2020 | -0.4 | -0.5 | -0.9 |
| ***Average*** | ***0.0*** | ***0.0*** | ***0.0*** |

Sources: RESI, REMI PI+

**Figure 188: Bike and Pedestrian Initiatives Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 189: Bike and Pedestrian Initiatives Status Quo—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 | -$5,816 | -$1,049 | -$6,867 |
| 2017 | $23,265 | $4,201 | $27,466 |
| 2018 | -$5,816 | -$1,049 | -$6,867 |
| 2019 | $23,265 | $4,201 | $27,466 |
| 2020 | -$23,265 | -$4,201 | -$27,466 |
| ***Average*** | ***$2,327*** | ***$420*** | ***$2,746*** |

Sources: RESI, REMI PI+

**Figure 190: Bike and Pedestrian Initiatives Enhancement—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 | 0.6 | 0.3 | 0.9 |
| 2014 | 0.0 | 0.0 | 0.3 |
| 2015 | 1.2 | 0.4 | 1.6 |
| 2016 | -1.2 | 0.0 | -1.2 |
| 2017 | 0.0 | 0.0 | 0.0 |
| 2018 | 0.0 | 0.0 | 0.0 |
| 2019 | 0.8 | 0.4 | 1.2 |
| 2020 | 0.0 | 0.0 | 0.0 |
| ***Average*** | ***0.1*** | ***0.1*** | ***0.3*** |

Sources: RESI, REMI PI+

**Figure 191: Bike and Pedestrian Initiatives Enhancement—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*** |

Sources: RESI, REMI PI+

**Figure 192: Bike and Pedestrian Initiatives Enhancement—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 | $12,848 | $2,408 | $15,260 |
| 2016 | -$12,848 | -$2,408 | -$15,260 |
| 2017 | $0 | $0 | $0 |
| 2018 | -$12,848 | -$2,408 | -$15,260 |
| 2019 | $25,700 | $4,820 | $30,516 |
| 2020 | $0 | $0 | $0 |
| ***Average*** | ***$1,168*** | ***$219*** | ***$1,387*** |

Sources: RESI, REMI PI+

## A.3 Agriculture and Forestry

**Figure 193: 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*** |

Sources: RESI, REMI PI+

**Figure 194: 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*** |

Sources: RESI, REMI PI+

**Figure 195: 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*** |

Sources: RESI, REMI PI+

**Figure 196: 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*** | ***-1,055.6*** |

Sources: RESI, REMI PI+

**Figure 197: 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*** | ***$52,761,078*** |

Sources: RESI, REMI PI+

**Figure 198: 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*** | ***$44,662,476*** |

Sources: RESI, REMI PI+

**Figure 199: Nutrient Trading for GHG Benefits Status Quo—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 1.3 | 1.1 | 2.5 |
| 2011 | 1.6 | 1.3 | 2.9 |
| 2012 | 1.7 | 1.4 | 3.1 |
| 2013 | 2.9 | 2.3 | 5.1 |
| 2014 | 0.1 | 0.1 | 0.1 |
| 2015 | 0.0 | -0.1 | -0.2 |
| 2016 | -0.2 | 0.0 | -0.2 |
| 2017 | -0.3 | -0.1 | -0.4 |
| 2018 | 0.3 | 0.1 | 0.4 |
| 2019 | 0.2 | 0.0 | 0.2 |
| 2020 | 0.1 | 0.0 | 0.1 |
| ***Average*** | ***0.7*** | ***0.6*** | ***1.2*** |

Sources: RESI, REMI PI+

**Figure 200: Nutrient Trading for GHG Benefits Status Quo—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $101,507 | $81,599 | $183,105 |
| 2011 | $118,424 | $95,199 | $213,623 |
| 2012 | $118,424 | $95,199 | $213,623 |
| 2013 | $169,178 | $135,998 | $305,176 |
| 2014 | $0 | $0 | $0 |
| 2015 | $0 | $0 | $0 |
| 2016 | $0 | $0 | $0 |
| 2017 | -$33,836 | -$27,200 | -$61,035 |
| 2018 | $33,836 | $27,200 | $61,035 |
| 2019 | $0 | $0 | $0 |
| 2020 | $0 | $0 | $0 |
| ***Average*** | ***$46,139*** | ***$37,090*** | ***$83,230*** |

Sources: RESI, REMI PI+

**Figure 201: Nutrient Trading for GHG Benefits Status Quo—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $44,409 | $35,700 | $80,109 |
| 2011 | $52,868 | $42,499 | $95,367 |
| 2012 | $50,753 | $40,799 | $91,553 |
| 2013 | $86,704 | $69,699 | $156,403 |
| 2014 | $2,115 | $1,700 | $3,815 |
| 2015 | $0 | $0 | $0 |
| 2016 | $0 | $0 | $0 |
| 2017 | -$12,688 | -$10,200 | -$22,888 |
| 2018 | $0 | $0 | $0 |
| 2019 | $0 | $0 | $0 |
| 2020 | $2,115 | $1,700 | $3,815 |
| ***Average*** | ***$20,570*** | ***$16,536*** | ***$37,107*** |

Sources: RESI, REMI PI+

**Figure 202: Nutrient Trading for GHG Benefits Enhancement—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 8.3 | 7.2 | 15.6 |
| 2011 | 10.0 | 8.3 | 18.3 |
| 2012 | 11.0 | 8.9 | 19.9 |
| 2013 | 18.2 | 14.3 | 32.5 |
| 2014 | 0.4 | 0.5 | 0.9 |
| 2015 | -0.2 | -0.8 | -1.0 |
| 2016 | -1.5 | 0.0 | -1.5 |
| 2017 | -1.9 | -0.7 | -2.6 |
| 2018 | 1.7 | 0.8 | 2.5 |
| 2019 | 1.5 | -0.2 | 1.4 |
| 2020 | 0.4 | 0.1 | 0.5 |
| ***Average*** | ***4.4*** | ***3.5*** | ***7.9*** |

Sources: RESI, REMI PI+

**Figure 203: Nutrient Trading for GHG Benefits Enhancement—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $642,841 | $516,766 | $1,159,607 |
| 2011 | $749,981 | $602,894 | $1,352,875 |
| 2012 | $749,981 | $602,894 | $1,352,875 |
| 2013 | $1,071,402 | $861,277 | $1,932,678 |
| 2014 | $0 | $0 | $0 |
| 2015 | $0 | $0 | $0 |
| 2016 | $0 | $0 | $0 |
| 2017 | -$214,280 | -$172,255 | -$386,536 |
| 2018 | $214,280 | $172,255 | $386,536 |
| 2019 | $0 | $0 | $0 |
| 2020 | $0 | $0 | $0 |
| ***Average*** | ***$292,200*** | ***$234,894*** | ***$527,094*** |

Sources: RESI, REMI PI+

**Figure 204: Nutrient Trading for GHG Benefits Enhancement—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $281,243 | $226,085 | $507,328 |
| 2011 | $334,813 | $269,149 | $603,962 |
| 2012 | $321,420 | $258,383 | $579,803 |
| 2013 | $549,093 | $441,404 | $990,498 |
| 2014 | $13,393 | $10,766 | $24,158 |
| 2015 | $0 | $0 | $0 |
| 2016 | $0 | $0 | $0 |
| 2017 | -$80,355 | -$64,596 | -$144,951 |
| 2018 | $0 | $0 | $0 |
| 2019 | $0 | $0 | $0 |
| 2020 | $13,393 | $10,766 | $24,158 |
| ***Average*** | ***$130,273*** | ***$104,723*** | ***$234,996*** |

Sources: RESI, REMI PI+

**Figure 205: Nutrient Trading for GHG Benefits Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 206: Nutrient Trading for GHG Benefits Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 207: Nutrient Trading for GHG Benefits Status Quo—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*** |

Sources: RESI, REMI PI+

**Figure 208: Nutrient Trading for GHG Benefits Enhancement—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*** |

Sources: RESI, REMI PI+

**Figure 209: Nutrient Trading for GHG Benefits Enhancement—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*** |

Sources: RESI, REMI PI+

**Figure 210: Nutrient Trading for GHG Benefits Enhancement—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*** |

Sources: RESI, REMI PI+

**Figure 211: 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*** |

Sources: RESI, REMI PI+

**Figure 212: 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*** |

Sources: RESI, REMI PI+

**Figure 213: 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*** |

Sources: RESI, REMI PI+

**Figure 214: 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*** | ***23.8*** | ***23.1*** | ***46.8*** |

Sources: RESI, REMI PI+

**Figure 215: 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*** | ***$667,758*** | ***$647,888*** | ***$1,315,647*** |

Sources: RESI, REMI PI+

**Figure 216: 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*** | ***$255,572*** | ***$247,968*** | ***$503,540*** |

Sources: RESI, REMI PI+

**Figure 217: 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*** |

Sources: RESI, REMI PI+

**Figure 218: 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*** |

Sources: RESI, REMI PI+

**Figure 219: 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*** |

Sources: RESI, REMI PI+

**Figure 220: 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*** |

Sources: RESI, REMI PI+

**Figure 221: 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*** |

Sources: RESI, REMI PI+

**Figure 222: 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*** |

Sources: RESI, REMI PI+

**Figure 223: 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*** |

Sources: RESI, REMI PI+

**Figure 224: 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*** |

Sources: RESI, REMI PI+

**Figure 225: 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*** |

Sources: RESI, REMI PI+

**Figure 226: 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*** |

Sources: RESI, REMI PI+

**Figure 227: 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*** |

Sources: RESI, REMI PI+

**Figure 228: 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*** |

Sources: RESI, REMI PI+

**Figure 229: 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*** |

Sources: RESI, REMI PI+

**Figure 230: 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*** |

Sources: RESI, REMI PI+

**Figure 231: 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*** |

Sources: RESI, REMI PI+

**Figure 232: 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*** |

Sources: RESI, REMI PI+

**Figure 233: 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*** |

Sources: RESI, REMI PI+

**Figure 234: 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*** |

Sources: RESI, REMI PI+

**Figure 235: 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*** |

Sources: RESI, REMI PI+

**Figure 236: 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*** |

Sources: RESI, REMI PI+

**Figure 237: 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*** |

Sources: RESI, REMI PI+

**Figure 238: 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*** |

Sources: RESI, REMI PI+

**Figure 239: 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*** |

Sources: RESI, REMI PI+

**Figure 240: 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*** |

Sources: RESI, REMI PI+

**Figure 241: Biomass 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*** |

Sources: RESI, REMI PI+

**Figure 242: Biomass 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*** |

Sources: RESI, REMI PI+

**Figure 243: Biomass 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*** |

Sources: RESI, REMI PI+

**Figure 244: Biomass 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*** |

Sources: RESI, REMI PI+

**Figure 245: Biomass 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*** |

Sources: RESI, REMI PI+

**Figure 246: Biomass 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*** |

Sources: RESI, REMI PI+

**Figure 247: Conservation of Agricultural Land for GHG Benefits—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 23.0 | 21.5 | 44.5 |
| 2011 | 23.4 | 22.0 | 45.5 |
| 2012 | 22.1 | 20.7 | 42.8 |
| 2013 | 16.8 | 15.9 | 32.7 |
| 2014 | 16.2 | 15.2 | 31.4 |
| 2015 | 15.2 | 14.3 | 29.5 |
| 2016 | 14.1 | 13.3 | 27.4 |
| 2017 | 13.2 | 12.4 | 25.6 |
| 2018 | 13.2 | 12.5 | 25.7 |
| 2019 | 12.3 | 11.7 | 24.1 |
| 2020 | 12.2 | 11.5 | 23.7 |
| ***Average*** | ***16.5*** | ***15.6*** | ***32.1*** |

Sources: RESI, REMI PI+

**Figure 248: Conservation of Agricultural Land for GHG Benefits—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $1,209,852 | $1,140,002 | $2,349,854 |
| 2011 | $1,241,276 | $1,169,612 | $2,410,889 |
| 2012 | $1,178,427 | $1,110,391 | $2,288,818 |
| 2013 | $879,892 | $829,092 | $1,708,984 |
| 2014 | $848,467 | $799,482 | $1,647,949 |
| 2015 | $785,618 | $740,261 | $1,525,879 |
| 2016 | $722,769 | $681,040 | $1,403,809 |
| 2017 | $659,919 | $621,819 | $1,281,738 |
| 2018 | $691,344 | $651,430 | $1,342,773 |
| 2019 | $597,070 | $562,598 | $1,159,668 |
| 2020 | $597,070 | $562,598 | $1,159,668 |
| ***Average*** | ***$855,609*** | ***$806,211*** | ***$1,661,821*** |

Sources: RESI, REMI PI+

**Figure 249: Conservation of Agricultural Land for GHG Benefits—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $437,982 | $412,695 | $850,677 |
| 2011 | $469,407 | $442,306 | $911,713 |
| 2012 | $469,407 | $442,306 | $911,713 |
| 2013 | $384,953 | $362,728 | $747,681 |
| 2014 | $386,917 | $364,578 | $751,495 |
| 2015 | $373,169 | $351,624 | $724,792 |
| 2016 | $359,420 | $338,669 | $698,090 |
| 2017 | $343,708 | $323,864 | $667,572 |
| 2018 | $345,672 | $325,715 | $671,387 |
| 2019 | $331,924 | $312,760 | $644,684 |
| 2020 | $337,816 | $318,312 | $656,128 |
| ***Average*** | ***$385,488*** | ***$363,233*** | ***$748,721*** |

Sources: RESI, REMI PI+

**Figure 250: Conservation of Agricultural Land for GHG Benefits—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 0.0 | 0.0 |
| 2011 | 327.8 | 272.5 | 600.3 |
| 2012 | 332.6 | 276.6 | 609.2 |
| 2013 | 326.2 | 270.9 | 597.1 |
| 2014 | 238.6 | 196.2 | 434.8 |
| 2015 | 214.0 | 173.9 | 387.9 |
| 2016 | 193.1 | 155.2 | 348.3 |
| 2017 | 178.5 | 141.9 | 320.4 |
| 2018 | 167.1 | 131.6 | 298.6 |
| 2019 | 158.3 | 123.6 | 281.9 |
| 2020 | 151.2 | 117.7 | 269.0 |
| ***Average*** | ***207.9*** | ***169.1*** | ***377.0*** |

Sources: RESI, REMI PI+

**Figure 251: Conservation of Agricultural Land for GHG Benefits—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $67,721,576 | $55,081,158 | $122,802,734 |
| 2012 | $68,175,971 | $55,450,738 | $123,626,709 |
| 2013 | $67,738,406 | $55,094,846 | $122,833,252 |
| 2014 | $50,690,206 | $41,228,740 | $91,918,945 |
| 2015 | $48,939,946 | $39,805,171 | $88,745,117 |
| 2016 | $47,425,299 | $38,573,236 | $85,998,535 |
| 2017 | $46,348,216 | $37,697,194 | $84,045,410 |
| 2018 | $45,506,745 | $37,012,786 | $82,519,531 |
| 2019 | $44,799,910 | $36,437,883 | $81,237,793 |
| 2020 | $44,295,027 | $36,027,239 | $80,322,266 |
| ***Average*** | ***$48,331,027*** | ***$39,309,908*** | ***$87,640,936*** |

Sources: RESI, REMI PI+

**Figure 252: Conservation of Agricultural Land for GHG Benefits—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | $8,747,090 | $7,114,421 | $15,861,511 |
| 2012 | $10,585,704 | $8,609,853 | $19,195,557 |
| 2013 | $11,675,408 | $9,496,161 | $21,171,570 |
| 2014 | $10,042,955 | $8,168,410 | $18,211,365 |
| 2015 | $9,514,932 | $7,738,944 | $17,253,876 |
| 2016 | $8,972,183 | $7,297,501 | $16,269,684 |
| 2017 | $8,471,508 | $6,890,278 | $15,361,786 |
| 2018 | $8,010,803 | $6,515,564 | $14,526,367 |
| 2019 | $7,640,556 | $6,214,425 | $13,854,980 |
| 2020 | $7,327,108 | $5,959,483 | $13,286,591 |
| ***Average*** | ***$8,271,659*** | ***$6,727,731*** | ***$14,999,390*** |

Sources: RESI, REMI PI+

## A.4 Zero Waste

**Figure 253: Recycling and Source Reduction Status Quo—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 457.2 | 416.2 | 873.3 |
| 2011 | 466.2 | 425.3 | 891.6 |
| 2012 | 465.9 | 425.7 | 891.6 |
| 2013 | 460.7 | 421.9 | 882.6 |
| 2014 | 452.7 | 414.9 | 867.6 |
| 2015 | 441.9 | 405.7 | 847.6 |
| 2016 | 430.7 | 396.2 | 826.9 |
| 2017 | 422.0 | 388.3 | 810.3 |
| 2018 | 414.2 | 381.4 | 795.6 |
| 2019 | 407.2 | 375.6 | 782.8 |
| 2020 | 402.0 | 371.1 | 773.1 |
| ***Average*** | ***438.3*** | ***402.0*** | ***840.3*** |

Sources: RESI, REMI PI+

**Figure 254: Recycling and Source Reduction Status Quo—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $35,192,272 | $32,282,093 | $67,474,365 |
| 2011 | $35,637,945 | $32,690,912 | $68,328,857 |
| 2012 | $35,717,530 | $32,763,915 | $68,481,445 |
| 2013 | $35,478,776 | $32,544,905 | $68,023,682 |
| 2014 | $35,017,186 | $32,121,486 | $67,138,672 |
| 2015 | $34,348,676 | $31,508,257 | $65,856,934 |
| 2016 | $33,712,000 | $30,924,230 | $64,636,230 |
| 2017 | $33,138,992 | $30,398,606 | $63,537,598 |
| 2018 | $32,661,485 | $29,960,586 | $62,622,070 |
| 2019 | $32,215,811 | $29,551,767 | $61,767,578 |
| 2020 | $31,929,307 | $29,288,955 | $61,218,262 |
| ***Average*** | ***$34,095,453*** | ***$31,275,974*** | ***$65,371,427*** |

Sources: RESI, REMI PI+

**Figure 255: Recycling and Source Reduction Status Quo—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $11,287,074 | $10,353,704 | $21,640,778 |
| 2011 | $12,182,399 | $11,174,992 | $23,357,391 |
| 2012 | $12,916,567 | $11,848,448 | $24,765,015 |
| 2013 | $13,489,575 | $12,374,072 | $25,863,647 |
| 2014 | $13,925,300 | $12,773,766 | $26,699,066 |
| 2015 | $14,227,722 | $13,051,179 | $27,278,900 |
| 2016 | $14,472,444 | $13,275,664 | $27,748,108 |
| 2017 | $14,695,281 | $13,480,073 | $28,175,354 |
| 2018 | $14,916,128 | $13,682,658 | $28,598,785 |
| 2019 | $15,174,777 | $13,919,919 | $29,094,696 |
| 2020 | $15,473,219 | $14,193,681 | $29,666,901 |
| ***Average*** | ***$13,887,317*** | ***$12,738,923*** | ***$26,626,240*** |

Sources: RESI, REMI PI+

**Figure 256: Recycling and Source Reduction Enhancement—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 457.2 | 416.2 | 873.3 |
| 2011 | 466.2 | 425.3 | 891.6 |
| 2012 | 465.9 | 425.7 | 891.6 |
| 2013 | 460.7 | 421.9 | 882.6 |
| 2014 | 452.7 | 414.9 | 867.6 |
| 2015 | 757.5 | 695.5 | 1,452.9 |
| 2016 | 738.3 | 679.1 | 1,417.5 |
| 2017 | 723.4 | 665.6 | 1,389.1 |
| 2018 | 710.1 | 653.8 | 1,364.0 |
| 2019 | 698.1 | 643.8 | 1,341.9 |
| 2020 | 689.2 | 636.1 | 1,325.3 |
| ***Average*** | ***601.8*** | ***552.5*** | ***1,154.3*** |

Sources: RESI, REMI PI+

**Figure 257: Recycling and Source Reduction Enhancement—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $35,192,272 | $32,282,093 | $67,474,365 |
| 2011 | $35,637,945 | $32,690,912 | $68,328,857 |
| 2012 | $35,717,530 | $32,763,915 | $68,481,445 |
| 2013 | $35,478,776 | $32,544,905 | $68,023,682 |
| 2014 | $35,017,186 | $32,121,486 | $67,138,672 |
| 2015 | $58,883,445 | $54,014,155 | $112,897,600 |
| 2016 | $57,792,000 | $53,012,966 | $110,804,966 |
| 2017 | $56,809,700 | $52,111,896 | $108,921,595 |
| 2018 | $55,991,116 | $51,361,004 | $107,352,120 |
| 2019 | $55,227,105 | $50,660,171 | $105,887,276 |
| 2020 | $54,735,954 | $50,209,636 | $104,945,591 |
| ***Average*** | ***$46,953,003*** | ***$43,070,285*** | ***$90,023,288*** |

Sources: RESI, REMI PI+

**Figure 258: Recycling and Source Reduction Enhancement—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $11,287,074 | $10,353,704 | $21,640,778 |
| 2011 | $12,182,399 | $11,174,992 | $23,357,391 |
| 2012 | $12,916,567 | $11,848,448 | $24,765,015 |
| 2013 | $13,489,575 | $12,374,072 | $25,863,647 |
| 2014 | $13,925,300 | $12,773,766 | $26,699,066 |
| 2015 | $24,390,380 | $22,373,449 | $46,763,828 |
| 2016 | $24,809,904 | $22,758,281 | $47,568,185 |
| 2017 | $25,191,909 | $23,108,697 | $48,300,606 |
| 2018 | $25,570,504 | $23,455,985 | $49,026,489 |
| 2019 | $26,013,904 | $23,862,718 | $49,876,621 |
| 2020 | $26,525,518 | $24,332,025 | $50,857,544 |
| ***Average*** | ***$19,663,912*** | ***$18,037,831*** | ***$37,701,743*** |

Sources: RESI, REMI PI+

**Figure 259: Recycling and Source Reduction Status Quo—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | -270.1 | -245.7 | -515.8 |
| 2011 | -275.5 | -251.5 | -527.0 |
| 2012 | -274.6 | -251.0 | -525.6 |
| 2013 | -267.6 | -245.0 | -512.6 |
| 2014 | -259.5 | -238.1 | -497.7 |
| 2015 | -252.8 | -232.2 | -485.1 |
| 2016 | -247.4 | -227.4 | -474.8 |
| 2017 | -240.8 | -221.9 | -462.7 |
| 2018 | -236.1 | -217.6 | -453.7 |
| 2019 | -233.6 | -215.4 | -449.0 |
| 2020 | -232.7 | -214.9 | -447.6 |
| ***Average*** | ***-253.7*** | ***-232.8*** | ***-486.5*** |

Sources: RESI, REMI PI+

**Figure 260: Recycling and Source Reduction Status Quo—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | -$20,736,625 | -$19,027,779 | -$39,764,404 |
| 2011 | -$21,039,001 | -$19,305,237 | -$40,344,238 |
| 2012 | -$20,991,257 | -$19,261,428 | -$40,252,686 |
| 2013 | -$20,609,309 | -$18,910,955 | -$39,520,264 |
| 2014 | -$20,115,958 | -$18,458,260 | -$38,574,219 |
| 2015 | -$19,670,352 | -$18,049,375 | -$37,719,727 |
| 2016 | -$19,288,403 | -$17,698,901 | -$36,987,305 |
| 2017 | -$18,874,626 | -$17,319,222 | -$36,193,848 |
| 2018 | -$18,524,506 | -$16,997,955 | -$35,522,461 |
| 2019 | -$18,429,019 | -$16,910,337 | -$35,339,355 |
| 2020 | -$18,397,190 | -$16,881,130 | -$35,278,320 |
| ***Average*** | ***-$19,697,840*** | ***-$18,074,598*** | ***-$37,772,439*** |

Sources: RESI, REMI PI+

**Figure 261: Recycling and Source Reduction Status Quo—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | -$6,664,207 | -$6,115,029 | -$12,779,236 |
| 2011 | -$7,203,311 | -$6,609,707 | -$13,813,019 |
| 2012 | -$7,605,153 | -$6,978,434 | -$14,583,588 |
| 2013 | -$7,855,807 | -$7,208,433 | -$15,064,240 |
| 2014 | -$8,016,942 | -$7,356,288 | -$15,373,230 |
| 2015 | -$8,152,215 | -$7,480,414 | -$15,632,629 |
| 2016 | -$8,303,403 | -$7,619,143 | -$15,922,546 |
| 2017 | -$8,384,965 | -$7,693,984 | -$16,078,949 |
| 2018 | -$8,498,356 | -$7,798,031 | -$16,296,387 |
| 2019 | -$8,669,437 | -$7,955,014 | -$16,624,451 |
| 2020 | -$8,904,176 | -$8,170,409 | -$17,074,585 |
| ***Average*** | ***-$8,023,452*** | ***-$7,362,262*** | ***-$15,385,714*** |

Sources: RESI, REMI PI+

**Figure 262: Recycling and Source Reduction Enhancement—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | -270.1 | -245.7 | -515.8 |
| 2011 | -275.5 | -251.5 | -527.0 |
| 2012 | -274.6 | -251.0 | -525.6 |
| 2013 | -267.6 | -245.0 | -512.6 |
| 2014 | -259.5 | -238.1 | -497.7 |
| 2015 | -433.4 | -398.1 | -831.5 |
| 2016 | -424.1 | -389.8 | -813.9 |
| 2017 | -412.9 | -380.4 | -793.2 |
| 2018 | -404.8 | -373.1 | -777.8 |
| 2019 | -400.4 | -369.3 | -769.7 |
| 2020 | -399.0 | -368.3 | -767.3 |
| ***Average*** | ***-347.4*** | ***-319.1*** | ***-666.6*** |

Sources: RESI, REMI PI+

**Figure 263: Recycling and Source Reduction Enhancement—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | -$20,736,625 | -$19,027,779 | -$39,764,404 |
| 2011 | -$21,039,001 | -$19,305,237 | -$40,344,238 |
| 2012 | -$20,991,257 | -$19,261,428 | -$40,252,686 |
| 2013 | -$20,609,309 | -$18,910,955 | -$39,520,264 |
| 2014 | -$20,115,958 | -$18,458,260 | -$38,574,219 |
| 2015 | -$33,720,603 | -$30,941,785 | -$64,662,388 |
| 2016 | -$33,065,834 | -$30,340,974 | -$63,406,808 |
| 2017 | -$32,356,501 | -$29,690,095 | -$62,046,595 |
| 2018 | -$31,756,296 | -$29,139,351 | -$60,895,647 |
| 2019 | -$31,592,604 | -$28,989,148 | -$60,581,752 |
| 2020 | -$31,538,039 | -$28,939,081 | -$60,477,120 |
| ***Average*** | ***-$27,047,457*** | ***-$24,818,554*** | ***-$51,866,011*** |

Sources: RESI, REMI PI+

**Figure 264: Recycling and Source Reduction Enhancement—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | -$6,664,207 | -$6,115,029 | -$12,779,236 |
| 2011 | -$7,203,311 | -$6,609,707 | -$13,813,019 |
| 2012 | -$7,605,153 | -$6,978,434 | -$14,583,588 |
| 2013 | -$7,855,807 | -$7,208,433 | -$15,064,240 |
| 2014 | -$8,016,942 | -$7,356,288 | -$15,373,230 |
| 2015 | -$13,975,226 | -$12,823,567 | -$26,798,793 |
| 2016 | -$14,234,405 | -$13,061,389 | -$27,295,794 |
| 2017 | -$14,374,225 | -$13,189,687 | -$27,563,912 |
| 2018 | -$14,568,610 | -$13,368,053 | -$27,936,663 |
| 2019 | -$14,861,892 | -$13,637,166 | -$28,499,058 |
| 2020 | -$15,264,302 | -$14,006,415 | -$29,270,717 |
| ***Average*** | ***-$11,329,462*** | ***-$10,395,834*** | ***-$21,725,295*** |

Sources: RESI, REMI PI+

### A.5 Buildings

**Figure 265: 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*** |

Sources: RESI, REMI PI+

**Figure 266: 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*** |

Sources: RESI, REMI PI+

**Figure 267: 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*** |

Sources: RESI, REMI PI+

**Figure 268: Building Codes—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 16.0 | 14.8 | 30.8 |
| 2011 | 47.6 | 43.7 | 91.3 |
| 2012 | 87.2 | 80.4 | 167.7 |
| 2013 | 137.7 | 127.3 | 265.0 |
| 2014 | 186.4 | 172.8 | 359.1 |
| 2015 | 231.4 | 214.9 | 446.4 |
| 2016 | 272.3 | 253.3 | 525.6 |
| 2017 | 304.1 | 283.2 | 587.3 |
| 2018 | 330.5 | 308.0 | 638.6 |
| 2019 | 350.6 | 327.1 | 677.7 |
| 2020 | 366.3 | 341.9 | 708.2 |
| ***Average*** | ***211.8*** | ***197.0*** | ***408.9*** |

Sources: RESI, REMI PI+

**Figure 269: Building Codes—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $1,264,841 | $1,176,565 | $2,441,406 |
| 2011 | $3,573,175 | $3,323,797 | $6,896,973 |
| 2012 | $6,498,120 | $6,044,605 | $12,542,725 |
| 2013 | $10,229,400 | $9,515,473 | $19,744,873 |
| 2014 | $13,850,007 | $12,883,391 | $26,733,398 |
| 2015 | $17,296,698 | $16,089,532 | $33,386,230 |
| 2016 | $20,458,800 | $19,030,946 | $39,489,746 |
| 2017 | $22,956,861 | $21,354,663 | $44,311,523 |
| 2018 | $25,107,090 | $23,354,824 | $48,461,914 |
| 2019 | $26,751,383 | $24,884,359 | $51,635,742 |
| 2020 | $28,079,466 | $26,119,753 | $54,199,219 |
| ***Average*** | ***$16,005,986*** | ***$14,888,901*** | ***$30,894,886*** |

Sources: RESI, REMI PI+

**Figure 270: Building Codes—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | -$964,441 | -$897,131 | -$1,861,572 |
| 2011 | -$1,298,438 | -$1,207,818 | -$2,506,256 |
| 2012 | -$1,092,902 | -$1,016,626 | -$2,109,528 |
| 2013 | -$569,178 | -$529,454 | -$1,098,633 |
| 2014 | $565,226 | $525,778 | $1,091,003 |
| 2015 | $1,875,522 | $1,744,626 | $3,620,148 |
| 2016 | $3,302,420 | $3,071,939 | $6,374,359 |
| 2017 | $4,699,674 | $4,371,676 | $9,071,350 |
| 2018 | $6,051,473 | $5,629,130 | $11,680,603 |
| 2019 | $7,300,503 | $6,790,989 | $14,091,492 |
| 2020 | $8,462,576 | $7,871,958 | $16,334,534 |
| ***Average*** | ***$2,575,676*** | ***$2,395,915*** | ***$4,971,591*** |

Sources: RESI, REMI PI+

## A.6 Land Use

**Figure 271: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Status Quo—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 1,020.5 | 1,383.3 | 2,403.9 |
| 2011 | 1,016.3 | 1,718.6 | 2,734.9 |
| 2012 | 998.7 | 1,855.4 | 2,854.1 |
| 2013 | 981.2 | 1,870.6 | 2,851.8 |
| 2014 | 963.7 | 1,824.5 | 2,788.2 |
| 2015 | 947.8 | 1,748.6 | 2,696.3 |
| 2016 | 933.0 | 1,666.0 | 2,598.9 |
| 2017 | 919.3 | 1,585.9 | 2,505.2 |
| 2018 | 906.7 | 1,511.5 | 2,418.2 |
| 2019 | 892.8 | 1,449.0 | 2,341.7 |
| 2020 | 854.7 | 1,406.2 | 2,261.0 |
| ***Average*** | ***948.6*** | ***1,638.1*** | ***2,586.7*** |

Sources: RESI, REMI PI+

**Figure 272: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Status Quo—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $149,267,643 | $230,490,757 | $379,758,400 |
| 2011 | $149,267,840 | $290,022,655 | $439,290,496 |
| 2012 | $149,267,262 | $319,771,285 | $469,038,548 |
| 2013 | $149,265,389 | $328,885,369 | $478,150,758 |
| 2014 | $149,262,135 | $327,194,090 | $476,456,226 |
| 2015 | $149,257,749 | $319,531,602 | $468,789,351 |
| 2016 | $149,252,520 | $309,942,609 | $459,195,129 |
| 2017 | $149,246,716 | $300,154,067 | $449,400,783 |
| 2018 | $149,240,593 | $290,938,405 | $440,178,997 |
| 2019 | $149,234,578 | $284,107,332 | $433,341,910 |
| 2020 | $141,775,706 | $273,146,725 | $414,922,431 |
| ***Average*** | ***$148,576,194*** | ***$297,653,172*** | ***$446,229,366*** |

Sources: RESI, REMI PI+

**Figure 273: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Status Quo—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $83,839,247 | $64,073,567 | $147,912,815 |
| 2011 | $86,706,609 | $95,172,590 | $181,879,199 |
| 2012 | $89,558,957 | $115,074,419 | $204,633,376 |
| 2013 | $92,887,918 | $125,983,740 | $218,871,658 |
| 2014 | $96,485,099 | $130,753,734 | $227,238,833 |
| 2015 | $100,229,721 | $131,367,967 | $231,597,688 |
| 2016 | $104,223,874 | $129,793,131 | $234,017,005 |
| 2017 | $108,458,792 | $126,982,304 | $235,441,095 |
| 2018 | $112,935,974 | $123,476,233 | $236,412,207 |
| 2019 | $117,515,291 | $120,330,118 | $237,845,409 |
| 2020 | $118,392,655 | $106,879,712 | $225,272,367 |
| ***Average*** | ***$101,021,285*** | ***$115,444,319*** | ***$216,465,605*** |

Sources: RESI, REMI PI+

**Figure 274: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Enhancement—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | 1,200.6 | 1,627.5 | 2,828.1 |
| 2011 | 1,195.6 | 2,021.9 | 3,217.6 |
| 2012 | 1,174.9 | 2,182.8 | 3,357.7 |
| 2013 | 1,154.4 | 2,200.7 | 3,355.1 |
| 2014 | 1,133.8 | 2,146.5 | 3,280.2 |
| 2015 | 1,115.0 | 2,057.1 | 3,172.1 |
| 2016 | 1,097.6 | 1,960.0 | 3,057.6 |
| 2017 | 1,081.5 | 1,865.7 | 2,947.3 |
| 2018 | 1,066.7 | 1,778.2 | 2,844.9 |
| 2019 | 1,050.3 | 1,704.7 | 2,755.0 |
| 2020 | 1,005.6 | 1,654.4 | 2,659.9 |
| ***Average*** | ***1,116.0*** | ***1,927.2*** | ***3,043.2*** |

Sources: RESI, REMI PI+

**Figure 275: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Enhancement—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $175,608,992 | $271,165,596 | $446,774,588 |
| 2011 | $175,609,224 | $341,203,124 | $516,812,348 |
| 2012 | $175,608,544 | $376,201,512 | $551,810,056 |
| 2013 | $175,606,340 | $386,923,964 | $562,530,304 |
| 2014 | $175,602,512 | $384,934,224 | $560,536,736 |
| 2015 | $175,597,352 | $375,919,532 | $551,516,884 |
| 2016 | $175,591,200 | $364,638,364 | $540,229,564 |
| 2017 | $175,584,372 | $353,122,432 | $528,706,804 |
| 2018 | $175,577,168 | $342,280,476 | $517,857,644 |
| 2019 | $175,570,092 | $334,243,920 | $509,814,012 |
| 2020 | $166,794,949 | $321,349,088 | $488,144,037 |
| ***Average*** | ***$174,795,522*** | ***$350,180,203*** | ***$524,975,725*** |

Sources: RESI, REMI PI+

**Figure 276: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Enhancement—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $98,634,409 | $75,380,667 | $174,015,076 |
| 2011 | $102,007,775 | $111,967,753 | $213,975,528 |
| 2012 | $105,363,479 | $135,381,669 | $240,745,148 |
| 2013 | $109,279,904 | $148,216,164 | $257,496,068 |
| 2014 | $113,511,881 | $153,827,923 | $267,339,804 |
| 2015 | $117,917,319 | $154,550,549 | $272,467,868 |
| 2016 | $122,616,323 | $152,697,801 | $275,314,124 |
| 2017 | $127,598,579 | $149,390,945 | $276,989,524 |
| 2018 | $132,865,851 | $145,266,157 | $278,132,008 |
| 2019 | $138,253,283 | $141,564,845 | $279,818,128 |
| 2020 | $139,285,476 | $125,740,838 | $265,026,315 |
| ***Average*** | ***$118,848,571*** | ***$135,816,846*** | ***$254,665,417*** |

Sources: RESI, REMI PI+

**Figure 277: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Status Quo—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 733.1 | 733.1 |
| 2011 | 0.0 | 824.8 | 824.8 |
| 2012 | 0.0 | 867.0 | 867.0 |
| 2013 | 0.0 | 870.3 | 870.3 |
| 2014 | 0.0 | 852.6 | 852.6 |
| 2015 | 0.0 | 825.7 | 825.7 |
| 2016 | 0.0 | 798.3 | 798.3 |
| 2017 | 0.0 | 772.3 | 772.3 |
| 2018 | 0.0 | 747.8 | 747.8 |
| 2019 | 0.0 | 727.3 | 727.3 |
| 2020 | 0.0 | 710.8 | 710.8 |
| ***Average*** | ***0.0*** | ***793.6*** | ***793.6*** |

Sources: RESI, REMI PI+

**Figure 278: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Status Quo—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $139,545,931 | $139,545,931 |
| 2011 | $0 | $160,052,214 | $160,052,214 |
| 2012 | $0 | $171,800,520 | $171,800,520 |
| 2013 | $0 | $174,957,962 | $174,957,962 |
| 2014 | $0 | $173,351,448 | $173,351,448 |
| 2015 | $0 | $169,266,828 | $169,266,828 |
| 2016 | $0 | $164,610,222 | $164,610,222 |
| 2017 | $0 | $159,923,499 | $159,923,499 |
| 2018 | $0 | $155,360,603 | $155,360,603 |
| 2019 | $0 | $151,908,068 | $151,908,068 |
| 2020 | $0 | $149,479,231 | $149,479,231 |
| ***Average*** | ***$0*** | ***$160,932,412*** | ***$160,932,412*** |

Sources: RESI, REMI PI+

**Figure 279: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Status Quo—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $42,727,625 | $42,727,625 |
| 2011 | $0 | $49,769,910 | $49,769,910 |
| 2012 | $0 | $53,594,770 | $53,594,770 |
| 2013 | $0 | $54,288,564 | $54,288,564 |
| 2014 | $0 | $53,037,899 | $53,037,899 |
| 2015 | $0 | $50,646,357 | $50,646,357 |
| 2016 | $0 | $47,898,859 | $47,898,859 |
| 2017 | $0 | $45,087,497 | $45,087,497 |
| 2018 | $0 | $42,370,042 | $42,370,042 |
| 2019 | $0 | $40,056,723 | $40,056,723 |
| 2020 | $0 | $38,228,325 | $38,228,325 |
| ***Average*** | ***$0*** | ***$47,064,234*** | ***$47,064,234*** |

Sources: RESI, REMI PI+

**Figure 280: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Enhancement—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 1,127.8 | 1,127.8 |
| 2011 | 0.0 | 1,268.9 | 1,268.9 |
| 2012 | 0.0 | 1,333.8 | 1,333.8 |
| 2013 | 0.0 | 1,338.9 | 1,338.9 |
| 2014 | 0.0 | 1,311.6 | 1,311.6 |
| 2015 | 0.0 | 1,270.4 | 1,270.4 |
| 2016 | 0.0 | 1,228.2 | 1,228.2 |
| 2017 | 0.0 | 1,188.1 | 1,188.1 |
| 2018 | 0.0 | 1,150.4 | 1,150.4 |
| 2019 | 0.0 | 1,118.9 | 1,118.9 |
| 2020 | 0.0 | 1,093.5 | 1,093.5 |
| ***Average*** | ***0.0*** | ***1,221.0*** | ***1,221.0*** |

Sources: RESI, REMI PI+

**Figure 281: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Enhancement—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $187,850,292 | $187,850,292 |
| 2011 | $0 | $215,454,904 | $215,454,904 |
| 2012 | $0 | $231,269,931 | $231,269,931 |
| 2013 | $0 | $235,520,334 | $235,520,334 |
| 2014 | $0 | $233,357,719 | $233,357,719 |
| 2015 | $0 | $227,859,191 | $227,859,191 |
| 2016 | $0 | $221,590,684 | $221,590,684 |
| 2017 | $0 | $215,281,633 | $215,281,633 |
| 2018 | $0 | $209,139,273 | $209,139,273 |
| 2019 | $0 | $204,491,630 | $204,491,630 |
| 2020 | $0 | $201,222,042 | $201,222,042 |
| ***Average*** | ***$0*** | ***$216,639,785*** | ***$216,639,785*** |

Sources: RESI, REMI PI+

**Figure 282: Reducing GHG Emissions from the Transportation Sector through Land Use and Location Efficiency Enhancement—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $82,168,510 | $82,168,510 |
| 2011 | $0 | $95,711,365 | $95,711,365 |
| 2012 | $0 | $103,066,865 | $103,066,865 |
| 2013 | $0 | $104,401,085 | $104,401,085 |
| 2014 | $0 | $101,995,960 | $101,995,960 |
| 2015 | $0 | $97,396,840 | $97,396,840 |
| 2016 | $0 | $92,113,190 | $92,113,190 |
| 2017 | $0 | $86,706,725 | $86,706,725 |
| 2018 | $0 | $81,480,850 | $81,480,850 |
| 2019 | $0 | $77,032,160 | $77,032,160 |
| 2020 | $0 | $73,516,010 | $73,516,010 |
| ***Average*** | ***$0*** | ***$90,508,142*** | ***$90,508,142*** |

Sources: RESI, REMI PI+

**Figure 283: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Status Quo—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 1,200.6 | 1,627.5 | 2,828.1 |
| 2011 | 1,195.6 | 2,021.9 | 3,217.6 |
| 2012 | 1,174.9 | 2,182.8 | 3,357.7 |
| 2013 | 1,154.4 | 2,200.7 | 3,355.1 |
| 2014 | 1,133.8 | 2,146.5 | 3,280.2 |
| 2015 | 1,115.0 | 2,057.1 | 3,172.1 |
| 2016 | 1,097.6 | 1,960.0 | 3,057.6 |
| 2017 | 1,081.5 | 1,865.7 | 2,947.3 |
| 2018 | 1,066.7 | 1,778.2 | 2,844.9 |
| 2019 | 1,050.3 | 1,704.7 | 2,755.0 |
| 2020 | 1,005.6 | 1,654.4 | 2,659.9 |
| ***Average*** | ***1,116.0*** | ***1,927.2*** | ***3,043.2*** |

Sources: RESI, REMI PI+

**Figure 284: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Status Quo—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $148,170,087 | $228,795,972 | $376,966,059 |
| 2011 | $148,170,283 | $287,890,136 | $436,060,419 |
| 2012 | $148,169,709 | $317,420,026 | $465,589,735 |
| 2013 | $148,167,849 | $326,467,095 | $474,634,944 |
| 2014 | $148,164,620 | $324,788,252 | $472,952,871 |
| 2015 | $148,160,266 | $317,182,105 | $465,342,371 |
| 2016 | $148,155,075 | $307,663,620 | $455,818,695 |
| 2017 | $148,149,314 | $297,947,052 | $446,096,366 |
| 2018 | $148,143,236 | $288,799,152 | $436,942,387 |
| 2019 | $148,137,265 | $282,018,308 | $430,155,573 |
| 2020 | $140,733,238 | $271,138,293 | $411,871,531 |
| ***Average*** | ***$147,483,722*** | ***$295,464,546*** | ***$442,948,268*** |

Sources: RESI, REMI PI+

**Figure 285: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Status Quo—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $83,222,782 | $63,602,438 | $146,825,220 |
| 2011 | $86,069,061 | $94,472,791 | $180,541,852 |
| 2012 | $88,900,435 | $114,228,283 | $203,128,719 |
| 2013 | $92,204,919 | $125,057,389 | $217,262,307 |
| 2014 | $95,775,650 | $129,792,310 | $225,567,960 |
| 2015 | $99,492,738 | $130,402,026 | $229,894,764 |
| 2016 | $103,457,522 | $128,838,770 | $232,296,292 |
| 2017 | $107,661,301 | $126,048,610 | $233,709,911 |
| 2018 | $112,105,562 | $122,568,320 | $234,673,882 |
| 2019 | $116,651,208 | $119,445,338 | $236,096,546 |
| 2020 | $117,522,121 | $106,093,832 | $223,615,953 |
| ***Average*** | ***$100,278,482*** | ***$114,595,464*** | ***$214,873,946*** |

Sources: RESI, REMI PI+

**Figure 286: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Enhancement—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 1,350.7 | 1,830.9 | 3,181.6 |
| 2011 | 1,345.1 | 2,274.7 | 3,619.8 |
| 2012 | 1,321.8 | 2,455.6 | 3,777.4 |
| 2013 | 1,298.7 | 2,475.8 | 3,774.5 |
| 2014 | 1,275.5 | 2,414.8 | 3,690.3 |
| 2015 | 1,254.4 | 2,314.3 | 3,568.6 |
| 2016 | 1,234.8 | 2,205.0 | 3,439.8 |
| 2017 | 1,216.7 | 2,098.9 | 3,315.7 |
| 2018 | 1,200.0 | 2,000.5 | 3,200.5 |
| 2019 | 1,181.6 | 1,917.7 | 3,099.4 |
| 2020 | 1,131.3 | 1,861.2 | 2,992.4 |
| ***Average*** | ***1,255.5*** | ***2,168.1*** | ***3,423.6*** |

Sources: RESI, REMI PI+

**Figure 287: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Enhancement—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $285,364,612 | $440,644,094 | $726,008,706 |
| 2011 | $285,364,989 | $554,455,077 | $839,820,066 |
| 2012 | $285,363,884 | $611,327,457 | $896,691,341 |
| 2013 | $285,360,303 | $628,751,442 | $914,111,744 |
| 2014 | $285,354,082 | $625,518,114 | $910,872,196 |
| 2015 | $285,345,697 | $610,869,240 | $896,214,937 |
| 2016 | $285,335,700 | $592,537,342 | $877,873,042 |
| 2017 | $285,324,605 | $573,823,952 | $859,148,557 |
| 2018 | $285,312,898 | $556,205,774 | $841,518,672 |
| 2019 | $285,301,400 | $543,146,370 | $828,447,770 |
| 2020 | $271,041,791 | $522,192,268 | $793,234,059 |
| ***Average*** | ***$284,042,724*** | ***$569,042,830*** | ***$853,085,553*** |

Sources: RESI, REMI PI+

**Figure 288: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Enhancement—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $184,939,516 | $141,338,751 | $326,278,268 |
| 2011 | $191,264,579 | $209,939,536 | $401,204,115 |
| 2012 | $197,556,523 | $253,840,629 | $451,397,153 |
| 2013 | $204,899,819 | $277,905,308 | $482,805,128 |
| 2014 | $212,834,777 | $288,427,355 | $501,262,133 |
| 2015 | $221,094,973 | $289,782,279 | $510,877,253 |
| 2016 | $229,905,605 | $286,308,377 | $516,213,983 |
| 2017 | $239,247,335 | $280,108,023 | $519,355,358 |
| 2018 | $249,123,472 | $272,374,043 | $521,497,515 |
| 2019 | $259,224,906 | $265,434,084 | $524,658,990 |
| 2020 | $261,160,268 | $235,764,072 | $496,924,340 |
| ***Average*** | ***$222,841,070*** | ***$254,656,587*** | ***$477,497,657*** |

Sources: RESI, REMI PI+

**Figure 289: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Status Quo—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 1,151.4 | 1,151.4 |
| 2011 | 0.0 | 1,295.5 | 1,295.5 |
| 2012 | 0.0 | 1,361.8 | 1,361.8 |
| 2013 | 0.0 | 1,367.0 | 1,367.0 |
| 2014 | 0.0 | 1,339.1 | 1,339.1 |
| 2015 | 0.0 | 1,296.9 | 1,296.9 |
| 2016 | 0.0 | 1,253.9 | 1,253.9 |
| 2017 | 0.0 | 1,213.0 | 1,213.0 |
| 2018 | 0.0 | 1,174.5 | 1,174.5 |
| 2019 | 0.0 | 1,142.4 | 1,142.4 |
| 2020 | 0.0 | 1,116.4 | 1,116.4 |
| ***Average*** | ***0.0*** | ***1,246.5*** | ***1,246.5*** |

Sources: RESI, REMI PI+

**Figure 290: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Status Quo—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $292,241,383 | $292,241,383 |
| 2011 | $0 | $335,186,272 | $335,186,272 |
| 2012 | $0 | $359,789,935 | $359,789,935 |
| 2013 | $0 | $366,402,348 | $366,402,348 |
| 2014 | $0 | $363,037,937 | $363,037,937 |
| 2015 | $0 | $354,483,799 | $354,483,799 |
| 2016 | $0 | $344,731,793 | $344,731,793 |
| 2017 | $0 | $334,916,712 | $334,916,712 |
| 2018 | $0 | $325,360,955 | $325,360,955 |
| 2019 | $0 | $318,130,550 | $318,130,550 |
| 2020 | $0 | $313,044,005 | $313,044,005 |
| ***Average*** | ***$0*** | ***$337,029,608*** | ***$337,029,608*** |

Sources: RESI, REMI PI+

**Figure 291: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Status Quo—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $89,481,507 | $89,481,507 |
| 2011 | $0 | $104,229,676 | $104,229,676 |
| 2012 | $0 | $112,239,816 | $112,239,816 |
| 2013 | $0 | $113,692,782 | $113,692,782 |
| 2014 | $0 | $111,073,600 | $111,073,600 |
| 2015 | $0 | $106,065,159 | $106,065,159 |
| 2016 | $0 | $100,311,264 | $100,311,264 |
| 2017 | $0 | $94,423,624 | $94,423,624 |
| 2018 | $0 | $88,732,646 | $88,732,646 |
| 2019 | $0 | $83,888,022 | $83,888,022 |
| 2020 | $0 | $80,058,935 | $80,058,935 |
| ***Average*** | ***$0*** | ***$98,563,366*** | ***$98,563,366*** |

Sources: RESI, REMI PI+

**Figure 292: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Enhancement—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.0 | 1,832.7 | 1,832.7 |
| 2011 | 0.0 | 2,062.0 | 2,062.0 |
| 2012 | 0.0 | 2,167.5 | 2,167.5 |
| 2013 | 0.0 | 2,175.8 | 2,175.8 |
| 2014 | 0.0 | 2,131.4 | 2,131.4 |
| 2015 | 0.0 | 2,064.3 | 2,064.3 |
| 2016 | 0.0 | 1,995.8 | 1,995.8 |
| 2017 | 0.0 | 1,930.7 | 1,930.7 |
| 2018 | 0.0 | 1,869.4 | 1,869.4 |
| 2019 | 0.0 | 1,818.3 | 1,818.3 |
| 2020 | 0.0 | 1,777.0 | 1,777.0 |
| ***Average*** | ***0.0*** | ***1,984.1*** | ***1,984.1*** |

Sources: RESI, REMI PI+

**Figure 293: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Enhancement—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $348,864,828 | $348,864,828 |
| 2011 | $0 | $400,130,536 | $400,130,536 |
| 2012 | $0 | $429,501,300 | $429,501,300 |
| 2013 | $0 | $437,394,906 | $437,394,906 |
| 2014 | $0 | $433,378,621 | $433,378,621 |
| 2015 | $0 | $423,167,069 | $423,167,069 |
| 2016 | $0 | $411,525,556 | $411,525,556 |
| 2017 | $0 | $399,808,747 | $399,808,747 |
| 2018 | $0 | $388,401,507 | $388,401,507 |
| 2019 | $0 | $379,770,170 | $379,770,170 |
| 2020 | $0 | $373,698,078 | $373,698,078 |
| ***Average*** | ***$0*** | ***$402,331,029*** | ***$402,331,029*** |

Sources: RESI, REMI PI+

**Figure 294: Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Enhancement—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $123,252,765 | $123,252,765 |
| 2011 | $0 | $143,567,048 | $143,567,048 |
| 2012 | $0 | $154,600,298 | $154,600,298 |
| 2013 | $0 | $156,601,628 | $156,601,628 |
| 2014 | $0 | $152,993,940 | $152,993,940 |
| 2015 | $0 | $146,095,260 | $146,095,260 |
| 2016 | $0 | $138,169,785 | $138,169,785 |
| 2017 | $0 | $130,060,088 | $130,060,088 |
| 2018 | $0 | $122,221,275 | $122,221,275 |
| 2019 | $0 | $115,548,240 | $115,548,240 |
| 2020 | $0 | $110,274,015 | $110,274,015 |
| ***Average*** | ***$0*** | ***$135,762,213*** | ***$135,762,213*** |

Sources: RESI, REMI PI+

## A.7 Innovative Initiatives

**Figure 295: Buy Local for GHG Benefits—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | 42.2 | 41.7 | 83.9 |
| 2011 | 42.4 | 41.4 | 83.8 |
| 2012 | 40.6 | 39.7 | 80.3 |
| 2013 | 15.0 | 14.6 | 29.7 |
| 2014 | 13.8 | 13.2 | 27.0 |
| 2015 | 13.2 | 12.8 | 26.1 |
| 2016 | 12.6 | 12.2 | 24.8 |
| 2017 | 12.1 | 11.8 | 24.0 |
| 2018 | 12.5 | 12.3 | 24.8 |
| 2019 | 12.1 | 11.6 | 23.6 |
| 2020 | 11.6 | 11.2 | 22.8 |
| ***Average*** | ***20.7*** | ***20.2*** | ***41.0*** |

Sources: RESI, REMI PI+

**Figure 296: Buy Local for GHG Benefits—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $540,594 | $527,521 | $1,068,115 |
| 2011 | $556,039 | $542,593 | $1,098,633 |
| 2012 | $525,148 | $512,449 | $1,037,598 |
| 2013 | $200,792 | $195,937 | $396,729 |
| 2014 | $123,564 | $120,576 | $244,141 |
| 2015 | $123,564 | $120,576 | $244,141 |
| 2016 | $92,673 | $90,432 | $183,105 |
| 2017 | $61,782 | $60,288 | $122,070 |
| 2018 | $154,455 | $150,720 | $305,176 |
| 2019 | $61,782 | $60,288 | $122,070 |
| 2020 | $61,782 | $60,288 | $122,070 |
| ***Average*** | ***$227,471*** | ***$221,970*** | ***$449,441*** |

Sources: RESI, REMI PI+

**Figure 297: Buy Local for GHG Benefits—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $417,030 | $406,945 | $823,975 |
| 2011 | $482,673 | $471,001 | $953,674 |
| 2012 | $509,703 | $497,377 | $1,007,080 |
| 2013 | $274,158 | $267,529 | $541,687 |
| 2014 | $231,683 | $226,081 | $457,764 |
| 2015 | $220,099 | $214,777 | $434,875 |
| 2016 | $195,000 | $190,285 | $385,284 |
| 2017 | $177,624 | $173,328 | $350,952 |
| 2018 | $181,485 | $177,096 | $358,582 |
| 2019 | $171,832 | $167,676 | $339,508 |
| 2020 | $158,317 | $154,488 | $312,805 |
| ***Average*** | ***$274,509*** | ***$267,871*** | ***$542,381*** |

Sources: RESI, REMI PI+

**Figure 298: Buy Local for GHG Benefits—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | 3.2 | 2.8 | 6.0 |
| 2011 | 4.1 | 3.5 | 7.5 |
| 2012 | 3.2 | 2.8 | 6.0 |
| 2013 | 3.5 | 2.9 | 6.4 |
| 2014 | 3.5 | 2.9 | 6.4 |
| 2015 | 3.2 | 2.5 | 5.7 |
| 2016 | 2.3 | 1.9 | 4.2 |
| 2017 | 2.4 | 2.0 | 4.4 |
| 2018 | 3.2 | 2.7 | 5.9 |
| 2019 | 2.9 | 2.3 | 5.2 |
| 2020 | 2.6 | 2.1 | 4.6 |
| ***Average*** | ***3.1*** | ***2.6*** | ***5.7*** |

Sources: RESI, REMI PI+

**Figure 299: Buy Local for GHG Benefits—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $648,928 | $541,257 | $1,190,186 |
| 2011 | $698,846 | $582,892 | $1,281,738 |
| 2012 | $665,567 | $555,136 | $1,220,703 |
| 2013 | $648,928 | $541,257 | $1,190,186 |
| 2014 | $632,289 | $527,379 | $1,159,668 |
| 2015 | $599,011 | $499,622 | $1,098,633 |
| 2016 | $565,732 | $471,865 | $1,037,598 |
| 2017 | $565,732 | $471,865 | $1,037,598 |
| 2018 | $632,289 | $527,379 | $1,159,668 |
| 2019 | $565,732 | $471,865 | $1,037,598 |
| 2020 | $565,732 | $471,865 | $1,037,598 |
| ***Average*** | ***$617,163*** | ***$514,762*** | ***$1,131,925*** |

Sources: RESI, REMI PI+

**Figure 300: Buy Local for GHG Benefits—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $83,196 | $69,392 | $152,588 |
| 2011 | $114,394 | $95,414 | $209,808 |
| 2012 | $108,155 | $90,210 | $198,364 |
| 2013 | $122,714 | $102,353 | $225,067 |
| 2014 | $131,034 | $109,292 | $240,326 |
| 2015 | $120,634 | $100,618 | $221,252 |
| 2016 | $112,315 | $93,679 | $205,994 |
| 2017 | $110,235 | $91,944 | $202,179 |
| 2018 | $131,034 | $109,292 | $240,326 |
| 2019 | $112,315 | $93,679 | $205,994 |
| 2020 | $108,155 | $90,210 | $198,364 |
| ***Average*** | ***$114,016*** | ***$95,099*** | ***$209,115*** |

Sources: RESI, REMI PI+

**Figure 301: Voluntary Stationary Source Reductions—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*** |

Sources: RESI, REMI PI+

**Figure 302: Voluntary Stationary Source Reductions—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*** |

Sources: RESI, REMI PI+

**Figure 303: Voluntary Stationary Source Reductions—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*** |

Sources: RESI, REMI PI+

**Figure 304: Voluntary Stationary Source Reductions—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*** |

Sources: RESI, REMI PI+

**Figure 305: Voluntary Stationary Source Reductions—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*** |

Sources: RESI, REMI PI+

**Figure 306: Voluntary Stationary Source Reductions—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*** |

Sources: RESI, REMI PI+

**Figure 307: 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*** |

Sources: RESI, REMI PI+

**Figure 308: 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*** |

Sources: RESI, REMI PI+

**Figure 309: 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*** |

Sources: RESI, REMI PI+

**Figure 310: 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 |
| ***Average*** | ***0.0*** | ***0.0*** | ***0.0*** |

Sources: RESI, REMI PI+

**Figure 311: 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 |
| ***Average*** | ***-$9,917*** | ***-$1,181*** | ***-$11,097*** |

Sources: RESI, REMI PI+

**Figure 312: 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 |
| ***Average*** | ***$2,479*** | ***$295*** | ***$2,774*** |

Sources: RESI, REMI PI+

**Figure 313: 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*** |

Sources: RESI, REMI PI+

**Figure 314: 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*** |

Sources: RESI, REMI PI+

**Figure 315: 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*** |

Sources: RESI, REMI PI+

**Figure 316: Leadership-by-Example-Local Government—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 | 1,484.9 | 352.5 | 1,837.4 |
| ***Average*** | ***1,484.9*** | ***352.5*** | ***1,837.4*** |

Sources: RESI, REMI PI+

**Figure 317: Leadership-by-Example-Local Government—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 | $79,885,067 | $29,428,898 | $109,313,965 |
| ***Average*** | ***$79,885,067*** | ***$29,428,898*** | ***$109,313,965*** |

Sources: RESI, REMI PI+

**Figure 318: Leadership-by-Example-Local Government—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 | $75,413,555 | $27,781,635 | $103,195,190 |
| ***Average*** | ***$75,413,555*** | ***$27,781,635*** | ***$103,195,190*** |

Sources: RESI, REMI PI+

**Figure 319: 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*** |

Sources: RESI, REMI PI+

**Figure 320: 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*** |

Sources: RESI, REMI PI+

**Figure 321: 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*** |

Sources: RESI, REMI PI+

**Figure 322: Leadership-by-Example-Federal Government—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 | 977.8 | 280.6 | 1,258.4 |
| ***Average*** | ***977.8*** | ***280.6*** | ***1,258.4*** |

Sources: RESI, REMI PI+

**Figure 323: Leadership-by-Example-Federal Government—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 | $64,437,579 | $27,664,472 | $92,102,051 |
| ***Average*** | ***$64,437,579*** | ***$27,664,472*** | ***$92,102,051*** |

Sources: RESI, REMI PI+

**Figure 324: Leadership-by-Example-Federal Government—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 | $48,114,673 | $20,656,689 | $68,771,362 |
| ***Average*** | ***$48,114,673*** | ***$20,656,689*** | ***$68,771,362*** |

Sources: RESI, REMI PI+

**Figure 325: State of Maryland Initiative to Lead by Example Status Quo—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 44.9 | 42.2 | 87.1 |
| 2011 | 15.7 | 14.6 | 30.3 |
| 2012 | 24.7 | 23.0 | 47.8 |
| 2013 | 88.9 | 83.6 | 172.5 |
| 2014 | 88.1 | 83.0 | 171.1 |
| 2015 | 86.3 | 81.2 | 167.5 |
| 2016 | 84.0 | 79.2 | 163.2 |
| 2017 | 81.8 | 77.1 | 158.9 |
| 2018 | 85.9 | 81.0 | 166.9 |
| 2019 | 12.6 | 11.7 | 24.3 |
| 2020 | 10.3 | 9.6 | 19.9 |
| ***Average*** | ***56.7*** | ***53.3*** | ***110.0*** |

Sources: RESI, REMI PI+

**Figure 326: State of Maryland Initiative to Lead by Example Status Quo—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $2,532,427 | $2,380,903 | $4,913,330 |
| 2011 | $865,115 | $813,352 | $1,678,467 |
| 2012 | $1,368,454 | $1,286,575 | $2,655,029 |
| 2013 | $5,017,666 | $4,717,441 | $9,735,107 |
| 2014 | $4,844,643 | $4,554,771 | $9,399,414 |
| 2015 | $4,781,726 | $4,495,618 | $9,277,344 |
| 2016 | $4,655,891 | $4,377,312 | $9,033,203 |
| 2017 | $4,467,138 | $4,199,854 | $8,666,992 |
| 2018 | $4,718,808 | $4,436,465 | $9,155,273 |
| 2019 | $220,211 | $207,035 | $427,246 |
| 2020 | $62,917 | $59,153 | $122,070 |
| ***Average*** | ***$3,048,636*** | ***$2,866,225*** | ***$5,914,862*** |

Sources: RESI, REMI PI+

**Figure 327: State of Maryland Initiative to Lead by Example Status Quo—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $1,034,205 | $972,325 | $2,006,531 |
| 2011 | $414,862 | $390,039 | $804,901 |
| 2012 | $639,005 | $600,771 | $1,239,777 |
| 2013 | $2,229,637 | $2,096,230 | $4,325,867 |
| 2014 | $2,373,167 | $2,231,172 | $4,604,340 |
| 2015 | $2,483,273 | $2,334,690 | $4,817,963 |
| 2016 | $2,552,089 | $2,399,388 | $4,951,477 |
| 2017 | $2,577,649 | $2,423,419 | $5,001,068 |
| 2018 | $2,778,198 | $2,611,969 | $5,390,167 |
| 2019 | $652,768 | $613,711 | $1,266,479 |
| 2020 | $462,050 | $434,404 | $896,454 |
| ***Average*** | ***$1,654,264*** | ***$1,555,284*** | ***$3,209,548*** |

Sources: RESI, REMI PI+

**Figure 328: State of Maryland Initiative to Lead by Example Enhancement—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 44.9 | 42.2 | 87.1 |
| 2011 | 15.7 | 14.6 | 30.3 |
| 2012 | 24.7 | 23.0 | 47.8 |
| 2013 | 88.9 | 83.6 | 172.5 |
| 2014 | 88.1 | 83.0 | 171.1 |
| 2015 | 117.7 | 110.7 | 228.4 |
| 2016 | 114.6 | 108.0 | 222.6 |
| 2017 | 111.6 | 105.1 | 216.7 |
| 2018 | 117.2 | 110.4 | 227.6 |
| 2019 | 17.2 | 15.9 | 33.1 |
| 2020 | 14.1 | 13.0 | 27.1 |
| ***Average*** | ***68.6*** | ***64.5*** | ***133.1*** |

Sources: RESI, REMI PI+

**Figure 329: State of Maryland Initiative to Lead by Example Enhancement—Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $2,532,427 | $2,380,903 | $4,913,330 |
| 2011 | $865,115 | $813,352 | $1,678,467 |
| 2012 | $1,368,454 | $1,286,575 | $2,655,029 |
| 2013 | $5,017,666 | $4,717,441 | $9,735,107 |
| 2014 | $4,844,643 | $4,554,771 | $9,399,414 |
| 2015 | $6,520,535 | $6,130,388 | $12,650,924 |
| 2016 | $6,348,942 | $5,969,062 | $12,318,005 |
| 2017 | $6,091,553 | $5,727,073 | $11,818,626 |
| 2018 | $6,434,739 | $6,049,725 | $12,484,464 |
| 2019 | $300,288 | $282,321 | $582,608 |
| 2020 | $85,797 | $80,663 | $166,460 |
| ***Average*** | ***$3,673,651*** | ***$3,453,843*** | ***$7,127,494*** |

Sources: RESI, REMI PI+

**Figure 330: State of Maryland Initiative to Lead by Example Enhancement—Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---:|---:|---:|
| 2010 | $1,034,205 | $972,325 | $2,006,531 |
| 2011 | $414,862 | $390,039 | $804,901 |
| 2012 | $639,005 | $600,771 | $1,239,777 |
| 2013 | $2,229,637 | $2,096,230 | $4,325,867 |
| 2014 | $2,373,167 | $2,231,172 | $4,604,340 |
| 2015 | $3,386,281 | $3,183,668 | $6,569,949 |
| 2016 | $3,480,121 | $3,271,893 | $6,752,014 |
| 2017 | $3,514,976 | $3,304,663 | $6,819,639 |
| 2018 | $3,788,452 | $3,561,776 | $7,350,228 |
| 2019 | $890,139 | $836,879 | $1,727,018 |
| 2020 | $630,068 | $592,369 | $1,222,437 |
| ***Average*** | ***$2,034,629*** | ***$1,912,890*** | ***$3,947,518*** |

Sources: RESI, REMI PI+

**Figure 331: State of Maryland Initiative to Lead by Example Status Quo—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.2 | 0.5 | 0.7 |
| 2011 | 0.0 | 0.0 | 0.0 |
| 2012 | 0.0 | 0.1 | 0.1 |
| 2013 | 0.4 | 0.5 | 0.9 |
| 2014 | 1.4 | 1.4 | 2.8 |
| 2015 | 0.6 | 0.5 | 1.1 |
| 2016 | -0.1 | 0.1 | 0.0 |
| 2017 | 0.4 | 0.4 | 0.8 |
| 2018 | 0.7 | 0.7 | 1.4 |
| 2019 | -0.1 | -0.1 | -0.2 |
| 2020 | 0.0 | 0.1 | 0.1 |
| ***Average*** | ***0.3*** | ***0.4*** | ***0.7*** |

Sources: RESI, REMI PI+

**Figure 332: State of Maryland Initiative to Lead by Example Status Quo—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | -$13,603 | -$16,914 | -$30,518 |
| 2012 | $0 | $0 | $0 |
| 2013 | -$27,207 | -$33,828 | -$61,035 |
| 2014 | -$81,621 | -$101,484 | -$183,105 |
| 2015 | -$81,621 | -$101,484 | -$183,105 |
| 2016 | -$81,621 | -$101,484 | -$183,105 |
| 2017 | -$81,621 | -$101,484 | -$183,105 |
| 2018 | -$54,414 | -$67,656 | -$122,070 |
| 2019 | -$81,621 | -$101,484 | -$183,105 |
| 2020 | -$54,414 | -$67,656 | -$122,070 |
| ***Average*** | ***-$50,704*** | ***-$63,043*** | ***-$113,747*** |

Sources: RESI, REMI PI+

**Figure 333: State of Maryland Initiative to Lead by Example Status Quo—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $3,401 | $4,229 | $7,629 |
| 2011 | -$1,700 | -$2,114 | -$3,815 |
| 2012 | $0 | $0 | $0 |
| 2013 | -$1,700 | -$2,114 | -$3,815 |
| 2014 | $5,101 | $6,343 | $11,444 |
| 2015 | -$8,502 | -$10,571 | -$19,073 |
| 2016 | -$6,802 | -$8,457 | -$15,259 |
| 2017 | -$1,700 | -$2,114 | -$3,815 |
| 2018 | $0 | $0 | $0 |
| 2019 | -$8,502 | -$10,571 | -$19,073 |
| 2020 | -$3,401 | -$4,229 | -$7,629 |
| ***Average*** | ***-$2,164*** | ***-$2,691*** | ***-$4,855*** |

Sources: RESI, REMI PI+

**Figure 334: State of Maryland Initiative to Lead by Example Enhancement—Operation Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 0.2 | 0.5 | 0.7 |
| 2011 | 0.0 | 0.0 | 0.0 |
| 2012 | 0.0 | 0.1 | 0.1 |
| 2013 | 0.4 | 0.5 | 0.9 |
| 2014 | 1.4 | 1.4 | 2.8 |
| 2015 | 0.8 | 0.7 | 1.6 |
| 2016 | -0.1 | 0.1 | 0.0 |
| 2017 | 0.5 | 0.6 | 1.1 |
| 2018 | 0.9 | 1.0 | 1.9 |
| 2019 | -0.2 | -0.1 | -0.3 |
| 2020 | 0.0 | 0.1 | 0.1 |
| ***Average*** | ***0.4*** | ***0.4*** | ***0.8*** |

Sources: RESI, REMI PI+

**Figure 335: State of Maryland Initiative to Lead by Example Enhancement—Operation Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $0 | $0 | $0 |
| 2011 | -$13,603 | -$16,914 | -$30,518 |
| 2012 | $0 | $0 | $0 |
| 2013 | -$27,207 | -$33,828 | -$61,035 |
| 2014 | -$81,621 | -$101,484 | -$183,105 |
| 2015 | -$111,301 | -$138,388 | -$249,689 |
| 2016 | -$111,301 | -$138,388 | -$249,689 |
| 2017 | -$111,301 | -$138,388 | -$249,689 |
| 2018 | -$74,201 | -$92,259 | -$166,460 |
| 2019 | -$111,301 | -$138,388 | -$249,689 |
| 2020 | -$74,201 | -$92,259 | -$166,460 |
| ***Average*** | ***-$65,094*** | ***-$80,936*** | ***-$146,030*** |

Sources: RESI, REMI PI+

**Figure 336: State of Maryland Initiative to Lead by Example Enhancement—Operation Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $3,401 | $4,229 | $7,629 |
| 2011 | -$1,700 | -$2,114 | -$3,815 |
| 2012 | $0 | $0 | $0 |
| 2013 | -$1,700 | -$2,114 | -$3,815 |
| 2014 | $5,101 | $6,343 | $11,444 |
| 2015 | -$11,594 | -$14,415 | -$26,009 |
| 2016 | -$9,275 | -$11,532 | -$20,807 |
| 2017 | -$2,319 | -$2,883 | -$5,202 |
| 2018 | $0 | $0 | $0 |
| 2019 | -$11,594 | -$14,415 | -$26,009 |
| 2020 | -$4,638 | -$5,766 | -$10,404 |
| ***Average*** | ***-$3,120*** | ***-$3,879*** | ***-$6,999*** |

Sources: RESI, REMI PI+

**Figure 337: 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*** |

Sources: RESI, REMI PI+

**Figure 338: 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*** |

Sources: RESI, REMI PI+

**Figure 339: 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*** |

Sources: RESI, REMI PI+

**Figure 340: Leadership-by-Example-Maryland Colleges and Universities—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 | 78.0 | 18.1 | 96.0 |
| ***Average*** | ***78.0*** | ***18.1*** | ***96.0*** |

Sources: RESI, REMI PI+

**Figure 341: Leadership-by-Example-Maryland Colleges and Universities—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 | $4,123,262 | $1,491,972 | $5,615,234 |
| ***Average*** | ***$4,123,262*** | ***$1,491,972*** | ***$5,615,234*** |

Sources: RESI, REMI PI+

**Figure 342: Leadership-by-Example-Maryland Colleges and Universities—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 | $3,955,194 | $1,431,158 | $5,386,353 |
| ***Average*** | ***$3,955,194*** | ***$1,431,158*** | ***$5,386,353*** |

Sources: RESI, REMI PI+

**Figure 343: 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*** |

Sources: RESI, REMI PI+

**Figure 344: 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*** |

Sources: RESI, REMI PI+

**Figure 345: 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*** |

Sources: RESI, REMI PI+

**Figure 346: 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 | 0.6 | 0.6 | 1.4 |
| 2014 | 1.4 | 0.3 | 1.7 |
| 2015 | 0.6 | 0.3 | 0.9 |
| 2016 | 2.0 | 0.9 | 2.6 |
| 2017 | 1.4 | 0.6 | 1.7 |
| 2018 | 0.6 | 0.0 | 0.6 |
| 2019 | 0.6 | 0.0 | 0.9 |
| 2020 | 0.6 | 0.0 | 0.6 |
| ***Average*** | ***1.0*** | ***0.3*** | ***1.3*** |

Sources: RESI, REMI PI+

**Figure 347: 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 | $63,960 | $23,231 | $87,194 |
| 2014 | $127,920 | $46,466 | $174,386 |
| 2015 | $0 | $0 | $0 |
| 2016 | $127,920 | $46,466 | $174,386 |
| 2017 | $127,920 | $46,466 | $174,386 |
| 2018 | $0 | $0 | $0 |
| 2019 | $127,920 | $46,466 | $174,386 |
| 2020 | $0 | $0 | $0 |
| ***Average*** | ***$18,316*** | ***$6,653*** | ***$98,092*** |

Sources: RESI, REMI PI+

**Figure 348: 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 | $63,960 | $23,231 | $87,194 |
| 2014 | $31,980 | $11,617 | $43,597 |
| 2015 | $31,980 | $11,617 | $43,597 |
| 2016 | $95,940 | $34,849 | $130,789 |
| 2017 | $127,920 | $46,466 | $174,386 |
| 2018 | $31,980 | $11,617 | $43,597 |
| 2019 | $63,960 | $23,231 | $87,194 |
| 2020 | $63,960 | $23,231 | $87,194 |
| ***Average*** | ***$46,516*** | ***$16,896*** | ***$87,194*** |

Sources: RESI, REMI PI+

**Figure 349: Greenhouse Gas Emissions Inventory Development—Investment Phase, Employment Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | 16.1 | 6.1 | 22.2 |
| 2011 | 16.6 | 6.5 | 23.2 |
| 2012 | 16.5 | 6.5 | 23.0 |
| 2013 | 16.2 | 6.3 | 22.5 |
| 2014 | 16.1 | 6.0 | 22.2 |
| 2015 | 15.5 | 5.4 | 20.9 |
| 2016 | 15.0 | 5.3 | 20.4 |
| 2017 | 14.9 | 5.1 | 20.0 |
| 2018 | 15.1 | 5.4 | 20.6 |
| 2019 | 14.7 | 5.2 | 20.0 |
| 2020 | 14.4 | 4.9 | 19.3 |
| ***Average*** | ***15.6*** | ***5.7*** | ***21.3*** |

Sources: RESI, REMI PI+

**Figure 350: Greenhouse Gas Emissions Inventory Development —Investment Phase, Output Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $1,250,023 | $458,961 | $1,708,984 |
| 2011 | $1,272,345 | $467,157 | $1,739,502 |
| 2012 | $1,316,988 | $483,549 | $1,800,537 |
| 2013 | $1,272,345 | $467,157 | $1,739,502 |
| 2014 | $1,294,667 | $475,353 | $1,770,020 |
| 2015 | $1,205,379 | $442,570 | $1,647,949 |
| 2016 | $1,205,379 | $442,570 | $1,647,949 |
| 2017 | $1,205,379 | $442,570 | $1,647,949 |
| 2018 | $1,205,379 | $442,570 | $1,647,949 |
| 2019 | $1,250,023 | $458,961 | $1,708,984 |
| 2020 | $1,205,379 | $442,570 | $1,647,949 |
| ***Average*** | ***$1,243,935*** | ***$456,726*** | ***$1,700,661*** |

Sources: RESI, REMI PI+

**Figure 351: Greenhouse Gas Emissions Inventory Development —Investment Phase, Wage Impacts**

| Fiscal Year | Direct | Spinoff | Total |
|---|---|---|---|
| 2010 | $580,368 | $213,089 | $793,457 |
| 2011 | $625,011 | $229,481 | $854,492 |
| 2012 | $691,977 | $254,068 | $946,045 |
| 2013 | $714,299 | $262,264 | $976,563 |
| 2014 | $725,460 | $266,362 | $991,821 |
| 2015 | $747,782 | $274,557 | $1,022,339 |
| 2016 | $758,942 | $278,655 | $1,037,598 |
| 2017 | $792,425 | $290,949 | $1,083,374 |
| 2018 | $825,908 | $303,242 | $1,129,150 |
| 2019 | $837,069 | $307,340 | $1,144,409 |
| 2020 | $825,908 | $303,242 | $1,129,150 |
| ***Average*** | ***$738,650*** | ***$271,205*** | ***$1,009,854*** |

Sources: RESI, REMI PI+

**Figure 352: Greenhouse Gas Emissions Inventory Development —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*** |

Sources: RESI, REMI PI+

**Figure 353: Greenhouse Gas Emissions Inventory Development —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*** |

Sources: RESI, REMI PI+

**Figure 354: Greenhouse Gas Emissions Inventory Development —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*** |

Sources: RESI, REMI PI+

## A.8 Outreach

**Figure 355: 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*** |

Sources: RESI, REMI PI+

**Figure 356: 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*** |

Sources: RESI, REMI PI+

**Figure 357: 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*** |

Sources: RESI, REMI PI+

**Figure 358: 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*** |

Sources: RESI, REMI PI+

**Figure 359: 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*** |

Sources: RESI, REMI PI+

**Figure 360: 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*** |

Sources: RESI, REMI PI+

# 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 for the given strategy. As such, RESI, in coordination with MDE, developed a methodology to analyze the reported data. 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. For each phase, where applicable, RESI disseminated the data related to a "status quo," meeting the current baseline reductions, and an "enhanced," a scenario where Maryland may be able to achieve higher reductions.

### 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. 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.

## 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 version 1.6 to analyze data for the 2014 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 361: 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 Opportunity |
| Michigan Technological University | Illinois Department of Revenue |
| Pennsylvania State University | Indiana Department of Transportation |
| Southwestern Oklahoma State University | Iowa Department of Revenue |
| University of Southern 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 Western 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 Associates |

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 362: 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 | X7809 | Production costs, Electrical power distribution, transmission, and generation |
| 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 Energy Efficiency in the Residential Sector | 98<br>63 | Investment Spending (Residential)<br>State Government Spending (Transfer of funds from SEIF) |
| 3.1.6 | EmPOWER Energy Efficiency in the Commercial and Industrial Sectors | 63<br>98 | State Government Spending<br>Investment Spending (Non-residential) |
| 3.1.7 | Energy Efficiency Appliances and Other Products | 605 | Consumer Spending on Household Appliances |
| 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<br>X7809 | Producer's Durable Equipment Investment, Electric distribution, transmission, and generation<br>Production costs, Electrical power distribution, |

| Strategy | Subprogram | Code | Description |
|---|---|---|---|
| | | | transmission, and generation |
| 3.1.10 | Incentives and Grant Subprograms to Support Renewable Energy | 98<br>99<br>63 | Investment Spending (Residential)<br>Investment Spending (Non-residential)<br>State Government Spending |
| 3.1.11 | Offshore Wind Initiatives to Support Renewable Energy | EQP 13 | Producer's Durable Equipment Investment, Electric distribution, transmission, and generation |
| 3.1.12 | Title V Permits | 63 | State Government Spending |
| 3.1.13 | BeSMART | 63<br>98 | State Government Spending<br>Investment Spending (Residential) |
| 3.1.14 | Weatherization and Energy Efficiency for Low-Income Houses | 63<br>98 | State Government Spending<br>Investment Spending (Residential) |
| 3.1.15 | GHG Prevention of Significant Deterioration Permitting Program | 63 | State Government Spending |
| **Transportation** | | | |
| 3.2.1 | Transportation Technology Initiatives | X3317<br>X3212<br>34 | Architectural, engineering, and related services<br>Construction<br>Household disposable income |
| 3.2.2 | Public Transportation Initiatives | X3317<br>X3212 | Architectural, engineering, and related services<br>Construction |

| Strategy | Subprogram | Code | Description |
|---|---|---|---|
| | | 34 | Household disposable income |
| 3.2.3 | Intercity Transportation Initiatives | X3317<br>X3212<br>34 | Architectural, engineering, and related services<br>Construction<br>Household disposable income |
| 3.2.4 | Pricing Initiatives | - | *No Investment Spending Specified* |
| 3.2.5 | Bike and Pedestrian Initiatives | X3317<br>X3212<br>34 | Architectural, engineering, and related services<br>Construction<br>Household disposable income |
| **Agriculture** | | | |
| 3.3.1 | Creating Ecosystem Markets to Encourage GHG Emissions Reductions | X6532 | Exogenous Final Demand (Other professional, scientific, and technical services |
| 3.3.2 | Nutrient Trading for GHG Benefits | X6532 | Exogenous Final Demand (Other professional, scientific, and technical services |
| 3.3.3 | Managing Forests to Capture Carbon | X6412<br>X6526<br>X3203 | Exogenous Final Demand (Construction)<br>Exogenous Final Demand (Architectural, engineering, and related services)<br>Exogenous Final Demand (Support activities for agriculture) |
| 3.3.4 | Increasing Urban Trees to Capture Carbon | X6412 | Exogenous Final Demand (Construction) |

| Strategy | Subprogram | Code | Description |
|---|---|---|---|
| | | X6526 | Exogenous Final Demand (Architectural, engineering, and related services) |
| | | X3203 | Exogenous Final Demand (Support activities for agriculture) |
| 3.3.5 | Creating and Protecting Wetlands and Waterway Borders to Capture Carbon | 63 | State Government Spending |
| 3.3.6 | Geological Opportunities to Store Carbon | X6530 | Exogenous Final Demand (Scientific and professional services) |
| 3.3.7 | Planting Forests in Maryland | X3203 | Industry Sales, Support activities for agriculture |
| 3.3.8 | Biomass for Energy Production | 99 | Investment Spending (Non-residential) |
| 3.3.9 | Conservation of Agricultural Land for GHG Benefits | X3203 | Industry Sales, Support activities for agriculture |
| **Recycling** | | | |
| 3.4.1 | Recycling and Source Reduction | 99 | Investment Spending (Non-residential) |
| **Buildings** | | | |
| 3.5.1 | Building and Trade Codes in Maryland | X4012 | Industry Employment (Construction) |
| **Land Use** | | | |
| 3.6.1 | Reducing Emissions through Smart Growth and Land Use/Location Efficiency | X6412 | Exogenous Final Demand (Construction) |
| | | DIND15 | Detailed Industry Sales (Water, |

| Strategy | Subprogram | Code | Description |
|---|---|---|---|
| | (Include Land Use Planning and Growth Boundary GHG Benefits) | 99 | sewage, and other systems)<br>Investment Spending (Non-residential) |
| 3.6.2 | Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) | X6412<br>DIND15<br>98 | Exogenous Final Demand (Construction)<br>Detailed Industry Sales (Water, sewage, and other systems)<br>Investment Spending (Residential) |
| **Innovative Initiatives** | | | |
| 3.7.1 | Buy Local for GHG Benefits | 63<br>X3203 | State Government Spending<br>Industry Sales, Support activities for agriculture |
| 3.7.2 | Voluntary Stationary Source Reductions | 63 | State Government Spending |
| 3.7.3 | PAYD Insurance in Maryland | - | *No Investment Spending Specified* |
| 3.7.4 | Leadership-by-Example – Local Government | 65 | Local Government Spending |
| 3.7.5 | Leadership-by-Example – Federal Government | 68 | Government Spending including Non-Pecuniary (Amenity) Aspects |
| 3.7.6 | Lead-by-Example: State of Maryland Initiatives and Carbon Footprint | 63 | State Government Spending |
| 3.7.7 | Leadership-by-Example – Maryland University Lead-by- | X5212 | Firm Sales (Construction) |

| Strategy | Subprogram | Code | Description |
|---|---|---|---|
| | Example Initiatives | | |
| 3.7.8 | Transportation and Climate Initiative | - | *No investment costs specified* |
| 3.7.9 | Greenhouse Gas Emissions Inventory Development | X6532 | Exogenous Final Demand (Other professional, scientific, and technical services |
| **Outreach** | | | |
| 3.8.1 | Outreach and Public Education | - | *No investment costs specified* |

Sources: REMI PI+, RESI

**Figure 363: REMI PI+ Industry Codes—Operation Phase**

| Strategy | Subprogram | Code | Description |
|---|---|---|---|
| **Energy** | | | |
| 3.1.1 | Regional Greenhouse Gas Initiative | X7809 | Production costs, Electrical power distribution, transmission, and generation |
| 3.1.2 | Greenhouse Gas Reductions from Imported Power | 63 | State Government Spending |
| 3.1.3 | Greenhouse Gas New Source Performance Standard | X7809 | Production costs, Electrical power distribution, transmission, and generation |
| 3.1.4 | Maximum Achievable Control Technology (MACT) | EQP 13 | Producer's Durable Equipment Investment, Electric distribution, transmission, and generation |
| 3.1.5 | EmPOWER Maryland Energy Efficiency in the Residential Sector | 78<br>638 | Consumer spending reallocation<br>Consumer spending electricity |
| 3.1.6 | EmPOWER Energy Efficiency in the Commercial and Industrial Sectors | 80<br>82 | Electricity Costs (Industrial Sectors)<br>Electricity Costs (Commercial Sectors |
| 3.1.7 | Energy Efficiency Appliances and Other Products | 78<br>638 | Consumer spending reallocation<br>Consumer spending electricity |
| 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 | X7809 | Production costs, Electrical power distribution, |

| Strategy | Subprogram | Code | Description |
|---|---|---|---|
| | | | transmission, and generation |
| | | 63 | State Government Spending |
| 3.1.10 | Incentives and Grant Subprograms to Support Renewable Energy | 80 | Electricity Costs (Industrial Sectors) |
| | | 82 | Electricity Costs (Commercial Sectors |
| | | 78 | Consumer spending reallocation |
| | | 638 | Consumer spending electricity |
| 3.1.11 | Offshore Wind Initiatives to Support Renewable Energy | X7809 | Production costs, Electrical power distribution, transmission, and generation |
| 3.1.12 | Title V Permits | 63 | State Government Spending |
| 3.1.13 | BeSMART | 78 | Consumer spending reallocation |
| | | 638 | Consumer spending electricity |
| 3.1.14 | Weatherization and Energy Efficiency for Low-Income Houses | 78 | Consumer spending reallocation |
| | | 638 | Consumer spending electricity |
| 3.1.15 | GHG Prevention of Significant Deterioration Permitting Program | 63 | State Government Spending |
| **Transportation** | | | |
| 3.2.1 | Transportation Technology Initiatives | 623 | Consumer Spending—Gasoline and oil |
| | | X6495 | Transit and ground passenger transportation |
| | | 78 | Consumption reallocation |

| Strategy | Subprogram | Code | Description |
|---|---|---|---|
| 3.2.2 | Public Transportation Initiatives | 623<br>X6495<br>78 | Consumer Spending—Gasoline and oil<br>Transit and ground passenger transportation<br>Consumption reallocation |
| 3.2.3 | Intercity Transportation Initiatives | 623<br>X6495<br>78 | Consumer Spending—Gasoline and oil<br>Transit and ground passenger transportation<br>Consumption reallocation |
| 3.2.4 | Pricing Initiatives | - | *No Operation Spending Specified* |
| 3.2.5 | Bike and Pedestrian Initiatives | 623<br>78 | Consumer Spending—Gasoline and oil<br>Consumption reallocation |
| **Agriculture** | | | |
| 3.3.1 | Creating Ecosystem Markets to Encourage GHG Emissions Reductions | 88<br>90 | Production costs (Industrial sectors)<br>Production costs (Commercial sectors) |
| 3.3.2 | Nutrient Trading for GHG Benefits | X7801 | Production costs (Forestry; fishing; hunting; and trapping) |
| 3.3.3 | Managing Forests to Capture Carbon | X3203 | Support activities for agriculture |
| 3.3.4 | Increasing Urban Trees to Capture Carbon | X3203 | Support activities for agriculture |
| 3.3.5 | Creating and Protecting Wetlands and Waterway | X3203 | Support activities for agriculture |

| Strategy | Subprogram | Code | Description |
|---|---|---|---|
| | Borders to Capture Carbon | | |
| 3.3.6 | Geological Opportunities to Store Carbon | X3203 | Support activities for agriculture |
| 3.3.7 | Planting Forests in Maryland | X3203 | Support activities for agriculture |
| 3.3.8 | Biomass for Energy Production | X3203 | Support activities for agriculture |
| 3.3.9 | Conservation of Agricultural Land for GHG Benefits | X3203 | Support activities for agriculture |
| **Recycling** | | | |
| 3.4.1 | Recycling and Source Reduction | 99 | Investment Spending (Non-residential) |
| **Buildings** | | | |
| 3.5.1 | Building and Trade Codes in Maryland | X4012 | Industry Employment (Construction) |
| **Land Use** | | | |
| 3.6.1 | Reducing Emissions through Smart Growth and Land Use/Location Efficiency (Include Land Use Planning and Growth Boundary GHG Benefits) | 45<br>623<br>78 | Investment spending (residential capital)<br>Consumer spending—Gasoline and oil<br>Consumption reallocation |
| 3.6.2 | Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) | 45<br>623<br>78 | Investment spending (residential capital)<br>Consumer spending—Gasoline and oil<br>Consumption reallocation |

| Strategy | Subprogram | Code | Description |
|---|---|---|---|
| **Innovative Initiatives** | | | |
| 3.7.1 | Buy Local for GHG Benefits | 617 | Consumer spending—Food and nonalcoholic beverages purchased for off-premises consumption |
| | | 78 | Consumption reallocation |
| 3.7.2 | Voluntary Stationary Source Reductions | 63 | State Government Spending |
| 3.7.3 | PAYD Insurance in Maryland | 617 | Consumer spending—Food and nonalcoholic beverages purchased for off-premises consumption |
| | | 78 | Consumption reallocation |
| 3.7.4 | Leadership-by-Example – Local Government | X6409 | Industry demand-Electric power generation, transmission, and distribution |
| | | 65 | Local Government Spending |
| 3.7.5 | Leadership-by-Example – Federal Government | 68 | Government Spending including Non-Pecuniary (Amenity) Aspects |
| | | X6409 | Industry demand-Electric power generation, transmission, and distribution |
| 3.7.6 | Lead-by-Example: State of Maryland Initiatives and Carbon Footprint | X6409 | Industry demand-Electric power generation, transmission, and distribution |
| | | 63 | State Government Spending |
| 3.7.7 | Leadership-by-Example – | X6409 | Industry demand-Electric |

| Strategy | Subprogram | Code | Description |
|---|---|---|---|
| | Maryland University Lead-by-Example Initiatives | | power generation, transmission, and distribution |
| | | 63 | State Government Spending |
| 3.7.8 | Transportation and Climate Initiative | 63 | State Government Spending |
| 3.7.9 | Greenhouse Gas Emissions Inventory Development | - | *No operation costs specified* |
| **Outreach** | | | |
| 3.8.1 | Outreach and Public Education | 63 | State Government Spending |

Source: REMI PI+, RESI

## 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 data provided by MDOT, 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.

**Modeling Steps Based on Data Provided**

***Investment Phase***

1. Determine relevant REMI sectors for each program under the policy.
    a. **Intercity Transportation Initiatives**
        i. X3317–Architectural, engineering, and related services
        ii. X3212—Construction
        iii. 34—Household disposable income
2. Assign data costs per agency provided data to inputs for each program under the policy.
    a. **Intercity Transportation Initiatives (2010-2014)**
        i. X3317— $21,323,000 total from 2010 to 2014
        ii. X3212— $267,381,000 total from 2010 to 2014
        iii. 34— $1,694,000 total from 2010 to 2014
    b. **Intercity Transportation Initiatives (2015-2020)**
        i. X3317— $92,328,000 total from 2015 to 2020
        ii. X3212— $298,480,000 total from 2015 to 2020
        iii. 34— $1,100,000 total from 2015 to 2020
3. Input investment by sector into REMI model by year and run impacts.
4. Export impacts and analyze.

***Operation Phase***

1. Determine relevant REMI sectors.
    a. **Intercity Transportation Initiatives**
        i. 623—Consumer Spending—Gasoline and oil
        ii. X6495—Transit and ground passenger transportation
        iii. 78—Consumption reallocation
2. Determine part of program to be affected by savings (from strategy write-up).
    a. **Intercity Transportation Initiatives**
        i. 623—Reduce fuel spending
        ii. X6495—Increase public ridership

iii. 78—Consumption reallocation of spending not used for transit

3. Estimate total annual increase in savings/revenue for each program and then calculate for complete study period (2011-2020
   a. **Intercity Transportation Initiatives**
      i. 623—$422,730 per year savings
      ii. X6495—$211,365 per year spending on public transit
      iii. 78—$211,365 per year reallocation
4. Input savings by sector into REMI model and run impacts.
5. Export impacts and analyze.

# Refined Economic Impact Analysis for the Greenhouse Gas Emissions Reduction Act 2012 Plan—Appendices C through D

*Prepared for*
Maryland Department of the Environment

October 6, 2015

Regional Economic Studies Institute

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# Appendix C—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. This analysis uses the industry level jobs impacts produced from the REMI PI+ analysis and RESI's Predictive Regional Occupational Matrix (PROM) to assess the top five occupations for each strategy.

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 in some cases, the occupations forgone during the investment phase may be redistributed within the operation phase.

For example, under the policy "Zero Waste," the reduction in the need for landfill space reduces the need for remediation and waste management personnel. However, the increased demand for recycling and facilities will increase the demand in this field during the operation phase. Therefore the next change in the occupational level jobs results in a gain.

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 C 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.

## C.1 Energy

### C.1.1 Regional Greenhouse Gas Initiative (RGGI) Status Quo—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 1.4 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Postal Service Workers<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants |
| Protective Service Occupations | 1.1 | Law Enforcement Workers<br>Police Officers<br>Police and Sheriff's Patrol Officers<br>Bailiffs, Correctional Officers, and Jailers<br>Correctional Officers and Jailers |
| Business and Financial Operations Occupations | 0.7 | Business Operations Specialists<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Accountants and Auditors |
| Management Occupations | 0.5 | Top Executives<br>Operations Specialties Managers<br>General and Operations Managers<br>Legislators<br>Other Management Occupations |
| Community and Social Service Occupations | 0.4 | Counselors, Social Workers, and Other Community and Social Service Specialists<br>Child, Family, and School Social Workers<br>Probation Officers and Correctional Treatment Specialists<br>Social and Human Service Assistants<br>Community and Social Service Specialists, All Other |

Sources: BLS, REMI PI+, RESI

### C.1.2 Regional Greenhouse Gas Initiative (RGGI) Enhancement—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 1.4 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Postal Service Workers<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants |
| Protective Service Occupations | 1.1 | Law Enforcement Workers<br>Police Officers<br>Police and Sheriff's Patrol Officers<br>Bailiffs, Correctional Officers, and Jailers<br>Correctional Officers and Jailers |
| Business and Financial Operations Occupations | 0.7 | Business Operations Specialists<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Accountants and Auditors |
| Management Occupations | 0.5 | Top Executives<br>Operations Specialties Managers<br>General and Operations Managers<br>Legislators<br>Other Management Occupations |
| Community and Social Service Occupations | 0.4 | Counselors, Social Workers, and Other Community and Social Service Specialists<br>Child, Family, and School Social Workers<br>Probation Officers and Correctional Treatment Specialists<br>Social and Human Service Assistants<br>Community and Social Service Specialists, All Other |

Sources: BLS, RESI

### C.1.3 Regional Greenhouse Gas Initiative (RGGI) Status Quo—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 31.4 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Postal Service Workers<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants |
| Protective Service Occupations | 27.2 | Law Enforcement Workers<br>Police Officers<br>Police and Sheriff's Patrol Officers<br>Bailiffs, Correctional Officers, and Jailers<br>Correctional Officers and Jailers |
| Business and Financial Operations Occupations | 14.5 | Business Operations Specialists<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Accountants and Auditors |
| Management Occupations | 8.4 | Top Executives<br>Operations Specialties Managers<br>General and Operations Managers<br>Legislators<br>Other Management Occupations |
| Community and Social Service Occupations | 6.6 | Counselors, Social Workers, and Other Community and Social Service Specialists<br>Child, Family, and School Social Workers<br>Probation Officers and Correctional Treatment Specialists<br>Social and Human Service Assistants<br>Community and Social Service Specialists, All Other |

Sources: BLS, REMI PI+, RESI

### C.1.4 Regional Greenhouse Gas Initiative (RGGI) Enhancement—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 197.3 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Postal Service Workers<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants |
| Protective Service Occupations | 156.8 | Law Enforcement Workers<br>Police Officers<br>Police and Sheriff's Patrol Officers<br>Bailiffs, Correctional Officers, and Jailers<br>Correctional Officers and Jailers |
| Business and Financial Operations Occupations | 83.7 | Business Operations Specialists<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Accountants and Auditors |
| Management Occupations | 52.6 | Top Executives<br>Operations Specialties Managers<br>General and Operations Managers<br>Legislators<br>Other Management Occupations |
| Community and Social Service Occupations | 43.5 | Counselors, Social Workers, and Other Community and Social Service Specialists<br>Child, Family, and School Social Workers<br>Probation Officers and Correctional Treatment Specialists<br>Social and Human Service Assistants<br>Community and Social Service Specialists, All Other |

Sources: BLS, REMI PI+, RESI

### C.1.5 GHG Reductions from Imported Power—Investment Phase

| | | |
|---|---|---|
| Protective service occupations | 0.0 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Management, business, financial occupations | 0.0 | Legislators<br>Advertising, marketing, and sales managers<br>Compliance officers<br>Cost estimators<br>Accountants and auditors |
| Legal occupations | 0.0 | Lawyers<br>Judicial law clerks<br>Judges, magistrates, and other judicial workers<br>Paralegals and legal assistants<br>Court reporters |
| Arts, design, entertainment, sports, media occupations | 0.0 | Artists and related workers<br>Designers<br>Entertainers and performers<br>Sports and related workers<br>Media and communications workers |
| Education, training, library occupations | 0.0 | Postsecondary teachers<br>Preschool, primary, and secondary teachers<br>Special education teachers<br>Librarians<br>Archivists, curators, and museum technicians |

Sources: BLS, REMI PI+, RESI

### C.1.6 GHG Reductions from Imported Power—Operation Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 1.4 | Construction Trades Workers<br>Construction Laborers<br>Carpenters<br>Electricians<br>Supervisors of Construction and Extraction Workers |
| Office and Administrative Support Occupations | 1.2 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Office Clerks, General |
| Personal Care and Service Occupations | 0.7 | Entertainment Attendants and Related Workers<br>Other Personal Care and Service Workers<br>Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Childcare Workers |
| Sales and Related Occupations | 0.6 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Wholesale and Manufacturing |
| Installation, Maintenance, and Repair Occupations | 0.6 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Maintenance and Repair Workers, General<br>Vehicle and Mobile Equipment Mechanics, Installers, and Repairers |

Sources: BLS, REMI PI+, RESI

### C.1.7 Federal New Source Performance Standard—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 1.7 | Information and Record Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Protective Service Occupations | 1.1 | Law Enforcement Workers<br>Other Protective Service Workers<br>Fire Fighting and Prevention Workers<br>Supervisors of Protective Service Workers<br>Security Guards |
| Construction and Extraction Occupations | 0.9 | Construction Trades Workers<br>Other Construction and Related Workers<br>Supervisors of Construction and Extraction Workers<br>Electricians<br>Highway Maintenance Workers |
| Business and Financial Operations Occupations | 0.7 | Business Operations Specialists<br>Financial Specialists<br>Business Operations Specialists, All Other<br>Accountants and Auditors<br>Management Analysts |
| Personal Care and Service Occupations | 0.5 | Other Personal Care and Service Workers<br>Entertainment Attendants and Related Workers<br>Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Recreation Workers |

Sources: BLS, REMI PI+, RESI

### C.1.8 Federal New Source Performance Standard—Operation Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 2.2 | Supervisors of construction trade workers<br>Carpenters<br>Brick masons, block masons, and stonemasons<br>Construction equipment operators<br>Electricians |
| Office and Administrative Support Occupations | 1.8 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Office Clerks, General<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Personal Care and Service Occupations | 1.1 | Entertainment Attendants and Related Workers<br>Other Personal Care and Service Workers<br>Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Fitness Trainers and Aerobics Instructors |
| Sales and Related Occupations | 1.0 | Cashiers<br>Retail Sales Workers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Wholesale and Manufacturing |
| Installation, Maintenance, and Repair Occupations | 1.0 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Maintenance and Repair Workers, General<br>Vehicle and Mobile Equipment Mechanics, Installers, and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers |

Sources: BLS, REMI PI+, RESI

### C.1.9 MACT—Investment Phase

| | | |
|---|---|---|
| Sales and Related Occupations | 0.2 | Retail sales workers<br>Advertising sales agents<br>Insurance sales agents<br>Sales representatives in wholesale and manufacturing<br>Models, demonstrators, and product promoters |
| Protective Service Occupations | 0.1 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Business and Financial Operations Occupations | 0.1 | Legislators<br>Advertising, marketing, and sales managers<br>Compliance officers<br>Cost estimators<br>Accountants and auditors |
| Healthcare Practitioners and Technical Occupations | 0.1 | Dentists<br>Dietitians and nutritionists<br>Physicians and surgeons<br>Nurses and home health aides<br>Occupational therapists |
| Construction and Extraction Occupations | 0.1 | Actuaries<br>Software developers and programmers<br>Database and system administrators<br>Computer support specialists<br>Aerospace, agricultural, biomedical, and other engineers |

Sources: BLS, REMI PI+, RESI

### C.1.10 MACT—Operation Phase

| | | |
|---|---|---|
| Protective Service Occupations | 26.4 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Sales and Related Occupations | 26.1 | Retail sales workers<br>Advertising sales agents<br>Insurance sales agents<br>Sales representatives in wholesale and manufacturing<br>Models, demonstrators, and product promoters |
| Business and Financial Operations Occupations | 13.4 | Legislators<br>Advertising, marketing, and sales managers<br>Compliance officers<br>Cost estimators<br>Accountants and auditors |
| Healthcare Practitioners and Technical Occupations | 8.5 | Dentists<br>Dietitians and nutritionists<br>Physicians and surgeons<br>Nurses and home health aides<br>Occupational therapists |
| Building and Grounds Cleaning and Maintenance Occupations | 7.8 | Supervisors of cleaning and maintenance workers<br>Housekeeping and janitorial workers<br>Pest control workers<br>Landscaping and grounds keeping workers<br>Pesticide handlers, sprayers, and applicators |

Sources: BLS, REMI PI+, RESI

### C.1.11 Energy Efficiency in the Residential Sector Status Quo—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 502.4 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Personal Care and Service Occupations | 245.1 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Office and Administrative Support Occupations | 215.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Food Preparation and Serving Related Occupations | 154.8 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | 129.0 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |

Sources: BLS, REMI PI+, RESI

### C.1.12 Energy Efficiency in the Residential Sector Enhancement—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 502.4 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Personal Care and Service Occupations | 245.1 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Office and Administrative Support Occupations | 215.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Food Preparation and Serving Related Occupations | 154.8 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | 129.0 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |

Sources: BLS, REMI PI+, RESI

### C.1.13 Energy Efficiency in the Residential Sector Status Quo—Operation Phase

| | | |
|---|---|---|
| Sales and Related Occupations | 12.4 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |
| Healthcare Practitioners and Technical Occupations | 8.9 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Office and Administrative Support Occupations | 5.5 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Food Preparation and Serving Related Occupations | 3.6 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Transportation and Material Moving Occupations | 2.2 | Laborers and Material Movers, Hand<br>Motor Vehicle Operators<br>Laborers and Freight, Stock, and Material Movers, Hand<br>Cleaners of Vehicles and Equipment<br>Light Truck or Delivery Services Drivers |

Sources: BLS, REMI PI+, RESI

### C.1.12 Energy Efficiency in the Residential Sector Enhancement—Operation Phase

| | | |
|---|---|---|
| Sales and Related Occupations | 12.4 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |
| Healthcare Practitioners and Technical Occupations | 8.9 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Office and Administrative Support Occupations | 5.5 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Food Preparation and Serving Related Occupations | 3.6 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Transportation and Material Moving Occupations | 2.2 | Laborers and Material Movers, Hand<br>Motor Vehicle Operators<br>Laborers and Freight, Stock, and Material Movers, Hand<br>Cleaners of Vehicles and Equipment<br>Light Truck or Delivery Services Drivers |

Sources: BLS, REMI PI+, RESI

### C.1.13 Energy Efficiency in the Commercial and Industrial Sectors Status Quo—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 585.9 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Protective Service Occupations | 363.4 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction, extraction occupations | 287.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 227.3 | Business Operations Specialists<br>Financial Specialists<br>Business Operations Specialists, All Other<br>Accountants and Auditors<br>Management Analysts |
| Food Preparation and Serving Related Occupations | 190.9 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |

Sources: BLS, REMI PI+, RESI

### C.1.14 Energy Efficiency in the Commercial and Industrial Sectors Enhancement—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 587.2 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Protective Service Occupations | 364.1 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction, extraction occupations | 289.3 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 230.1 | Business Operations Specialists<br>Financial Specialists<br>Business Operations Specialists, All Other<br>Accountants and Auditors<br>Management Analysts |
| Food Preparation and Serving Related Occupations | 195.4 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |

Sources: BLS, REMI PI+, RESI

### 3.1.6 Energy Efficiency in the Commercial and Industrial Sectors—Investment Phase

| | | |
|---|---|---|
| Professional, scientific, and technical services | 4.2 | Lawyers<br>Accountants and auditors<br>Management analysts<br>Architectural and civil drafters<br>Market research analysts |
| Retail trade | 3.6 | Retail salespersons<br>Cashiers<br>Stock clerks and order fillers<br>First-line supervisors/managers of retail sales workers<br>Customer service representatives |
| Construction | 1.1 | Construction laborers<br>Carpenters<br>Electricians<br>Operating engineers and other construction equipment operators<br>Construction managers |
| Health care and social assistance | 0.8 | Registered nurses<br>Nursing aides, orderlies, and attendants<br>Home health aides<br>Licensed practical and licensed vocational nurses<br>Medical and health services managers |
| Administrative and support and waste management and remediation services | 0.7 | Janitors and cleaners, except maids and housekeeping cleaners<br>Security guards<br>Landscaping and grounds keeping workers<br>Laborers and freight, stock, and material movers, hand<br>Office clerks, general |

Sources: BLS, RESI

**C.1.15 Energy Efficiency in the Commercial and Industrial Sectors Status Quo—Operation Phase**

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 308.5 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 222.0 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |
| Food Preparation and Serving Related Occupations | 170.0 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Construction and Extraction Occupations | 108.5 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Installation, Maintenance, and Repair Occupations | 106.3 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Maintenance and Repair Workers, General<br>Vehicle and Mobile Equipment Mechanics, Installers, and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers |

Sources: BLS, REMI PI+, RESI

### C.1.16 Energy Efficiency in the Commercial and Industrial Sectors Enhancement—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 310.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 224.2 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |
| Food Preparation and Serving Related Occupations | 171.6 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Construction and Extraction Occupations | 110.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Installation, Maintenance, and Repair Occupations | 108.3 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Maintenance and Repair Workers, General<br>Vehicle and Mobile Equipment Mechanics, Installers, and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers |

Sources: BLS, REMI PI+, RESI

### C.1.17 Energy Efficiency—Appliances and Other Products—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | -25.5 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Personal Care and Service Occupations | -12.5 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Office and Administrative Support Occupations | -10.9 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Food Preparation and Serving Related Occupations | -7.5 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | -6.6 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |

Sources: BLS, REMI PI+, RESI

**C.1.18 Energy Efficiency—Appliances and Other Products—Operation Phase**

| | | |
|---|---|---|
| Sales and Related Occupations | 4.8 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |
| Healthcare Practitioners and Technical Occupations | 3.4 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Office and Administrative Support Occupations | 2.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Healthcare Support Occupations | 1.9 | Nursing, Psychiatric, and Home Health Aides<br>Nursing Assistants<br>Home Health Aides<br>Medical Assistants<br>Dental Assistants |
| Food Preparation and Serving Related Occupations | 1.3 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |

Sources: BLS, REMI PI+, RESI

### C.1.19 Energy Efficiency in the Power Sector, General Status Quo—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | -337.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | -287.3 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | -173.5 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Food Preparation and Serving Related Occupations | -156..7 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | -156.5 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |

Sources: BLS, REMI PI+, RESI

### C.1.20 Energy Efficiency in the Power Sector, General Enhancement—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | -338.2 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | -288.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | -173.9 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Food Preparation and Serving Related Occupations | -157.4 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | -157.1 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |

Sources: BLS, REMI PI+, RESI

### C.1.21 Energy Efficiency in the Power Sector, General Status Quo—Operation Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 59.4 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 50.0 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | 30.6 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Food Preparation and Serving Related Occupations | 27.3 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | 27.1 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |

Sources: BLS, REMI PI+, RESI

### C.1.22 Energy Efficiency in the Power Sector, General Enhancement—Operation Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 59.4 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 50.0 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | 30.6 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Food Preparation and Serving Related Occupations | 27.3 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | 27.1 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |

Sources: BLS, REMI PI+, RESI

### C.1.23 Maryland Renewable Energy Portfolio Standard Status Quo—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 2,238.8 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 1,178.0 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | 1,110.6 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Sales and Related Occupations | 726.6 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |
| Food Preparation and Serving Related Occupations | 709.2 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |

Sources: BLS, RESI, REMI PI+

### C.1.24 Maryland Renewable Energy Portfolio Standard Enhancement—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 2,242.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 1,179.6 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | 1,112.4 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Sales and Related Occupations | 728.1 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |
| Food Preparation and Serving Related Occupations | 711.8 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |

Sources: BLS, RESI, REMI PI+

### C.1.25 Maryland Renewable Energy Portfolio Standard Status Quo—Operation Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | -220.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | -151.0 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | -110.4 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Food Preparation and Serving Related Occupations | -86.3 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | -84.3 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |

Sources: BLS, RESI, REMI PI+

### C.1.26 Maryland Renewable Energy Portfolio Standard Enhancement—Operation Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | -221.2 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | -151.4 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | -110.6 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Food Preparation and Serving Related Occupations | -86.7 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | -84.5 | Retail Sales Workers<br>Cashiers<br>Retail Salespersons<br>Sales Representatives, Services<br>Sales Representatives, Services, All Other |

Sources: BLS, RESI, REMI PI+

### C.1.27 Incentives and Grant Subprograms to Support Renewable Energy—Investment Phase

| | | |
|---|---|---|
| Protective Service Occupations | 17.1 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Office and Administrative Support Occupations | 7.8 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Business and Financial Operations Occupations | 5.0 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Community and Social Service Occupations | 4.2 | Social Workers<br>Probation Officers and Correctional Treatment Specialists<br>Social and Human Service Assistants<br>Community and Social Service Specialists, All Other<br>Educational, Guidance, School, and Vocational Counselors |
| Healthcare Practitioners and Technical Occupations | 4.2 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.1.28 Incentives and Grant Subprograms to Support Renewable Energy—Operation Phase

| | | |
|---|---|---|
| Food Preparation and Serving Related Occupations | 13.3 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | 9..8 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Building and Grounds Cleaning and Maintenance Occupations | 4.4 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Personal Care and Service Occupations | 2.4 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Transportation and Material Moving Occupations | 2.1 | Laborers and Material Movers, Hand<br>Motor Vehicle Operators<br>Laborers and Freight, Stock, and Material Movers, Hand<br>Cleaners of Vehicles and Equipment<br>Light Truck or Delivery Services Drivers |

Sources: BLS, RESI, REMI PI+

### 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<br>Housekeeping and janitorial workers<br>Pest control workers<br>Landscaping and grounds keeping workers<br>Pesticide handlers, sprayers, and applicators |
| Food preparation, serving related occupations | 11.3 | Cooks<br>Supervisors of food preparation workers<br>Bartenders<br>Waiters and waitresses<br>Dishwashers |
| Sales, office, administrative occupations | 7.8 | Retail sales workers<br>Advertising sales agents<br>Insurance sales agents<br>Sales representatives in wholesale and manufacturing<br>Models, demonstrators, and product promoters |
| Healthcare occupations | 4.9 | Dentists<br>Dietitians and nutritionists<br>Physicians and surgeons<br>Nurses and home health aides<br>Occupational therapists |
| Arts, design, entertainment, sports, media occupations | 0.9 | Artists and related workers<br>Designers<br>Entertainers and performers<br>Sports and related workers<br>Media and communications workers |

Sources: BLS, RESI

### C.1.29 Offshore Wind Initiatives to Support Renewable Energy—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 33.2 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 19.2 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Business and Financial Operations Occupations | 14.9 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Production Occupations | 13.6 | Other Production Occupations<br>Metal Workers and Plastic Workers<br>Assemblers and Fabricators<br>Team Assemblers<br>Inspectors, Testers, Sorters, Samplers, and Weighers |
| Computer and Mathematical Occupations | 12.8 | Software Developers and Programmers<br>Computer and Information Analysts<br>Computer Systems Analysts<br>Database and Systems Administrators and Network Architects<br>Computer Programmers |

Sources: BLS, RESI, REMI PI+

### C.1.30 Offshore Wind Initiatives to Support Renewable Energy—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 23.2 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 19.1 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Business and Financial Operations Occupations | 5.6 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Production Occupations | 3.6 | Other Production Occupations<br>Metal Workers and Plastic Workers<br>Assemblers and Fabricators<br>Team Assemblers<br>Inspectors, Testers, Sorters, Samplers, and Weighers |
| Computer and Mathematical Occupations | 2.8 | Software Developers and Programmers<br>Computer and Information Analysts<br>Computer Systems Analysts<br>Database and Systems Administrators and Network Architects<br>Computer Programmers |

Sources: BLS, RESI, REMI PI+

### C.1.31 Title V Permits for GHG Sources—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 0.2 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Protective Service Occupations | 0.1 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Business and Financial Operations Occupations | 0.1 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Healthcare Practitioners and Technical Occupations | 0.1 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Construction and Extraction Occupations | 0.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |

Sources: BLS, RESI, REMI PI+

### C.1.32 Title V Permits for GHG Sources—Operation Phase

| | | |
|---|---|---|
| Protective Service Occupations | 0.9 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Office and Administrative Support Occupations | 0.8 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Business and Financial Operations Occupations | 0.4 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Building, grounds, personal care, service occupations | 0.3 | Building Cleaning and Pest Control Workers<br>Building Cleaning Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers |
| Healthcare Practitioners and Technical Occupations | 0.3 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.1.33 BeSMART Status Quo—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 216.2 | Construction Trades Workers<br>Construction Laborers<br>Carpenters<br>Electricians<br>Supervisors of Construction and Extraction Workers |
| Office and Administrative Support Occupations | 174.0 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Business and Financial Operations Occupations | 86.1 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Computer and Mathematical Occupations | 76.8 | Software Developers and Programmers<br>Computer and Information Analysts<br>Computer Systems Analysts<br>Database and Systems Administrators and Network Architects<br>Computer Programmers |
| Sales and Related Occupations | 73.7 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |

Sources: BLS, RESI, REMI PI+

### C.1.34 BeSMART Enhancement—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 353.1 | Construction Trades Workers<br>Construction Laborers<br>Carpenters<br>Electricians<br>Supervisors of Construction and Extraction Workers |
| Office and Administrative Support Occupations | 283.6 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Business and Financial Operations Occupations | 140.4 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Computer and Mathematical Occupations | 124.9 | Software Developers and Programmers<br>Computer and Information Analysts<br>Computer Systems Analysts<br>Database and Systems Administrators and Network Architects<br>Computer Programmers |
| Sales and Related Occupations | 119.0 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |

Sources: BLS, RESI, REMI PI+

### C.1.35 BeSMART Status Quo—Operation Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 0.1 | Construction Trades Workers<br>Construction Laborers<br>Carpenters<br>Electricians<br>Supervisors of Construction and Extraction Workers |
| Office and Administrative Support Occupations | 0.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Farming, Fishing, and Forestry Occupations | 0.0 | Farmworkers and Laborers, Crop, Nursery, and Greenhouse<br>Agricultural Workers<br>Farmworkers, Farm, Ranch, and Aquacultural Animals<br>Supervisors of Farming, Fishing, and Forestry Workers<br>Forest, Conservation, and Logging Workers |
| Sales and Related Occupations | 0.0 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Installation, Maintenance, and Repair Occupations | 0.0 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |

Sources: BLS, RESI, REMI PI+

**C.1.36 BeSMART Enhancement—Operation Phase**

| | | |
|---|---|---|
| Construction and Extraction Occupations | 0.1 | Construction Trades Workers<br>Construction Laborers<br>Carpenters<br>Electricians<br>Supervisors of Construction and Extraction Workers |
| Office and Administrative Support Occupations | 0.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 0.1 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Food Preparation and Serving Related Occupations | 0.1 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Healthcare Practitioners and Technical Occupations | 0.0 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.1.37 Weatherization and Energy Efficiency for Low-Income Houses Status Quo—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 88.7 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | 64.8 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Building and Grounds Cleaning and Maintenance Occupations | 50.1 | Building Cleaning and Pest Control Workers<br>Building Cleaning Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers |
| Installation, Maintenance, and Repair Occupations | 45.0 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Sales and Related Occupations | 42.6 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |

Sources: BLS, RESI, REMI PI+

### C.1.38 Weatherization and Energy Efficiency for Low-Income Houses Enhancement—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 143.5 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | 104.3 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Building and Grounds Cleaning and Maintenance Occupations | 81.2 | Building Cleaning and Pest Control Workers<br>Building Cleaning Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers |
| Installation, Maintenance, and Repair Occupations | 72.8 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Sales and Related Occupations | 68.3 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |

Sources: BLS, RESI, REMI PI+

### C.1.39 Weatherization and Energy Efficiency for Low-Income Houses Status Quo—Operation Phase

| | | |
|---|---|---|
| Healthcare Practitioners and Technical Occupations | 0.3 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Food Preparation and Serving Related Occupations | 0.3 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Office and Administrative Support Occupations | 0.3 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | 0.2 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Healthcare Support Occupations | 0.2 | Nursing, Psychiatric, and Home Health Aides<br>Nursing Assistants<br>Medical Assistants<br>Dental Assistants<br>Occupational Therapy and Physical Therapist Assistants and Aides |

Sources: BLS, RESI, REMI PI+

**C.1.40 Weatherization and Energy Efficiency for Low-Income Houses Enhancement—Operation Phase**

| | | |
|---|---|---|
| Healthcare Practitioners and Technical Occupations | 0.5 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Food Preparation and Serving Related Occupations | 0.4 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Office and Administrative Support Occupations | 0.4 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | 0.3 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Healthcare Support Occupations | 0.3 | Nursing, Psychiatric, and Home Health Aides<br>Nursing Assistants<br>Medical Assistants<br>Dental Assistants<br>Occupational Therapy and Physical Therapist Assistants and Aides |

Sources: BLS, RESI, REMI PI+

**C.1.41 GHG Prevention of Significant Deterioration Permitting Program—Investment Phase**

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 0.2 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Protective Service Occupations | 0.1 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Business and Financial Operations Occupations | 0.1 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Healthcare Practitioners and Technical Occupations | 0.1 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Construction and Extraction Occupations | 0.1 | Construction Trades Workers<br>Construction Laborers<br>Carpenters<br>Electricians<br>Supervisors of Construction and Extraction Workers |

Sources: BLS, RESI, REMI PI+

### C.1.42 GHG Prevention of Significant Deterioration Permitting Program—Operation Phase

| | | |
|---|---|---|
| Protective Service Occupations | 0.2 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Office and Administrative Support Occupations | 0.2 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Business and Financial Operations Occupations | 0.1 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Healthcare Practitioners and Technical Occupations | 0.1 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 0.1 | Building Cleaning and Pest Control Workers<br>Building Cleaning Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers |

Sources: BLS, RESI, REMI PI+

## C.2 Transportation

### C.2.1 Transportation Technology Initiatives Status Quo—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 183.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 92.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 48.2 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Installation, Maintenance, and Repair Occupations | 37.3 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Management Occupations | 36.1 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.2.2 Transportation Technology Initiatives Enhancement—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 219.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 110.5 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 57.9 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Installation, Maintenance, and Repair Occupations | 44.8 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Management Occupations | 43.3 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.2.3 Transportation Technology Initiatives Status Quo—Operation Phase

| | | |
|---|---|---|
| Healthcare Practitioners and Technical Occupations | 141.7 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 128.1 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Food Preparation and Serving Related Occupations | 41.8 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Education, Training, and Library Occupations | 14.7 | Preschool, Primary, Secondary, and Special Education School Teachers<br>Other Education, Training, and Library Occupations<br>Other Teachers and Instructors<br>Librarians, Curators, and Archivists<br>Postsecondary Teachers |
| Community and Social Service Occupations | 10.5 | Social Workers<br>Probation Officers and Correctional Treatment Specialists<br>Social and Human Service Assistants<br>Community and Social Service Specialists, All Other<br>Educational, Guidance, School, and Vocational Counselors |

Sources: BLS, RESI, REMI PI+

### C.2.4 Transportation Technology Initiatives Enhancement—Operation Phase

| | | |
|---|---|---|
| Healthcare Practitioners and Technical Occupations | 152.7 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 133.1 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Food Preparation and Serving Related Occupations | 46.2 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Education, Training, and Library Occupations | 17.9 | Preschool, Primary, Secondary, and Special Education School Teachers<br>Other Education, Training, and Library Occupations<br>Other Teachers and Instructors<br>Librarians, Curators, and Archivists<br>Postsecondary Teachers |
| Community and Social Service Occupations | 12.8 | Social Workers<br>Probation Officers and Correctional Treatment Specialists<br>Social and Human Service Assistants<br>Community and Social Service Specialists, All Other<br>Educational, Guidance, School, and Vocational Counselors |

Sources: BLS, RESI, REMI PI+

### C.2.5 Public Transportation Initiatives Status Quo—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 183.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 92.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 48.2 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Installation, Maintenance, and Repair Occupations | 37.3 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Management Occupations | 36.1 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.2.6 Public Transportation Initiatives Enhancement—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 219.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 110.5 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 57.9 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Installation, Maintenance, and Repair Occupations | 44.8 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Management Occupations | 43.3 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.2.7 Public Transportation Initiatives Status Quo—Operation Phase

| | | |
|---|---|---|
| Healthcare Practitioners and Technical Occupations | 99.2 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 84.5 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Transportation, material moving occupations | 67.3 | Aircraft cargo handling supervisors<br>Air traffic controllers<br>Ambulance drivers and attendants<br>Driver/Sales workers and truck drivers<br>Subway and streetcar operators |
| Food Preparation and Serving Related Occupations | 31.2 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Protective Service Occupations | 29.9 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |

Sources: BLS, RESI, REMI PI+

### C.2.8 Public Transportation Initiatives Enhancement—Operation Phase

| | | |
|---|---|---|
| Healthcare Practitioners and Technical Occupations | 104.5 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 92.6 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Transportation, material moving occupations | 74.3 | Aircraft cargo handling supervisors<br>Air traffic controllers<br>Ambulance drivers and attendants<br>Driver/Sales workers and truck drivers<br>Subway and streetcar operators |
| Food Preparation and Serving Related Occupations | 42.3 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Protective Service Occupations | 37.8 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |

Sources: BLS, RESI, REMI PI+

### C.2.9 Intercity Transportation Initiatives Status Quo—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 45.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 16.2 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Installation, Maintenance, and Repair Occupations | 8.1 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Sales and Related Occupations | 7.5 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Management Occupations | 7.0 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.2.10 Intercity Transportation Initiatives Enhancement—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 54.8 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 19.4 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Installation, Maintenance, and Repair Occupations | 9.8 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Sales and Related Occupations | 9.0 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Management Occupations | 8.5 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.2.11 Intercity Transportation Initiatives Status Quo—Operation Phase

| | | |
|---|---|---|
| Transportation and Material Moving Occupations | 6.5 | Motor Vehicle Operators<br>Material Moving Workers<br>Driver/Sales Workers and Truck Drivers<br>Heavy and Tractor-Trailer Truck Drivers<br>Laborers and Freight, Stock, and Material Movers, Hand |
| Office and Administrative Support Occupations | 1.2 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Building and Grounds Cleaning and Maintenance Occupations | 0.4 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Healthcare Practitioners and Technical Occupations | 0.3 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Business and Financial Operations Occupations | 0.2 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |

Sources: BLS, RESI, REMI PI+

### C.2.12 Intercity Transportation Initiatives Enhancement—Operation Phase

| | | |
|---|---|---|
| Transportation and Material Moving Occupations | 7.1 | Motor Vehicle Operators<br>Material Moving Workers<br>Driver/Sales Workers and Truck Drivers<br>Heavy and Tractor-Trailer Truck Drivers<br>Laborers and Freight, Stock, and Material Movers, Hand |
| Office and Administrative Support Occupations | 1.6 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Building and Grounds Cleaning and Maintenance Occupations | 0.8 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Healthcare Practitioners and Technical Occupations | 0.5 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Business and Financial Operations Occupations | 0.4 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |

Sources: BLS, RESI, REMI PI+

### C.2.13 Pricing Initiatives Status Quo—Investment Phase

*This policy has no investment costs associated with implementation in status quo.*

### C.2.14 Pricing Initiatives Enhancement—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 423.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 198.9 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 132.2 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Installation, Maintenance, and Repair Occupations | 118.3 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Management Occupations | 96.6 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

**C.2.15 Pricing Initiatives Status Quo—Operation Phase**

*This policy has no operation benefits or costs associated with status quo.*

### C.2.14 Pricing Initiatives Enhancement—Operation Phase

| | | |
|---|---|---|
| Healthcare Practitioners and Technical Occupations | 172.1 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 164.2 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Food Preparation and Serving Related Occupations | 58.9 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Education, Training, and Library Occupations | 19.0 | Preschool, Primary, Secondary, and Special Education School Teachers<br>Other Education, Training, and Library Occupations<br>Other Teachers and Instructors<br>Librarians, Curators, and Archivists<br>Postsecondary Teachers |
| Business and Financial Operations Occupations | 18.3 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |

Sources: BLS, RESI, REMI PI+

### C.2.15 Bike and Pedestrian Initiatives Status Quo—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 325.9 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 211.7 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 133.8 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Installation, Maintenance, and Repair Occupations | 121.1 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Management Occupations | 98.7 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.2.16 Bike and Pedestrian Initiatives Enhancement—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 522.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 326.8 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 210.2 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Installation, Maintenance, and Repair Occupations | 189.9 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Management Occupations | 114.4 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.2.17 Bike and Pedestrian Initiatives Status Quo—Operation Phase

| | | |
|---|---|---|
| Healthcare Practitioners and Technical Occupations | 0.1 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 0.0 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Food Preparation and Serving Related Occupations | 0.0 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Education, Training, and Library Occupations | 0.0 | Preschool, Primary, Secondary, and Special Education School Teachers<br>Other Education, Training, and Library Occupations<br>Other Teachers and Instructors<br>Librarians, Curators, and Archivists<br>Postsecondary Teachers |
| Business and Financial Operations Occupations | 0.0 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |

Sources: BLS, RESI, REMI PI+

### C.2.18 Bike and Pedestrian Initiatives Enhancement—Operation Phase

| | | |
|---|---|---|
| Healthcare Practitioners and Technical Occupations | 0.3 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 0.2 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Food Preparation and Serving Related Occupations | 0.1 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Education, Training, and Library Occupations | 0.1 | Preschool, Primary, Secondary, and Special Education School Teachers<br>Other Education, Training, and Library Occupations<br>Other Teachers and Instructors<br>Librarians, Curators, and Archivists<br>Postsecondary Teachers |
| Business and Financial Operations Occupations | 0.0 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |

Sources: BLS, RESI, REMI PI+

## C.3 Agriculture and Forestry

### C.3.1 Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 0.2 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Protective Service Occupations | 0.2 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Business and Financial Operations Occupations | 0.1 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Construction and Extraction Occupations | 0.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Healthcare Practitioners and Technical Occupations | 0.1 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.3.2 Creating Ecosystem Markets to Encourage GHG Emissions Reductions—Operation Phase

| | | |
|---|---|---|
| Protective Service Occupations | 84.8 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction and Extraction Occupations | 46.8 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 43.0 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Healthcare Practitioners and Technical Occupations | 31.7 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Sales and Related Occupations | 25.5 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |

Sources: BLS, RESI, REMI PI+

### C.3.3 Nutrient Trading for GHG Benefits Status Quo—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 1.6 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Protective Service Occupations | 1.2 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction and Extraction Occupations | 0.8 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 0.8 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Healthcare occupations | 0.4 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.3.4 Nutrient Trading for GHG Benefits Enhancement—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 3.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Protective Service Occupations | 2.3 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction and Extraction Occupations | 1.6 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 1.5 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Healthcare occupations | 1.2 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.3.5 Nutrient Trading for GHG Benefits Status Quo—Operation Phase

*To date there is a program that duplicates the work of this policy and therefore has no impact in the operation phase.*

### C.3.6 Nutrient Trading for GHG Benefits Status Quo—Operation Phase

*To date there is a program that duplicates the work of this policy and therefore has no impact in the operation phase.*

### C.3.7 Managing Forests to Capture Carbon—Investment Phase

| | | |
|---|---|---|
| Farming, Fishing, and Forestry Occupations | 45.6 | Agricultural Workers<br>Farmworkers and Laborers, Crop, Nursery, and Greenhouse<br>Farmworkers, Farm, Ranch, and Aquacultural Animals<br>Forest, Conservation, and Logging Workers<br>Supervisors of Farming, Fishing, and Forestry Workers |
| Management Occupations | 16.8 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |
| Office and Administrative Support Occupations | 4.4 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Transportation and Material Moving Occupations | 4.3 | Motor Vehicle Operators<br>Material Moving Workers<br>Driver/Sales Workers and Truck Drivers<br>Heavy and Tractor-Trailer Truck Drivers<br>Laborers and Freight, Stock, and Material Movers, Hand |
| Installation, Maintenance, and Repair Occupations | 2.2 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |

Sources: BLS, RESI, REMI PI+

### C.3.8 Managing Forests to Capture Carbon—Operation Phase

| | | |
|---|---|---|
| Farming, Fishing, and Forestry Occupations | 9.6 | Agricultural Workers<br>Farmworkers and Laborers, Crop, Nursery, and Greenhouse<br>Farmworkers, Farm, Ranch, and Aquacultural Animals<br>Forest, Conservation, and Logging Workers<br>Supervisors of Farming, Fishing, and Forestry Workers |
| Management Occupations | 3.6 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |
| Office and Administrative Support Occupations | 1.2 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Transportation and Material Moving Occupations | 1.0 | Motor Vehicle Operators<br>Material Moving Workers<br>Driver/Sales Workers and Truck Drivers<br>Heavy and Tractor-Trailer Truck Drivers<br>Laborers and Freight, Stock, and Material Movers, Hand |
| Installation, Maintenance, and Repair Occupations | 0.5 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |

Sources: BLS, RESI, REMI PI+

### C.3.9 Increasing Urban Trees to Capture Carbon—Investment Phase

| | | |
|---|---|---|
| Farming, Fishing, and Forestry Occupations | 0.9 | Agricultural Workers<br>Farmworkers and Laborers, Crop, Nursery, and Greenhouse<br>Farmworkers, Farm, Ranch, and Aquacultural Animals<br>Forest, Conservation, and Logging Workers<br>Supervisors of Farming, Fishing, and Forestry Workers |
| Management Occupations | 0.4 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |
| Construction and Extraction Occupations | 0.4 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 0.3 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Transportation and Material Moving Occupations | 0.3 | Motor Vehicle Operators<br>Material Moving Workers<br>Driver/Sales Workers and Truck Drivers<br>Heavy and Tractor-Trailer Truck Drivers<br>Laborers and Freight, Stock, and Material Movers, Hand |

Sources: BLS, RESI, REMI PI+

### C.3.10 Increasing Urban Trees to Capture Carbon—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 37.8 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Food Preparation and Serving Related Occupations | 27.9 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | 25.3 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Healthcare Practitioners and Technical Occupations | 13.6 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 13.1 | Legislators<br>Advertising, marketing, and sales managers<br>Compliance officers<br>Cost estimators<br>Accountants and auditors |

Sources: BLS, RESI, REMI PI+

### C.3.11 Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 2.9 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Business and Financial Operations Occupations | 1.7 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Computer and Mathematical Occupations | 1.7 | Software Developers and Programmers<br>Computer and Information Analysts<br>Computer Systems Analysts<br>Database and Systems Administrators and Network Architects<br>Computer Programmers |
| Architecture and Engineering Occupations | 1.2 | Engineers<br>Drafters, Engineering Technicians, and Mapping Technicians<br>Civil Engineers<br>Engineering Technicians, Except Drafters<br>Electrical and Electronics Engineers |
| Management Occupations | 1.0 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

**C.3.12 Creating and Protecting Wetlands and Waterway Borders to Capture Carbon—Operation Phase**

| | | |
|---|---|---|
| Food Preparation and Serving Related Occupations | 23.1 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Sales and Related Occupations | 8.6 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Office and Administrative Support Occupations | 6.7 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Personal Care and Service Occupations | 5.9 | Recreation and Fitness Workers<br>Amusement and Recreation Attendants<br>Personal Care Aides<br>Childcare Workers<br>Supervisors of Personal Care and Service Workers |
| Building and Grounds Cleaning and Maintenance Occupations | 3.6 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |

Sources: BLS, RESI, REMI PI+

### C.3.13 Geological Opportunities to Store Carbon—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 0.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Construction and Extraction Occupations | 0.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Food Preparation and Serving Related Occupations | 0.0 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Business and Financial Operations Occupations | 0.0 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Sales and Related Occupations | 0.0 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |

Sources: BLS, RESI, REMI PI+

### C.3.14 Geological Opportunities to Store Carbon—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 33.4 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Sales and Related Occupations | 27.5 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Food Preparation and Serving Related Occupations | 13.2 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Installation, Maintenance, and Repair Occupations | 11.4 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Management Occupations | 10.5 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

**C.3.15 Planting Forests in Maryland—Investment Phase**

| | | |
|---|---|---|
| Farming, Fishing, and Forestry Occupations | 22.4 | Agricultural Workers<br>Farmworkers and Laborers, Crop, Nursery, and Greenhouse<br>Farmworkers, Farm, Ranch, and Aquacultural Animals<br>Forest, Conservation, and Logging Workers<br>Supervisors of Farming, Fishing, and Forestry Workers |
| Business and Financial Operations Occupations | 7.3 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Transportation and Material Moving Occupations | 7.1 | Motor Vehicle Operators<br>Material Moving Workers<br>Driver/Sales Workers and Truck Drivers<br>Heavy and Tractor-Trailer Truck Drivers<br>Laborers and Freight, Stock, and Material Movers, Hand |
| Building and Grounds Cleaning and Maintenance Occupations | 5.1 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Office and Administrative Support Occupations | 3.4 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |

Sources: BLS, RESI, REMI PI+

### C.3.16 Planting Forests in Maryland—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 0.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Healthcare Practitioners and Technical Occupations | 0.1 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 0.0 | Building Cleaning Workers<br>Maids and Housekeeping Cleaners<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Landscaping and Groundskeeping Workers<br>Grounds Maintenance Workers |
| Food Preparation and Serving Related Occupations | 0.0 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Transportation and Material Moving Occupations | 0.0 | Motor Vehicle Operators<br>Material Moving Workers<br>Driver/Sales Workers and Truck Drivers<br>Heavy and Tractor-Trailer Truck Drivers<br>Laborers and Freight, Stock, and Material Movers, Hand |

Sources: BLS, RESI, REMI PI+

### C.3.17 Biomass for Energy Production—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 41.4 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Protective Service Occupations | 30.7 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction and Extraction Occupations | 20.9 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 20.2 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Healthcare Practitioners and Technical Occupations | 12.0 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.3.18 Biomass for Energy Production—Operation Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 1.2 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 1.1 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Business and Financial Operations Occupations | 0.5 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Installation, Maintenance, and Repair Occupations | 0.4 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Computer and Mathematical Occupations | 0.3 | Software Developers and Programmers<br>Computer and Information Analysts<br>Computer Systems Analysts<br>Database and Systems Administrators and Network Architects<br>Computer Programmers |

Sources: BLS, RESI, REMI PI+

### C.3.19 Conservation of Agricultural Land for GHG Benefits—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 8.0 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Protective Service Occupations | 5.3 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction and Extraction Occupations | 4.0 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 3.2 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Management Occupations | 2.3 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.3.20 Conservation of Agricultural Land for GHG Benefits—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 46.0 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Farming, Fishing, and Forestry Occupations | 41.2 | Agricultural Workers<br>Farmworkers and Laborers, Crop, Nursery, and Greenhouse<br>Farmworkers, Farm, Ranch, and Aquacultural Animals<br>Forest, Conservation, and Logging Workers<br>Supervisors of Farming, Fishing, and Forestry Workers |
| Construction and Extraction Occupations | 29.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Sales and Related Occupations | 29.2 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Management Occupations | 27.8 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

## C.4 Zero Waste

### C.4.1 Recycling and Source Reduction Status Quo—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 150.5 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Building and Grounds Cleaning and Maintenance Occupations | 108.4 | Building Cleaning and Pest Control Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Grounds Maintenance Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers<br>Custodial Supervisors |
| Transportation and Material Moving Occupations | 65.4 | Material Moving Workers<br>Laborers and Material Movers, Hand<br>Driver/Sales Workers and Truck Drivers<br>Refuse and Recyclable Material Collectors<br>Industrial Truck and Tractor Operators |
| Construction and Extraction Occupations | 62.3 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Sales and Related Occupations | 61.7 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |

Sources: BLS, RESI, REMI PI+

### C.4.2 Recycling and Source Reduction Enhancement—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 200.7 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Building and Grounds Cleaning and Maintenance Occupations | 144.5 | Building Cleaning and Pest Control Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Grounds Maintenance Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers<br>Custodial Supervisors |
| Transportation and Material Moving Occupations | 87.2 | Material Moving Workers<br>Laborers and Material Movers, Hand<br>Driver/Sales Workers and Truck Drivers<br>Refuse and Recyclable Material Collectors<br>Industrial Truck and Tractor Operators |
| Construction and Extraction Occupations | 83.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Sales and Related Occupations | 82.3 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |

Sources: BLS, RESI, REMI PI+

### C.4.3 Recycling and Source Reduction Status Quo—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | -67.7 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Building and Grounds Cleaning and Maintenance Occupations | -48.7 | Building Cleaning and Pest Control Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Grounds Maintenance Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers<br>Custodial Supervisors |
| Transportation and Material Moving Occupations | -29.4 | Material Moving Workers<br>Laborers and Material Movers, Hand<br>Driver/Sales Workers and Truck Drivers<br>Refuse and Recyclable Material Collectors<br>Industrial Truck and Tractor Operators |
| Construction and Extraction Occupations | -28.3 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Sales and Related Occupations | -27.8 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |

Sources: BLS, RESI, REMI PI+

### C.4.4 Recycling and Source Reduction Enhancement—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | -111.2 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Building and Grounds Cleaning and Maintenance Occupations | -80.0 | Building Cleaning and Pest Control Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Grounds Maintenance Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers<br>Custodial Supervisors |
| Transportation and Material Moving Occupations | -48.3 | Material Moving Workers<br>Laborers and Material Movers, Hand<br>Driver/Sales Workers and Truck Drivers<br>Refuse and Recyclable Material Collectors<br>Industrial Truck and Tractor Operators |
| Construction and Extraction Occupations | -46.5 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Sales and Related Occupations | -45.7 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |

Sources: BLS, RESI, REMI PI+

## C.5 Buildings

### C.5.1 Building Codes—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 3.3 | Material Recording, Scheduling, Dispatching, and Distributing Workers<br>Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Secretaries and Administrative Assistants<br>Financial Clerks |
| Protective Service Occupations | 2.1 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction and Extraction Occupations | 1.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 1.3 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Management Occupations | 0.9 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.5.2 Building Codes—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 99.0 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Business and Financial Operations Occupations | 53.8 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Management Occupations | 49.2 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |
| Sales and Related Occupations | 37.8 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Construction and Extraction Occupations | 36.3 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |

Sources: BLS, RESI, REMI PI+

## C.6 Land Use

### C.6.1 Reducing Emissions through Smart Growth and Land Use/Location Efficiency (Include Land Use Planning and Growth Boundary GHG Benefits) Status Quo—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 651.4 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 281.9 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Installation, Maintenance, and Repair Occupations | 175.7 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Sales and Related Occupations | 134.6 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Management Occupations | 115.1 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.6.2 Reducing Emissions through Smart Growth and Land Use/Location Efficiency (Include Land Use Planning and Growth Boundary GHG Benefits) Enhancement—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 961.6 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 416.1 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Installation, Maintenance, and Repair Occupations | 259.4 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Sales and Related Occupations | 198.8 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Management Occupations | 170.0 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.6.3 Reducing Emissions through Smart Growth and Land Use/Location Efficiency (Include Land Use Planning and Growth Boundary GHG Benefits) Status Quo—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 97.0 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Sales and Related Occupations | 82.5 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Construction and Extraction Occupations | 76.2 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Food Preparation and Serving Related Occupations | 51.2 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Healthcare Practitioners and Technical Occupations | 36.7 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.6.4 Reducing Emissions through Smart Growth and Land Use/Location Efficiency (Include Land Use Planning and Growth Boundary GHG Benefits) Enhancement—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 161.6 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Sales and Related Occupations | 137.5 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Construction and Extraction Occupations | 127.0 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Food Preparation and Serving Related Occupations | 85.4 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Healthcare Practitioners and Technical Occupations | 61.2 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.6.5 Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Status Quo—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 930.6 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 402.7 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Installation, Maintenance, and Repair Occupations | 251.1 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Sales and Related Occupations | 192.4 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Management Occupations | 164.5 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.6.6 Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Enhancement—Investment Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 1,054.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Office and Administrative Support Occupations | 456.4 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Installation, Maintenance, and Repair Occupations | 284.5 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Sales and Related Occupations | 218.0 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Management Occupations | 186.4 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

**C.6.5 Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Status Quo—Operation Phase**

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 177.8 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Sales and Related Occupations | 151.3 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Construction and Extraction Occupations | 139.8 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Food Preparation and Serving Related Occupations | 106.8 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Healthcare Practitioners and Technical Occupations | 67.3 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

**C.6.6 Priority Funding Area (Growth Boundary) Related Benefits (Transportation Sector through Smart Growth) Enhancement—Investment Phase**

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 282.9 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Sales and Related Occupations | 240.7 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Construction and Extraction Occupations | 222.3 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Food Preparation and Serving Related Occupations | 149.4 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Healthcare Practitioners and Technical Occupations | 107.1 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

## C.7 Innovative Initiatives

### C.7.1 Buy Local for GHG Benefits—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 7.6 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Protective Service Occupations | 5.2 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction and Extraction Occupations | 3.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 3.1 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Management Occupations | 2.1 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.7.2 Buy Local for GHG Benefits—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 1.0 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Farming, Fishing, and Forestry Occupations | 0.9 | Agricultural Workers<br>Farmworkers and Laborers, Crop, Nursery, and Greenhouse<br>Farmworkers, Farm, Ranch, and Aquacultural Animals<br>Forest, Conservation, and Logging Workers<br>Supervisors of Farming, Fishing, and Forestry Workers |
| Construction and Extraction Occupations | 0.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Sales and Related Occupations | 0.6 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Management Occupations | 0.6 | General and Operations Managers<br>Construction Managers<br>Operations Specialties Managers<br>Advertising, Marketing, Promotions, Public Relations, and Sales Managers<br>Financial Managers |

Sources: BLS, RESI, REMI PI+

### C.7.3 Voluntary Stationary Source Reductions—Investment Phase

| | | |
|---|---|---|
| Sales and Related Occupations | 0.1 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Protective Service Occupations | 0.1 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Business and Financial Operations Occupations | 0.0 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Construction and Extraction Occupations | 0.0 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Building and Grounds Cleaning and Maintenance Occupations | 0.0 | Building Cleaning and Pest Control Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Grounds Maintenance Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers<br>Custodial Supervisors |

Sources: BLS, RESI, REMI PI+

### C.7.4 Voluntary Stationary Source Reductions—Operation Phase

| | | |
|---|---|---|
| Construction and Extraction Occupations | 0.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Sales and Related Occupations | 0.1 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Business and Financial Operations Occupations | 0.2 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Installation, Maintenance, and Repair Occupations | 0.2 | Other Installation, Maintenance, and Repair Occupations<br>Line Installers and Repairers<br>Electrical Power-Line Installers and Repairers<br>Electrical and Electronic Equipment Mechanics, Installers, and Repairers<br>Maintenance and Repair Workers, General |
| Computer and Mathematical Occupations | 0.1 | Software Developers and Programmers<br>Computer and Information Analysts<br>Computer Systems Analysts<br>Database and Systems Administrators and Network Architects<br>Computer Programmers |

Sources: BLS, RESI, REMI PI+

### C.7.5 PAYD Insurance in Maryland—Investment Phase

*There are no specified costs with this policy to date.*

### C.7.6 PAYD Insurance in Maryland—Operation Phase

| | | |
|---|---|---|
| Computer and Mathematical Occupations | 0.0 | Software Developers and Programmers<br>Computer and Information Analysts<br>Computer Systems Analysts<br>Database and Systems Administrators and Network Architects<br>Computer Programmers |
| Healthcare Practitioners and Technical Occupations | 0.0 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 0.0 | Building Cleaning and Pest Control Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Grounds Maintenance Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers<br>Custodial Supervisors |
| Office and Administrative Support Occupations | 0.0 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Sales and Related Occupations | 0.0 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |

Sources: BLS, RESI, REMI PI+

### C.7.7 Leadership-by-Example—Local Government—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 33.2 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Construction and Extraction Occupations | 23.8 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Protective Service Occupations | 18.7 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Business and Financial Operations Occupations | 14.7 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Food Preparation and Serving Related Occupations | 9.0 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |

Sources: BLS, RESI, REMI PI+

### C.7.8 Leadership-by-Example—Local Government—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 51.2 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Business and Financial Operations Occupations | 31.9 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Building and Grounds Cleaning and Maintenance Occupations | 26.8 | Building Cleaning and Pest Control Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Grounds Maintenance Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers<br>Custodial Supervisors |
| Food Preparation and Serving Related Occupations | 19.4 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Construction and Extraction Occupations | 12.8 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |

Sources: BLS, RESI, REMI PI+

### C.7.9 Leadership-by-Example—Federal Government—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 16.4 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Protective Service Occupations | 12.3 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction and Extraction Occupations | 8.0 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 7.9 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Healthcare Practitioners and Technical Occupations | 4.7 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

**C.7.10 Leadership-by-Example—Federal Government—Operation Phase**

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 206.2 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Protective Service Occupations | 174.9 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Business and Financial Operations Occupations | 105.3 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Construction and Extraction Occupations | 78.5 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Healthcare Practitioners and Technical Occupations | 68.8 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.7.11 State of Maryland Initiatives to Lead by Example Status Quo—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 33.2 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Construction and Extraction Occupations | 23.8 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Protective Service Occupations | 18.7 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Business and Financial Operations Occupations | 14.7 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Food Preparation and Serving Related Occupations | 9.0 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |

Sources: BLS, RESI, REMI PI+

### C.7.12 State of Maryland Initiatives to Lead by Example Enhancement—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 36.4 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Construction and Extraction Occupations | 26.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Protective Service Occupations | 21.2 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Business and Financial Operations Occupations | 16.8 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Food Preparation and Serving Related Occupations | 11.1 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |

Sources: BLS, RESI, REMI PI+

**C.7.13 State of Maryland Initiatives to Lead by Example Status Quo—Operation Phase**

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 0.7 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Business and Financial Operations Occupations | 0.5 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Building and Grounds Cleaning and Maintenance Occupations | 0.2 | Building Cleaning and Pest Control Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Grounds Maintenance Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers<br>Custodial Supervisors |
| Food preparation, serving related occupations | 0.1 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Construction and Extraction Occupations | 0.1 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |

Sources: BLS, RESI, REMI PI+

### C.7.14 State of Maryland Initiatives to Lead by Example Enhancement—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 1.0 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Business and Financial Operations Occupations | 0.7 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Building and Grounds Cleaning and Maintenance Occupations | 0.6 | Building Cleaning and Pest Control Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Grounds Maintenance Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers<br>Custodial Supervisors |
| Food preparation, serving related occupations | 0.3 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |
| Construction and Extraction Occupations | 0.3 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |

Sources: BLS, RESI, REMI PI+

### C.7.15 Leadership-by-Example—Maryland University Lead-by-Example Initiatives—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 15.8 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Protective Service Occupations | 11.9 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction and Extraction Occupations | 7.7 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 7.7 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Healthcare Practitioners and Technical Occupations | 4.5 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.7.16 Leadership-by-Example—Maryland University Lead-by-Example Initiatives—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 16.1 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Protective Service Occupations | 15.4 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Business and Financial Operations Occupations | 8.4 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Healthcare Practitioners and Technical Occupations | 5.6 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Building and Grounds Cleaning and Maintenance Occupations | 5.0 | Building Cleaning and Pest Control Workers<br>Janitors and Cleaners, Except Maids and Housekeeping Cleaners<br>Grounds Maintenance Workers<br>Supervisors of Building and Grounds Cleaning and Maintenance Workers<br>Custodial Supervisors |

Sources: BLS, RESI, REMI PI+

**C.7.17 Transportation and Climate Initiative—Investment Phase**

*There are no costs to date associated with the implementation of this program during the investment phase.*

### C.7.18 Transportation Climate Initiative—Operation Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 4.3 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Protective Service Occupations | 2.8 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Business and Financial Operations Occupations | 1.7 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Sales and Related Occupations | 1.3 | Retail Sales Workers<br>Cashiers<br>Counter and Rental Clerks and Parts Salespersons<br>Retail Salespersons<br>Other Sales and Related Workers |
| Healthcare Practitioners and Technical Occupations | 1.1 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |

Sources: BLS, RESI, REMI PI+

### C.7.19 GHG Emissions Inventory Development—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 2.9 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Protective Service Occupations | 1.9 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Construction and Extraction Occupations | 1.5 | Construction Laborers<br>Carpenters<br>Construction Equipment Operators<br>First-Line Supervisors of Construction Trades and Extraction Workers<br>Electricians |
| Business and Financial Operations Occupations | 1.2 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Management Occupations | 0.8 | Supervisors of construction trade workers<br>Carpenters<br>Brick masons, block masons, and stonemasons<br>Construction equipment operators<br>Electricians |

Sources: BLS, RESI, REMI PI+

**C.7.20 GHG Prevention of Significant Deterioration Permitting Program—Operation Phase**

*There is no specified cost or benefit to this program during the operation phase.*

## C.8 Outreach

### C.8.1 Outreach and Public Education—Investment Phase

*There are no costs associated with the investment phase of this policy.*

### C.8.2 Outreach and Public Education—Investment Phase

| | | |
|---|---|---|
| Office and Administrative Support Occupations | 0.0 | Information and Record Clerks<br>Other Office and Administrative Support Workers<br>Customer Service Representatives<br>Financial Clerks<br>Material Recording, Scheduling, Dispatching, and Distributing Workers |
| Business and Financial Operations Occupations | 0.0 | Business Operations Specialists, All Other<br>Financial Specialists<br>Compliance Officers<br>Management Analysts<br>Tax Examiners and Collectors, and Revenue Agents |
| Protective Service Occupations | 0.0 | Fire fighters and inspectors<br>Bailiffs, correctional officers, and jailers<br>Fish and game wardens<br>Animal control workers<br>Private detectives and investigators |
| Healthcare Practitioners and Technical Occupations | 0.0 | Health Diagnosing and Treating Practitioners<br>Registered Nurses<br>Health Technologists and Technicians<br>Licensed Practical and Licensed Vocational Nurses<br>Physicians and Surgeons |
| Food Preparation and Serving Related Occupations | 0.0 | Food and Beverage Serving Workers<br>Waiters and Waitresses<br>Cooks and Food Preparation Workers<br>Fast Food and Counter Workers<br>Cooks |

Sources: BLS, RESI, REMI PI+

# Appendix D—References by Subject Area

### D.1 Energy

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*This Appendix is based upon material provided by the University of Maryland Center for Environmental Science.*

## Frequently Used Abbreviations and Acronyms

$CO_2$: Carbon Dioxide
IPCC: Intergovernmental Panel on Climate Change
RCP: Representative Concentration Pathways

# Introduction

Science has demonstrated with a high degree of certainty that Earth's climate is being changed by human activities, particularly the emission of heat-trapping gases, generally called greenhouse gases, including carbon dioxide, methane, and nitrous oxide. Science has also provided a reliable description of (1) how further emissions will warm the Earth, (2) how this will alter the climate and have consequences for human society and the natural systems on which it depends, and (3) the amount and timing of reductions in emissions needed to limit climate change in order to avoid its most harmful consequences.

Maryland's **Greenhouse Gas Reductions Act of 2009** requires the State to reduce Statewide greenhouse gas emissions by 25% from 2006 levels by 2020. The Act further directs the Maryland Department of the Environment to report on "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" on or before 2020.

The **Maryland Climate Change Commission**, established by Executive Order in 2007, was responsible for laying the groundwork for the Greenhouse Gas Reduction Act by developing a Climate Action Plan in 2008. During the 2015 Session the Maryland General Assembly passed House Bill 514, which codified the Maryland Climate Change Commission. House Bill 514 was signed into law by Governor Hogan and became effective on June 1, 2015. Among the actions the Commission is charged to undertake include "maintaining a comprehensive action plan, with 5-year benchmarks, to achieve science-based reductions in Maryland's greenhouse gas emissions." Toward this end, the Commission's Mitigation Working Group requested advice from the **Scientific and Technical Working Group (STWG)** to inform its considerations of the greenhouse gas emissions reductions that should be pursued beyond 2020 in the preparation of the Commission's first annual report, due on November 15, 2015.

The STWG provided its interim appraisal of the scientific basis for setting targets for emissions reductions beyond 2020. This appraisal is founded on the Fifth Assessment of the **Intergovernmental Panel on Climate Change (IPCC)** that was completed in 2014, over five years after the enactment of Maryland's Greenhouse Gas Reductions Act. This reliance is appropriate because the IPCC assessment was both comprehensive (integrating global and regional climate and emission trends, credible evaluation of likely future impacts, and state-of-the-art projections of climate change as a function of global greenhouse gas emissions) and subjected to extensive internal and external review. The IPCC Fifth Assessment is the most through and recent scientific appraisal available of greenhouse gas emissions reduction pathways and is accepted and relied on by nations around the world.

The IPCC Fifth Assessment includes an evaluation of the amount and timing of reductions in greenhouse gas emissions required globally in order to avoid increases in global average temperature and associated climate disruption that would result in dangerous risks to society and the natural systems on which it depends. It is appropriate that these scientifically determined pathways inform the determination of greenhouse gas reduction targets for Maryland. It is also understood that the Commission's recommendations will also take into account additional economic, social and political factors that go beyond the science. For example, in June 2015 the leaders of the Group of Seven industrialized nations agreed to take steps to phase out fossil fuel use by the end of this century. The national commitments the United States will make during the United Nations Conference on Climate Change to be held in Paris in November and December of 2015 will be particularly consequential for Maryland's reduction pathway. These international deliberations have been and will be informed principally by the IPCC scientific assessment.

# IPCC Approach

The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change. It was initiated in 1988 by the World Meteorological Organization and the United Nations Environment Program to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation1, IPCC assessments are written by prominent scientists who serve as lead or contributing authors. The assessments undergo multiple rounds of drafting and peer review. The last assessment, completed in 2014, was the IPCC's fifth and had 235 authors from 58 countries and received and considered over 38,000 comments on drafts.

The IPCC Fifth Assessment presents the results of three working groups:

- Working Group I (WGI) addressed *The Physical Science Basis*, including climate observations; ancient climate archives; carbon and other biogeochemical cycles; anthropogenic and natural forces that affect the retention of heat from solar radiation; evaluation of climate models; detection and attribution of climate change; and near and long-term projections of climate change and sea level change.
- Working Group II (WGII) addressed *Impacts, Adaptation and Variability*, including observed impacts; vulnerability and adaptation; future risks and opportunities for adaptation; and managing future risks and building resilience.
- Working Group III (WGIII) addressed *Mitigation of Climate Change*, including approaches to climate change mitigation; trends in stocks and flows of greenhouse gases and their drivers; mitigation pathways and measures; and mitigation policies and institutions.

The determination of appropriate pathways for reductions of greenhouse gases requires the integration of the analyses of all three IPCC working groups. This integration is brought together in separate **Climate Change 2014 Synthesis Report**. The results and graphs presented here come from the Synthesis Report.

## Rationale for Limiting Global Warming to 2°C

The degree of global warming and climate disruption we will experience in the future depends on the concentration of greenhouse gases in the atmosphere. These greenhouse gases accumulate in the atmosphere over time. Once released into the atmosphere carbon dioxide, in particular, can persist there for hundreds of years if not taken up by growing vegetation or dissolved in the ocean. Once elevated, the concentrations of these greenhouse gases decline slowly. Complex computer simulations, or models as they are called, estimate the net accumulation of greenhouse gases in the atmosphere and, based on their known heat-trapping properties, estimate the degree of warming over the planet. The higher the accumulated greenhouse gas concentrations, the warmer the average temperature over the surface of Earth (in the air and oceans) will become. Thus, the emissions pathway that we chose to take depends on the degree of warming we are willing to risk.

IPCC WGII assessed the likely consequences of increased global temperature and associated climate disruption in five Reasons for Concern: unique and threatened systems, extreme weather events, distribution of impacts, global aggregate impacts, and large-scale singular events (Figure 1). For each of these criteria WGII rated the global mean temperature change at which risks from climate disruption would be undetectable, moderate, high or very high. Note that Earth has already (2003-2012 average) experienced an increase in global mean temperature of about 0.8°C (1.4°F) when measured from the benchmark of pre-industrial conditions (1850-1900).

Based on the IPCC analysis, risks become moderate for some criteria and high for others as the global mean temperature increase exceeds 2°C (3.6°F). Based on the analyses in both the IPCC Fourth and Fifth Assessment, avoiding an increase of greater than 2°C has become an internationally accepted goal. Some scientists have argued that limiting the increase in global mean temperature to 1.5°C or less would be a more prudent goal and that serious irreversible impacts would occur if that level of warming were exceeded. On the other hand, an increase in global mean temperature of 3°C or more would impose high to very high risks across all of the Reasons of Concern criteria.

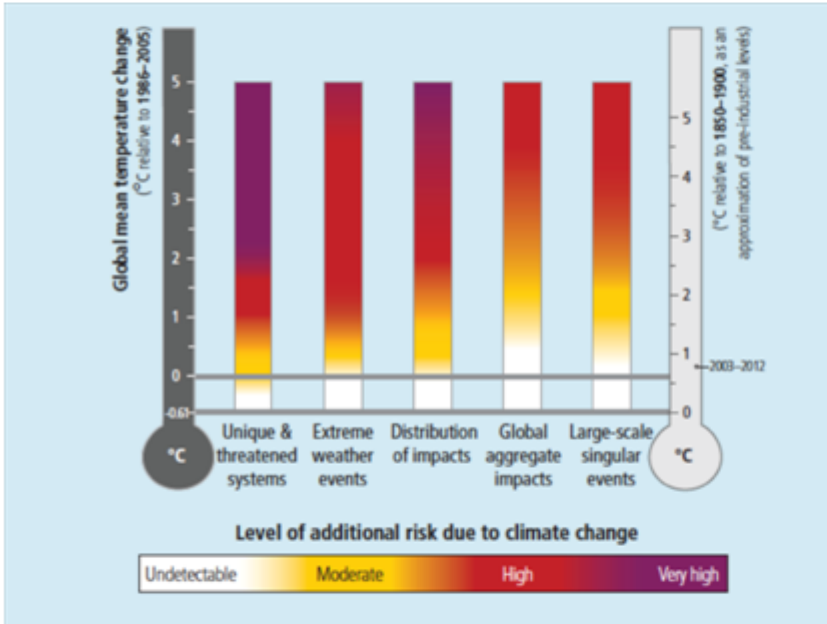


**Figure 1.** Risks at a global scale for increasing levels of climate change.

## Determining the Required Amount and Timing of CO2 Emission Reductions

IPCC WGI used ensembles of different computer simulations to project global average surface temperature change through the 21st century and beyond using four uniform greenhouse gas emission pathway scenarios. These scenarios are called Representative Concentration Pathways (RCP) and range from aggressive reductions in emissions beginning around 2020 and leading to no net emissions before the end of the century (RCP2.6), to continued growth in emissions throughout the rest of the century (RCP8.5). The figure below shows the change in global average temperature (relative to 1986-2005) for these two scenarios as the multi-model means (solid colored lines, with number of models on which they depend indicated) and the 5 to 95% statistical range across the distribution of individual models. In other words, there is very high confidence that the global average surface temperature change would fall within the colored bands around the means. On the right, the means and statistical ranges for the last 20 years of the century are shown for all four RCP scenarios.

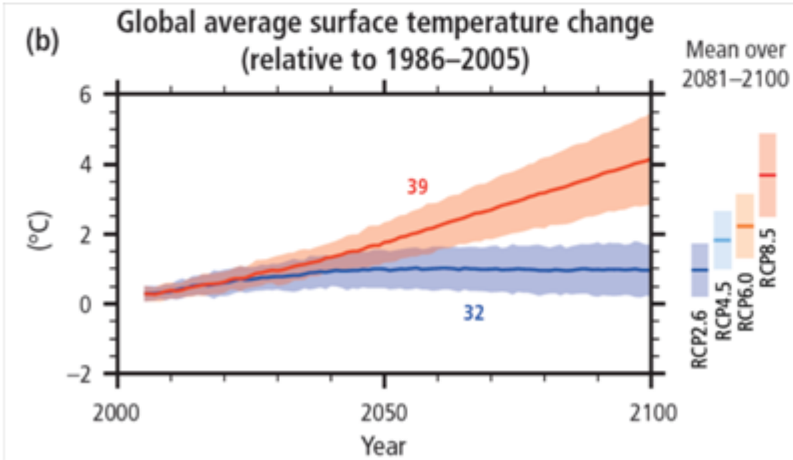


**Figure 2.** Global average temperature change for RCP scenarios.

It is clear that of the four RCPs only RCP2.6 would result in a high likelihood of keeping the change in global average temperature to less than 2°C—but this is relative to the 1986-2005 average temperature, not the pre-industrial benchmark discussed earlier. Even under RCP4.5, which entails substantial reductions in emissions beginning around mid-century, the change in global average temperature would likely exceed 2°C.

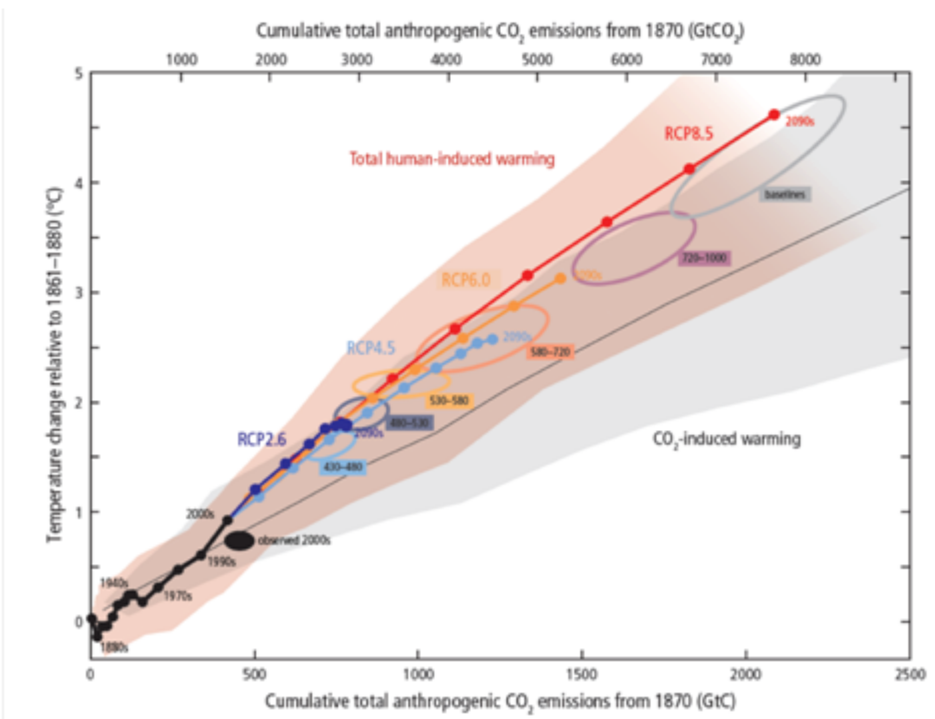


**Figure 3.** Global mean surface temperature increase as a function of cumulative global carbon dioxide ($CO_2$) emissions in gigatons of $CO_2$ ($GtCO_2$) or carbon (GtC).

Another way that the IPCC looked at this relationship of emissions pathways to temperature change was to compare the relationship of the cumulative total $CO_2$ emission from human

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sources since 1870 to the temperature change. This is appropriate because of the large role of $CO_2$ in total human induced warming and the long persistence of $CO_2$ in the atmosphere compared to other greenhouse gases.  The relationship of cumulative $CO_2$ emissions through the century to temperature change is shown below in Figure 3.

This approach allowed to IPCC to consider cumulative emissions in the context of a budget constrained by how much $CO_2$ can be emitted over time and still keep the temperature change below 2°C. The black dots and lines show the historical pathway up to the 2000s as estimated by hincast computer simulations. Future pathways for the four RCPs used by the IPCC are also shown over the rest of this century. The ellipses show the ranges in total anthropogenic warming in 2100 versus cumulative emissions from a simpler climate model, labeled with the associated concentration ranges of greenhouse gases in parts per million (ppm) of $CO_2$-equivalents.

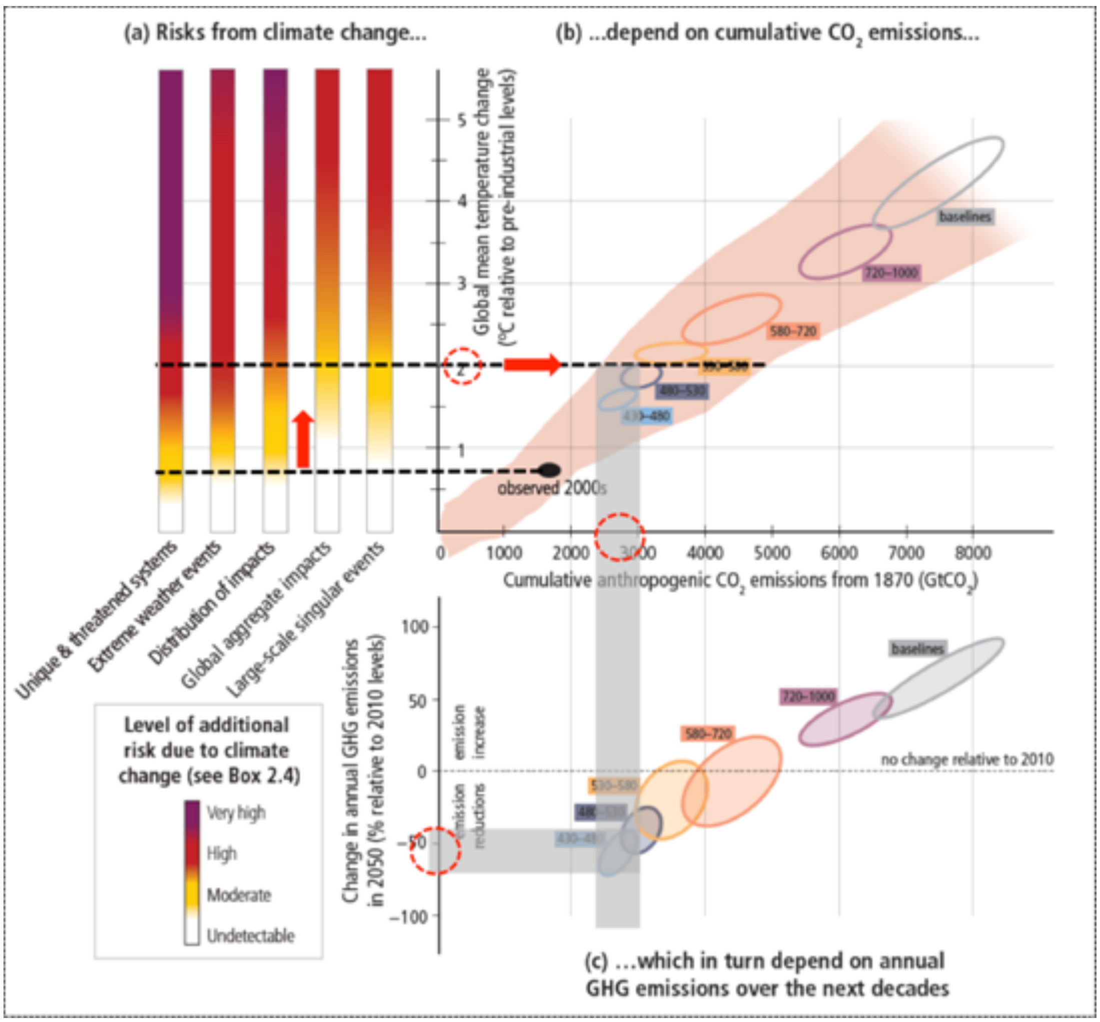


**Figure 4.** The relationships among risks from climate change, cumulative $CO_2$ emissions and changes in annual greenhouse gas emissions by 2050.

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This cumulative emissions approach allowed the IPCC to determine the reductions in greenhouse gas emissions that would be required over the few next decades in order to achieve a given greenhouse gas concentration range by the end of the century. This synthesis is shown in Figure 4, which relates the risks from climate change [(a) from Figure 1] with cumulative $CO_2$ emissions though this century [(b) from Figure 3]. From these cumulative emissions the amount of change in greenhouse gas emissions over the next decades that are required in order to achieve these cumulative amounts is then determined (c).

So, for example, if one wanted to insure that it the global mean temperature increase line would not likely cross 2°C, this would require constraining anthropogenic greenhouse gas concentrations to about 450 (430-480) ppm $CO_2$-eq. Thus, this would require constraining cumulative $CO_2$ emissions through this century to less than 3000 $GtCO_2$. This is equivalent to the RCP2.6 scenario. Achieving that objective would, in turn, require reducing annual greenhouse gas emissions somewhere between 41 to 72% (compared to 2010) by 2050, with the range reflective of the uncertainties included in the analyses of computer simulations.

From the extensive IPCC analyses using this approach the likelihood of staying below a specific increase in global mean temperature over the 21st century as a function of greenhouse gas emissions pathways is summarized in Table 1.

**Table 1.** Key characteristics of the scenarios assessed by IPCC. For all parameters the $10^{th}$ and $90^{th}$ percentile of the scenarios is shown.

<table>
<tr><th rowspan="2">$CO_2$-eq Concentrations in 2100 (ppm $CO_2$-eq)[f]<br>Category label (conc. range)</th><th rowspan="2">Subcategories</th><th rowspan="2">Relative position of the RCPs[d]</th><th colspan="2">Change in $CO_2$-eq emissions compared to 2010 (in %)[c]</th><th colspan="4">Likelihood of staying below a specific temperature level over the 21st century (relative to 1850–1900)[d,e]</th></tr>
<tr><th>2050</th><th>2100</th><th>1.5°C</th><th>2°C</th><th>3°C</th><th>4°C</th></tr>
<tr><td><430</td><td colspan="8">Only a limited number of individual model studies have explored levels below 430 ppm $CO_2$-eq[j]</td></tr>
<tr><td>450<br>(430 to 480)</td><td>Total range[a,g]</td><td>RCP2.6</td><td>−72 to −41</td><td>−118 to −78</td><td>More unlikely than likely</td><td>Likely</td><td rowspan="6">Likely</td><td rowspan="7">Likely</td></tr>
<tr><td rowspan="2">500<br>(480 to 530)</td><td>No overshoot of 530 ppm $CO_2$-eq</td><td></td><td>−57 to −42</td><td>−107 to −73</td><td rowspan="6">Unlikely</td><td>More likely than not</td></tr>
<tr><td>Overshoot of 530 ppm $CO_2$-eq</td><td></td><td>−55 to −25</td><td>−114 to −90</td><td>About as likely as not</td></tr>
<tr><td rowspan="2">550<br>(530 to 580)</td><td>No overshoot of 580 ppm $CO_2$-eq</td><td></td><td>−47 to −19</td><td>−81 to −59</td><td rowspan="3">More unlikely than likely[i]</td></tr>
<tr><td>Overshoot of 580 ppm $CO_2$-eq</td><td></td><td>−16 to 7</td><td>−183 to −86</td></tr>
<tr><td>(580 to 650)</td><td>Total range</td><td rowspan="2">RCP4.5</td><td>−38 to 24</td><td>−134 to −50</td></tr>
<tr><td>(650 to 720)</td><td>Total range</td><td>−11 to 17</td><td>−54 to −21</td><td rowspan="2">Unlikely</td><td>More likely than not</td></tr>
<tr><td>(720 to 1000)[b]</td><td>Total range</td><td>RCP6.0</td><td>18 to 54</td><td>−7 to 72</td><td rowspan="2">Unlikely[h]</td><td>More unlikely than likely</td></tr>
<tr><td>>1000[b]</td><td>Total range</td><td>RCP8.5</td><td>52 to 95</td><td>74 to 178</td><td>Unlikely[h]</td><td>Unlikely</td><td>More unlikely than likely</td></tr>
</table>

Limiting the increase in global mean temperature to 1.5 °C is unlikely under any emissions pathway that has been studied. Limiting the increase to 2°C would only be more likely than not if greenhouse gas emissions were reduced by at least 42% by 2050, but greater reductions are required to make this confidently likely. IPCC analyses not shown in this table further suggest that annual global greenhouse gas emissions would have to be reduced by about 25% by 2030 to

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achieve this pathway. This pathway would also require reducing net emissions to near-zero (by 78-118%) by 2100. Emissions reductions of greater than 100% implies that the rate of carbon sequestration (either by organic growth or capture and storage) would have to exceed emissions. Even to limit the increase in global mean temperature to 3°C (5.4°F) would entail reducing greenhouse gas emissions 24-38% by 2050 and near carbon neutrality by the end of the century.

## Implications for Setting Maryland's Goals

It is important to understand that the IPCC's analyses are for global mean temperatures and global greenhouse gas emissions. Realized warming for Maryland will differ from the global average; in fact, because of our relatively high latitude, it is very likely to be greater. Furthermore, warming in Maryland will be controlled by global emission and not Maryland's own emissions. Of course, Maryland contributes only a small part of annual global greenhouse gas emissions, but a disproportionately large share on a per capita basis. Because of the higher per capita emissions rates in the United States it will be reasonably expected in international negotiations that U.S. commitments should be toward at least the higher end if not beyond the 41 to 72% reductions required by 2050 to avoid exceeding the 2°C warming goal, based on the IPCC analysis. On the other hand, per capita emissions in Maryland (11 metric tons per year) are less than the average for the United States (17 metric tons per year), so it might be argued that emission reductions in more energy intensive states should be more aggressive than that for Maryland. These considerations go beyond what the IPCC scientific analyses tell us.

In May 2015 the United States government submitted its intended nationally determined contribution to the United Nations, indicating that the U.S. had taken steps to reduce its GHG emissions by 17% below the 2015 baseline and intended to achieve an economy-wide target of reducing emissions by 26-28% by 2025, making best efforts to reduce emissions by at least 28%. If that trend in emissions reduction were continued, it would result in an 80% reduction in emissions by 2050. If, for example, Maryland achieves its goal of reducing GHG emissions by 25% by 2020 and plans to reduce emissions to 72% of 2006 levels by 2050, a 40% reduction by 2030 would be required assuming steady progress (i.e., a linear trend in emission reductions).

The leaders of the Group of Seven nations agreed in June 2015 to limit global warming to 2°C and declared their support for 40 to 70% reductions in greenhouse gas emissions by 2050 (compared to 2010 levels). A month earlier California, Vermont, Oregon and Washington joined in a nonbinding "Under 2 MOU" with states and regions in Germany, the United Kingdom, Brazil, Germany, Mexico, Spain, Columbia and Canada that commits them to either reduce greenhouse gas emissions by 80-95% by 2050 or achieve a per-capita annual emissions target of less than 2 metric tons per year.

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