

Table C-1. Strategy Assigned Reductions.

<b>Program I.D.</b>	<b>Program</b>	<b>Lead Agency</b>	<b>Potential GHG Emission Reductions (MMtCO<sub>2</sub>e) Revised for 2015</b>
<b>ENERGY</b>			
<b>A</b>	<b>EmPOWER Maryland</b>	-	<b>7.24</b>
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>B</b>	<b>The Maryland Renewable Energy Portfolio Standard (RPS)</b>	-	<b>4.13</b>
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
<b>C</b>	<b>The Regional Greenhouse Gas Initiative (RGGI)</b>	<b>MDE</b>	<b>3.60</b>
<b>D</b>	<b>Other Energy Programs</b>	-	<b>0.14</b>
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
<b>TRANSPORTATION</b>			
<b>E</b>	<b>Transportation Technologies</b>	-	<b>6.88</b>
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 (CAFE): 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
<b>F</b>	<b>Public Transportation</b>	-	<b>1.85</b>
F.1	Public Transportation Initiatives	MDOT	1.85
F.2	Intercity Transportation Initiatives	MDOT	Included in F.1
<b>G</b>	<b>Pricing Initiatives</b>	<b>MDOT</b>	<b>1.99</b>
<b>H</b>	<b>Other Innovative Transportation Strategies/Programs</b>	-	<b>Included in F.1</b>
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
<b>AGRICULTURE AND FORESTRY</b>			
<b>I</b>	<b>Forestry and Sequestration</b>	-	<b>4.55</b>
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
<b>J</b>	<b>Ecosystems Markets</b>	-	<b>0.68</b>
J.1	Creating Ecosystems Markets to Encourage GHG Emission Reductions	DNR	0.11
J.2	Nutrient Trading for GHG Benefits	MDA	0.57
<b>BUILDING</b>			
<b>K</b>	<b>Building and Trade Codes in Maryland</b>	<b>DHCD</b>	<b>3.15</b>
<b>RECYCLING</b>			
<b>L</b>	<b>Zero Waste</b>	<b>MDE</b>	<b>1.48</b>
<b>MARYLAND'S INNOVATIVE INITIATIVES</b>			
<b>M</b>	<b>Leadership-By-Example</b>	-	<b>1.78</b>
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
<b>N</b>	<b>Maryland's Innovative Initiatives</b>	-	<b>0.21</b>
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
<b>O</b>	<b>Future or Developing Programs</b>	-	<b>0.02</b>
O.1	The Transportation and Climate	MDE/	0.02

	Initiative	MDOT	
O.2	Clean Fuels Standard	MDE	0.00
<b>LAND USE</b>			
<b>P</b>	<b>Land Use Programs</b>	-	<b>0.64</b>
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
<b>PUBLIC</b>			
<b>Q</b>	<b>Outreach and Public Education</b>	<b>MDE</b>	<b>0.03</b>
<b>TOTAL EMISSIONS REDUCTIONS</b>			
<b>TOTAL</b>			<b>38.37</b>
<b>GGRA 2020 GOAL</b>			<b>34.66</b>
<b>2020 REDUCTIONS</b>			<b>3.71</b>

## **The Energy Sector**

**Table C-2.** Energy Sector GHG Reduction Programs.

<b>ENERGY</b>		
<b>Program I.D.</b>	<b>Program</b>	<b>Potential GHG Emission Reductions (MMtCO<sub>2</sub>e) Revised for 2015</b>
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
<b>Total</b>		<b>15.11</b>

### **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 MMtCO<sub>2</sub>e.

Following a 2012 Program Review, RGGI states implemented a new 2014 RGGI cap of 91 million short tons. The RGGI CO<sub>2</sub> 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](http://www.rggi.org/design/program_review/materials-by-topic/modeling)). From the baseline run it is projected the CO<sub>2</sub>e 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 facilities 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 were 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<sub>2</sub>e.

#### **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.<sup>1</sup> Actual emissions from this sector have been calculated as approximately 1.45 MMtCO<sub>2</sub>e per year if the affected boilers operate at average 15 percent capacity factor.<sup>2</sup> 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 MMtCO<sub>2</sub>e.

### **D.1.B. GHG New Source Performance Standard**

<sup>1</sup> 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.

<sup>2</sup> 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<sub>2</sub>e

### **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.

- 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.

- 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.
- The reduction in MMBtu for each upgrade, is calculated as follows:

$$(\text{Annual MMBtu/property}) * (\% \text{ reduction of upgrade type}) = \text{MMBtu reduction/upgrade}$$

$$(350 \text{ MMBtu/commercial property})(15\% \text{ reduction for HVAC}) = 52.5 \text{ MMBtu/HVAC}$$

- The total reduction in MMBtu, for the type of upgrade (i.e., HVAC, windows/doors, or insulation/lighting), is calculated as follows:

$$(\text{MMBtu reduction/upgrade}) * (\# \text{ of upgrades/year}) = \text{Total MMBtu reduction/}$$

$$\text{Year per upgrade type}$$

$$(52.5 \text{ MMBtu/HVAC})(21 \text{ HVAC/year}) = 1,125 \text{ MMBtu/year from HVAC upgrades}$$

- 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:

$$[\text{MMBtu reduction/yr per upgrade type i}] * [\text{MMBtu reduction/yr per upgrade type ii}] * [\text{MMBtu reduction/yr per upgrade type iii}] = \text{Total reduction per year in MMBtu}$$

$$1,125 \text{ MMBtu/year per HVAC} \quad * \quad 3,111 \text{ MMBtu/year per windows/door} \quad * \quad 3,150 \text{ MMBtu/year per insulation/lighting} \quad = \quad 7,386$$

- The MMBtu value is converted to million metric tons of CO<sub>2</sub>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.

Year	MMtCO <sub>2</sub> e		
	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	<b>0.0064</b>
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**Table C-4.** Energy-15 High Estimate Summary.

Year	MMtCO <sub>2</sub> e		
	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	<b>0.0214</b>

### ***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<sub>2</sub>e

#### **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
<b>TOTAL</b>	<b>\$56,267,796</b>	<b>\$9,565,525</b>	<b>\$46,702,271</b>

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 conversion 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

$$(\text{Total grant}) / (\text{cost per property}) = \text{Number of properties retrofitted}$$

$$(\$46,702,271) / (\$5,268 \text{ per property retrofit}) = 8,865 \text{ retrofits}$$

- The following values are given:
  - 32 percent reduction in natural gas usage
  - 87.1 MMBtu per property, average current residential usage, annual

$$(\text{Number of retrofits}) * (\text{current energy use/property}) * (\% \text{ reduction}) = \text{energy savings}$$

$$(8,865 \text{ retrofits}) * (87.1 \text{ MMBtu/property}) * (32\% \text{ reduction}) = 247,093 \text{ MMBtu savings}$$

- 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
<b>0.0311</b>	<b>million metric ton GHG saved/not emitted, 2020</b>

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
<b>0.0383</b>	<b>million metric ton GHG saved/not emitted, 2020</b>

## 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.

<b>TRANSPORTATION</b>		
<b>Program I.D.</b>	<b>Program</b>	<b>Potential GHG Emission Reductions (MMtCO<sub>2</sub>e) Revised for 2015</b>
E	Transportation Technologies	6.88
F	Public Transportation	1.85
G	Pricing Initiatives	1.99
H	Other Innovative Transportation Programs	Included in F
<b>Total</b>		<b>10.72</b>

**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 <sub>2</sub> e)	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
<b>TOTAL GHG Emissions</b>	<b>35.06</b>	<b>44.26</b>

#### 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 <sup>2</sup>	4.33	5.06 <sup>4</sup>
E.1.B	CAFE 2008-2011	2.27	2.27	NA
E.1.C	National Medium and Heavy Duty Standards	0.88 <sup>3</sup>	0.88	0.28 <sup>5</sup>
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
	<b>TOTAL</b>	<b>13.29</b>	<b>16.58</b>	<b>10.72</b>

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.

<b>AGRICULTURE AND FORESTRY</b>		
<b>Program I.D.</b>	<b>Program</b>	<b>Potential GHG Emission Reductions (MMtCO<sub>2</sub>e) Revised for 2015</b>
I	Forestry and Sequestration	4.55
J	Ecosystem Markets	0.68
<b>Total</b>		<b>5.23</b>

### **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<sub>2</sub>e

## **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<sub>2</sub>-equivalent for the practices. The result is 2.70 MMtCO<sub>2</sub>e estimated to be sequestered in 2020. This result is adjusted for overlap resulting in 1.80 MMtCO<sub>2</sub>e.

### **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<sub>2</sub>e; this is calculated by adding the Private Forest Stewardship Impact 2.15 MMtCO<sub>2</sub>e to the State Forest 0.55 MMtCO<sub>2</sub>e. 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<sub>2</sub>-equivalent per acre and divided 1,000,000 conversion factor to get 0.13 annual MMtCO<sub>2</sub>e, then added to the previous 20 years of private land improvements sequestration to get 2.15 MMtCO<sub>2</sub>e sequestration credit plus adding the State lands of 62,500 acres multiplied times the carbon rate of 0.98 tonnes CO<sub>2</sub>-equivalent per acre and divided 1,000,000 conversion factor to get 0.06 annual MMtCO<sub>2</sub>e, then added to the previous 20 years of State land improvements sequestration

to get 0.55 MMtCO<sub>2</sub>e sequestration credit, for a total of 2.70 MMtCO<sub>2</sub>e sequestration credit.

## Calculations

Total MMtCO<sub>2</sub>e = Private + State

The Yearly Private FS Impact MMtCO<sub>2</sub>e = (FS acres \* 4.43 tonnes CO<sub>2</sub>-equivalent per acre / 1,000,000) + previous years credit (up to 20 years prior)

The Yearly State Forest MMtCO<sub>2</sub>e = (State acres \* 0.98 tonnes CO<sub>2</sub>-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<sub>2</sub>-equivalent per acre from – 1.5 tonnes CO<sub>2</sub>-equivalent per acre for unmanaged forest vs. 8.4 tonnes CO<sub>2</sub>-equivalent per acre for managed forest, therefore a total of 6.9 tonnes CO<sub>2</sub>-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<sub>2</sub>-equivalent per acre for each acre improved in a year. This is the average between DNR 6.9 tonnes CO<sub>2</sub>-equivalent per acre and 1.96 tonnes CO<sub>2</sub>-equivalent per acre from the Maryland D-GORCAM model report for public forest improvements.

[3] Annual MMtCO<sub>2</sub>e = Private Forest Service Impact acres times carbon rate

[4] Yearly MMtCO<sub>2</sub>e = 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<sub>2</sub>-equivalent per acre vs. 4.46 tonnes CO<sub>2</sub>-equivalent per acre = 1.99 tonnes CO<sub>2</sub>-equivalent per acre
- For Red Maple 1.47 tonnes CO<sub>2</sub>-equivalent per acre vs. 3.40 tonnes CO<sub>2</sub>-equivalent per acre = 1.93 tonnes CO<sub>2</sub>-equivalent per acre
- Average of the two tree types was assumed =1.96 tonnes CO<sub>2</sub>-equivalent per acre

The Rate used was 0.98 tonnes CO<sub>2</sub>-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<sub>2</sub>-equivalent per acre.

[7] Annual MMtCO<sub>2</sub>e = State Forest acres times carbon rate

[8] Yearly MMtCO<sub>2</sub>e = 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 <sub>2</sub> -equivalent per acre [2]	Annual MMtCO <sub>2</sub> e [3]	Yearly MMtCO <sub>2</sub> e (Stack credit from previous year) [4]	State Forest dual-certified 500,000 acres [5]	Carbon Rate tons CO <sub>2</sub> -equivalent per acre [6]	Annual MMtCO <sub>2</sub> e [7]	Yearly MMtCO <sub>2</sub> e (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
<b>2020</b>	<b>30,000</b>	4.43	<b>0.13</b>	<b>2.15</b>	<b>62,500</b>	0.98	<b>0.06</b>	<b>0.55</b>
	484,392		2.15		562,500		0.55	

**TOTAL 2.70 MMtCO<sub>2</sub>e**

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<sub>2</sub>-equivalent per acre and 1.96 tonnes CO<sub>2</sub>-equivalent per acre from Maryland-GORCAM report = 4.43 tonnes CO<sub>2</sub>-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<sub>2</sub>-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<sub>2</sub>-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.

## **1.2. 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<sub>2</sub>e

#### **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<sub>2</sub>-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 <sub>2</sub> e Reforestation						
	Private Lands		Public Lands			
	Loblolly	Mixed Upland	Loblolly	Mixed Upland		
	Pine <sup>3,4,5,6,4</sup>	Hardwood <sup>133,134,136,7</sup>	Pine <sup>133,134,135,136</sup>	Hardwood <sup>133,134,136,8</sup>	Total	
Year	(Acres)	(Acres)	(Acres)	(Acres)	(MMtCO <sub>2</sub> 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.
<b>Total</b>	<b>33,283</b>	<b>3,698</b>	<b>2,489</b>	<b>9,978</b>	<b>1.95</b>	<b>MMtCO<sub>2</sub>e</b>

**Table C-13.** Potential Carbon Sequestration from Afforestation.

MMtCO <sub>2</sub> e Afforestation			
	Loblolly	Mixed Upland	

<sup>3</sup> Includes soil carbon estimate of 34.51 tonnes per acre

<sup>4</sup> Assumes constant rate of reforestation annually, based on median acreage planted years 2006-2010.

<sup>5</sup> From Carbon On Line Estimator report for Maryland

<sup>6</sup> U.S. Dept of Agriculture Forest Service-NRS GTR NE-343

<sup>7</sup> Assumes 90 percent reforestation post-harvest is pine. See Table above

<sup>8</sup> Assumes 90 percent reforestation post-harvest is pine. See Table above

	Pine <sup>9,10,11,12</sup>	Hardwood <sup>13,140,142,14</sup>	Total	
Year	(tons CO <sub>2</sub> -equivalent)	(tons CO <sub>2</sub> -equivalent)	(tons CO <sub>2</sub> -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	<b>0.72</b>	<b>MMtCO<sub>2</sub>e</b>

### **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<sub>2</sub>e.

#### **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

<sup>9</sup> Includes soil carbon average of 26.17 tonnes per acre per year.

<sup>10</sup> Assumes constant rate of afforestation annually, as based on median acreage planted years 2006-2010

<sup>11</sup> From Table 4, Carbon On Line Estimator report for Maryland. Based on U.S. Dept of Agriculture Forest Service-NRS GTR NE-343

<sup>12</sup> Assumes 80 percent of all afforestation is mixed hardwood.

<sup>13</sup> Includes soil carbon average of 17.93 tonnes per acre per year.

<sup>14</sup> From Table above.



dioxide cap set for Maryland in the RGGI program – up to 0.15 MMtCO<sub>2</sub>e (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 <sub>2</sub> e 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.

#### **1.4. 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<sub>2</sub>e

##### **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<sub>2</sub>e. 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<sub>2e</sub> 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<sub>2</sub>-equivalent.

Assuming three systems installed per year beginning in 2015, the potential displacement of CO<sub>2</sub>-equivalent is displayed in Table C-15.

**Table C-15.** Potential CO<sub>2</sub>-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	
		<b>4.33</b>	<b>MMtCO<sub>2</sub>e</b>	

### **1.5. 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<sub>2</sub>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.

### **1.6. 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<sub>2</sub>e

#### **DNR Quantification**

**Table C-16.** Urban Forest Carbon Calculation.

	<b>Forest Conservation Act and NRA 5-103(h) Tree Planting</b>	<b>TreeMendous Maryland &amp; Marylanders Plant Trees Programs</b>	
Year	Number of Trees Planted	Number of Trees Planted	MMtCO <sub>2</sub> e
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
	<b>12,556,050</b>	<b>317,058</b>	<b>0.16 MMtCO<sub>2</sub>e</b>

**Note:** 2020 estimates reflect values for trees planted in 2020 (if grown to 2021), so trees planted in 2019 will collect 0.0262 MMtCO<sub>2</sub>e 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 <sub>2</sub> e)		
	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	<i>De minimis</i>		

#### 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.

	<b>Forest Conservation Act and NRA 5-103(h) Tree Planting</b>	<b>TreeMendous Maryland &amp; Marylanders Plant Trees Programs</b>		
Planted Year	Number of Trees Planted	Number of Trees Planted	MMtCO <sub>2</sub> e/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	*
	<b>12,556,050</b>	<b>317,058</b>	<b>0.16</b>	

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																		Convert to	TOTAL	TOTAL
Year	Trees Planted	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	TOTAL lbs. C	Metric Tonne	MTCO <sub>2e</sub>	MMTCO <sub>2e</sub>
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	2,986,677	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																		Convert to	TOTAL	TOTAL
Year	Trees Planted	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	TOTAL lbs. C	Metric Tonne	MTCO <sub>2e</sub>	MMTCO <sub>2e</sub>
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	15,920	15,920	15,920	15,920	15,920	15,920	108,120	49	180	0.00018
2008			2,160	582	582	582	1,568	1,568	1,568	1,568	5,677	5,677	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			
	MMTCO <sub>2e</sub> /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<sub>2</sub>e

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<sub>2</sub>e

#### **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<sub>2</sub>e 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<sub>2</sub>e in 2020. MDE estimated an additional 0.21 MMtCO<sub>2</sub>e 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<sub>2</sub>e 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.

<b>BUILDINGS SECTOR</b>		
<b>Program I.D.</b>	<b>Program</b>	<b>Potential GHG Emission Reductions (MMtCO<sub>2</sub>e) Revised for 2015</b>
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<sub>2</sub>e

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.<sup>15</sup> 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.

<sup>15</sup> 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.**

<b>RECYCLING</b>		
<b>Program I.D.</b>	<b>Program</b>	<b>Potential GHG Emission Reductions (MMtCO<sub>2</sub>e) Revised for 2015</b>
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 MMtCO<sub>2</sub>e

#### **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.

<b>MARYLAND'S INNOVATIVE INITIATIVES</b>		
<b>Program I.D.</b>	<b>Programs</b>	<b>Potential GHG Emission Reductions (MMtCO<sub>2</sub>e) Revised for 2015</b>

M	Leadership-By-Example	1.78
N	Maryland's Innovative Initiatives	0.21
O	Future or Developing Programs	0.02
<b>Total</b>		<b>2.01</b>

## **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<sub>2</sub>e.

### **Estimated Greenhouse Gas Emission Reductions in 2020**

**Table C-23.** Summary of Estimated Avoided GHG Emissions in 2020 (MMtCO<sub>2</sub>e).

<b>Emissions Reductions</b>	<b>Enhanced</b>
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
<b>Total</b>	<b>1.45</b>

#### 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](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.

<b>2008 Base Year MMtCO<sub>2</sub>e</b>	<b>25% Reduction</b>	<b>Low Estimate</b>	<b>50% Reduction</b>
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.

County	Base Year	Base Year Emissions		25% Reduction from Base	Reduction Estimate
		Metric tons of CO <sub>2</sub> -equivalent	MMtCO <sub>2</sub> e		
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
					<b>0.45</b>

### 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	Reduction Estimate
		2020	
MMtCO <sub>2</sub> e	0.80	0.6	<b>0.20</b>

#### 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 <sub>2</sub> e)		
	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,<sup>16</sup> 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

<sup>16</sup> 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 <sub>2</sub> e
Fiscal Year	Projects	Certification	Points	2015	2020	2015	2020	2020
2012	66	Silver	33	2,000	3,200	132000	211200	0.21
							<b>Total</b>	<b>0.26</b>

## **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<sub>2</sub>e.

### **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<sub>2</sub>e). 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.<sup>17</sup> 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<sub>2</sub>e).<sup>18</sup>

## 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<sub>2</sub>-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<sub>2</sub>e).

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<sub>2</sub>-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<sub>2</sub>-equivalent (0.821 MMtCO<sub>2</sub>e).

<sup>17</sup> 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>)

<sup>18</sup> 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:

$$GHG_i = \text{Slope} * \text{Year}_i + \text{intercept}$$

Where

$$GHG_i = \text{Baseline GHG emissions projected in year } i$$

The 2020 reductions in Tables 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

$SCP_i$  = 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<sub>2</sub>-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	<b>36,065</b>
Community College of Baltimore County			18,135	18,498	18,868	19,245	21,248	<b>23,460</b>
Coppin State University				3,975	4,055	4,136	4,566	<b>5,041</b>
Frostburg State University	30,299	30,335	30,370	32,388	33,300	34,212	38,775	<b>43,337</b>
Goucher College								<b>11,500</b>
Harford Community College				6,057	6,178	6,302	6,958	<b>7,682</b>
Howard Community	30,045	30,839	34,095	35,710	37,734	39,759	49,883	<b>60,007</b>

College								
McDaniel College				15,259	15,564	15,875	17,528	<b>19,352</b>
Morgan State University					45,753	46,668	51,525	<b>56,888</b>
Mount St. Mary's University	15,621	15,826	16,899	16,734	17,021	17,307	18,740	<b>20,173</b>
Salisbury University	26,696	27,230	27,775	28,330	28,897	29,475	32,542	<b>35,929</b>
St. Mary's College of Maryland	14,289	16,036	21,085	25,937	19,322	20,379	25,701	<b>31,367</b>
Towson University			52,653	53,706	54,780	55,876	61,691	<b>68,112</b>
University of Baltimore				16,220	16,544	16,875	18,632	<b>20,571</b>
University of Maryland, Baltimore				166,307	169,633	173,026	191,034	<b>210,917</b>
University of Maryland, Baltimore County			89,761	90,952	92,143	93,335	99,291	<b>105,246</b>
University of Maryland, Center for Environmental Science				13,399	13,667	13,940	15,391	<b>16,993</b>
University of Maryland, College Park	365,334	370,506	387,967	405,428	422,889	440,350	527,655	<b>614,959</b>
University of Maryland, Eastern Shore					23,207	23,671	26,135	<b>28,855</b>
University of Maryland, University College				22,806	23,262	23,727	26,197	<b>28,924</b>
Washington			15,289	15,595	15,907	16,225	17,914	<b>19,778</b>

**Table C-32.** Schools with Established 2020 GHG Reduction Targets (metric tons of CO<sub>2</sub>-equivalent).

<b>Institution</b>	<b>Assumptions for 2020 Reductions</b>	<b>2020</b>	<b>2020</b>
		<b>Business As Usual Emissions</b>	<b>Reductions</b>
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
<b>TOTAL (metric tons of CO<sub>2</sub>-equivalent)</b>			<b>546,097</b>
<b>Total Emissions Avoided (MMtCO<sub>2</sub>e)</b>			<b>0.546</b>

**Table C-33.** ACUPCC Schools with Estimated 2020 GHG Reductions (metric tons of CO<sub>2</sub>-equivalent).

<b>Institution</b>	<b>Assumptions for 2020 Reductions</b>	<b>2020 Business As Usual Emissions</b>	<b>2020 Reductions</b>
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
<b>TOTAL (mtCO<sub>2</sub>)</b>			<b>565,146</b>
<b>Total Emissions Avoided (MMtCO<sub>2</sub>e)</b>			<b>0.565</b>

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<sub>2e</sub>.

### **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 (MMtCO <sub>2e</sub> )	Scope 3 Emissions (MMtCO <sub>2e</sub> )	Total Employees	Total Facilities	Scope 1&2 Reductions (MMtCO <sub>2e</sub> )	Scope 3 Reductions (MMtCO <sub>2e</sub> )
Advisory Council on Historic Preservation	N/A	N/A	Blank	44.3	36	1	0	0

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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



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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
<b>Totals</b>	<b>690.4</b>	<b>344.8</b>	<b>5,488,921</b>	<b>2,561,118</b>	<b>4,291,579</b>	<b>405,947</b>	<b>1,420,149</b>	<b>213,962</b>

The White House established a 2008 baseline of 68.9 MMtCO<sub>2</sub>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 MMtCO<sub>2</sub>e in 2020.

To obtain the GHG reduction estimate, 1.5/51 of the total federal reductions was assumed, resulting in 0.415 MMtCO<sub>2</sub>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 MMtCO<sub>2</sub>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<sub>2</sub>-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<sub>2</sub>-

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 <sub>2</sub> -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						
							<b>TOTAL</b>	<b>378,753</b>

## **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<sub>2</sub>e.

#### **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<sub>2</sub>-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<sub>2</sub>e.

The Maryland Farmers Market Association ([www.marylandfma.org](http://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<sub>2</sub>e

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:

$$TER_i = VMT_i * PR_i * EF * ER$$

Where

TER<sub>i</sub> = Total GHG emission reduction from PAYD Insurance in year i (million metric tons CO<sub>2</sub>e)

VMT = Relevant VMT (million)

PR<sub>i</sub> = Participation Rate in year i

ER = Effectiveness Rate

EF = Composite CO<sub>2</sub>e 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<sub>2</sub>e

##### **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<sub>2</sub>e. 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.

<b>LAND USE</b>
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<b>Program I.D.</b>	<b>Program</b>	<b>Potential GHG Emission Reductions (MMtCO<sub>2</sub>e) Revised for 2015</b>
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<sub>2</sub>e

### **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.**

<b>PUBLIC</b>		
<b>Program I.D.</b>	<b>Program</b>	<b>Potential GHG Emission Reductions (MMtCO<sub>2</sub>e) Revised for 2015</b>
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<sub>2</sub>e.

#### **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<sub>2</sub>e reduction is calculated to illustrate GHG reductions potential as participation in the programs increase.

**Table C-38.** High Range GHG Benefits (MMtCO<sub>2</sub>e).

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 (MMtCO<sub>2</sub>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 MMtCO<sub>2</sub>e emissions avoided.

**Table C-40.** Bike to Work Benefits.

Year	People	GHG emissions avoided (pounds)	GHG emissions avoided (Metric Tons)	GHG emissions avoided (MMtCO <sub>2</sub> 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

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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