

The 2015 Greenhouse Gas Emissions Reduction Act Plan Update

The Maryland Department of the Environment

October 2015

The 2015 Greenhouse Gas Emissions Reduction Act of 2009
(GGRA) Plan Update

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Executive Summary

Background

The Greenhouse Gas Emissions Reduction Act of 2009 and the 2012 Plan

In 2009 the Greenhouse Gas Emissions Reduction Act (GGRA) was signed into law. The GGRA requires the State to achieve a minimum 25 percent reduction in Statewide greenhouse gas (GHG) emissions from 2006 levels by 2020. The State was also required to demonstrate that the reduction goal could be achieved in a way that has a positive impact on Maryland's economy, protects existing manufacturing jobs and creates significant new jobs in Maryland.

To achieve this goal, the GGRA required the Maryland Department of the Environment (MDE) to develop a proposed Statewide GHG reduction plan, to solicit public comment on the proposed plan from interested stakeholders and the public, and to adopt a final plan by 2012.

To achieve a 25 percent reduction in Maryland's GHG emissions from 2006 levels by 2020 while fostering a healthy economy and creating new jobs, the State developed a comprehensive, multi-sector, multi-agency plan with input from more than a dozen state agencies and non-governmental organizations. The *2012 GGRA Plan* lays out a blueprint which, when fully implemented, will achieve the 25 percent GHG reduction required by the GGRA, with positive job and other economic benefits. The *2015 GGRA Plan Update* will also provide additional environmental benefits by helping the State restore the Chesapeake Bay, improve air quality, and preserve agricultural and forest lands.

The 2015 GGRA Plan Update

The GGRA requires MDE to submit an updated report to the Governor and General Assembly by October 1, 2015. This report updates the information contained within the *2012 GGRA Plan*. The *2015 GGRA Plan Update* summarizes the State's progress toward achieving the 2020 emissions reduction goal established by the GGRA and shows that Maryland is on target to not only meet, but to exceed the emission reduction goal of 34.66 MMtCO₂e by generating 38.37 MMtCO₂e of reductions. The reduction programs outlined in the *2015 GGRA Plan Update* have worked well, but changes in the energy market and travel behavior have also helped Maryland achieve the goals of the GGRA. While this is a positive first step to combating climate change in Maryland, efforts to continue the progress will be needed because scientific consensus is that worldwide GHG reductions as high as 72 percent by 2050, or earlier, are needed to minimize the impacts of climate change. As discussed in Chapter 2, Maryland is already experiencing loss of land from sea level rise, which has risen over one foot in the last 100 years. Maryland has also experienced floods, heavy rains, heat, and strong winds over the past three years, which have led to millions of dollars in property losses and the loss of human life.

Maryland Commission on Climate Change

On May 12, 2015 the Maryland Climate Change Commission Act of 2015 was signed into law. MDE has worked with the Maryland Commission on Climate Change (MCCC) on the *2015 GGRA Plan Update* and will continue to work through the Commission on both implementation of the *2012 GGRA Plan* through 2020 and any beyond 2020 efforts to continue to address climate change.

The Commission is chaired by MDE Secretary Ben Grumbles and is supported by four working groups who all assisted in the development of the *2015 GGRA Plan Update*. The MCCC Greenhouse Gas Mitigation Working Group (MWG) focuses on regulatory, market-based and voluntary programs to reduce GHG emissions while supporting economic development and job creation. The Adaptation and Response Working Group (ARWG) is charged with developing a comprehensive strategy for reducing Maryland's climate change vulnerability through both short- and long-term measures that State and local governments may use to plan for and adapt to a rise in sea levels due to climate change. The Scientific and Technical Working Group (STWG) has prepared much of the material in this report on the science of climate change. The Education, Communication and Outreach Working Group (ECO) assisted with the public outreach and public meetings on climate change. All of the Workgroups have provided valuable input on the *2015 GGRA Plan Update*.

Status of the 2012 GGRA Plan – Are We Meeting 2020 Goals?

Maryland Jobs and the Economy

The *2015 GGRA Plan Update* will support new industry and will accelerate investments in green technologies in Maryland by encouraging investments in the energy, transportation, and land use sectors of our economy. Implementing the *2015 GGRA Plan Update* will lead to increased investments in energy efficiency, green buildings, renewable energy and low emission vehicles. Investing in Maryland's green economy now will encourage smarter investments and support more sustainable economic growth for generations to come. Current analyses project that the *2012 GGRA Plan* will result in estimated economic benefits of between \$2.5 billion and \$3.5 billion in increased economic output by 2020 and help create and maintain between 26,000 and 33,000 new jobs.

Updated Estimates of 2020 GHG Emission Reductions

The *2015 GGRA Plan Update* summarizes the various strategies, programs and initiatives that the State is developing and employing to meet the GGRA's emission reduction and economic benefits goals. The State is already implementing the *2015 GGRA Plan Update* and as implementation continues, there may be opportunities to enhance emission reductions and economic and job creation benefits through additional legislative, budgetary or regulatory action.

The suite of programs have been updated for 2015 to include revised benefits from program enhancements to date, refined estimated emissions reductions, revised estimated economic and job benefits, summaries of progress including current implementation efforts and where applicable, recommendations for enhancements by the lead implementing agency.

Through the process used to develop the *2015 GGRA Plan Update*, the 25 percent reduction in Statewide GHG emissions from 2006 levels by 2020 goal of the GGRA was calculated to be 34.66 MMtCO₂e. The combined emissions reductions of all programs in the *2015 GGRA Plan Update* are projected to yield a total of 38.37 MMtCO₂e in emissions reductions. This will exceed the GGRA 2020 goal by 3.71 MMtCO₂e. Figure ES-1 illustrates the *2015 GGRA Plan Update*'s emissions reductions in a dashboard format grouped by sector.

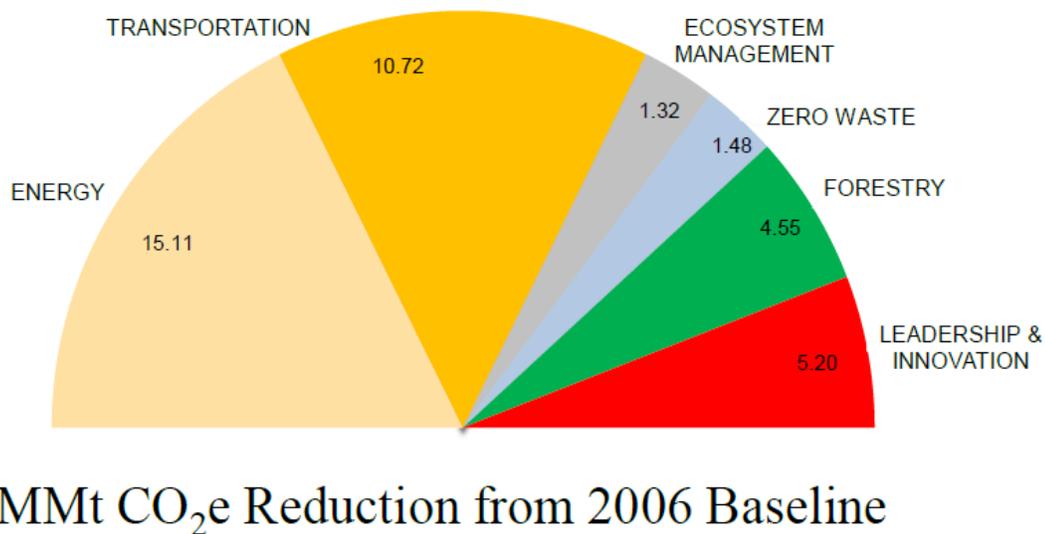


Figure ES-1. GHG Emission Reduction Dashboard.

Table ES-1, provides a more detailed summary of the GHG emissions reductions associated with the major program groups contained in the *2015 GGRA Plan Update* and how those reductions are projected to meet the requirements of the law. It includes refined estimates of emission reductions for each program and updates to projected GHG emissions growth through 2020.

Table ES-1. GHG Reductions by Major Program Groups.

Program	Projected 2020 GHG Emission Reductions (MMtCO ₂ e) Revised for 2015
EmPOWER Maryland	7.24

The Maryland Renewable Energy Portfolio Standard (RPS)	4.13
The Regional Greenhouse Gas Initiative (RGGI)	3.60
Other Energy Programs	0.14
Transportation Technologies	6.88
Public Transportation	1.85
Pricing Initiatives	1.99
Other Innovative Transportation Strategies/Programs	Included in F
Forestry and Sequestration	4.55
Ecosystems Markets	0.68
Building and Trade Codes in Maryland	3.15
Zero Waste	1.48
Leadership-By-Example	1.78
Maryland's Innovative Initiatives	0.21
Future or Developing Programs	0.02
Land Use Programs	0.64
Outreach and Public Education	0.03
Total Reductions	38.37
GGRA 2020 Emission Reduction Goal	34.66
Meeting the 2020 Goal?	Yes. 3.71 MMtCO₂e above required reductions.

The Public Review/Comment Process

The ECO Working Group of the MCCC held a series of five public meetings across Maryland between July and August of 2015. The purpose of these meetings was to inform the public of the mission and actions of the MCCC, the purpose of the GGRA and the content of the *2015 GGRA Plan Update*, and to take public comment on relevant issues of concern regarding climate change in Maryland.

Time was allotted during each meeting for attendees to address members of the MCCC with comments, and written comments were collected at the conclusion of each meeting. While these comments addressed a wide range of topics related to climate change, comments addressing the dangers of climate change and Maryland's vulnerability, the Cove Point natural gas facility, hydraulic fracturing in Maryland, amending Maryland's Renewable Portfolio Standard (RPS) and the renewal of the GGRA occurred with the greatest frequency.

Beyond 2020

An Update on the Science of Climate Change

The *2015 GGRA Plan Update* includes an update from the MCCC's STWG on how climate change is already impacting Maryland and what additional future GHG reductions need to be considered to continue the State's progress in reducing GHG emissions.

MDE Recommendations on Continuing Progress

The GGRA requires MDE to provide recommendations in the *2015 GGRA Plan Update* on how the State should move forward on climate change. The law requires the General Assembly to take an action in 2016 or the requirements of the GGRA sunset. The *2015 GGRA Plan Update* is intended to provide the General Assembly with the information they need to determine how the State should move forward. MDE's recommendations include the following:

- Continue to implement and enhance the programs in the *2012 GGRA Plan* with a increased focus on finding ways to continue emission reductions that also support economic development and job creation.
 - Work through the MCCC and the Workgroups to develop these enhancements where appropriate.
- Move beyond 2020 by adopting a “next step” of incremental progress towards the deeper reductions needed by 2050. This next step should also increase the emphasis on improving Maryland's economy by establishing quantitative goals for economic growth, job creation and wages linked to the GHG reduction efforts.
- Continue efforts to analyze issues linked to continuing the progress the State has made in reducing GHGs that have been identified by MDE over the past ten years, the MCCC Workgroups and stakeholders. These emerging issues include:
 - Enhanced efforts on renewable energy, energy efficiency and transportation that seek to further reduce emissions in a way that fosters economic development, creates new jobs and protects consumers
 - Continuing analyses of new scientific and technical issues like life-cycle analysis, hydraulic fracturing and other natural gas related topics, fast acting climate changers, and other emerging issues related to the science and mitigation of climate change.
- Increase the emphasis on adaptation, resilience and preparedness.

Chapter 1: Background and the Science of Climate Change in Maryland

Frequently Used Abbreviations and Acronyms

CO₂-equivalent: Carbon Dioxide Equivalent

GGRA: Greenhouse Gas Emissions Reduction Act

GHG: Greenhouse Gas

MDE: Maryland Department of the Environment

Background

The Greenhouse Gas Emissions Reduction Act of 2009

In 2009 the Greenhouse Gas Emissions Reduction Act (GGRA) was signed into law. The GGRA requires the State to achieve a minimum 25 percent reduction in Statewide greenhouse gas (GHG) emissions from 2006 levels by 2020. This reduction goal evolved from the Maryland Commission on Climate Change's Climate Action Plan, which was released in August 2008. To achieve this goal, the GGRA required the Maryland Department of the Environment (MDE) to develop a proposed Statewide GHG reduction plan by 2011, to solicit public comment on the proposed plan from interested stakeholders and the public, and to adopt a final plan by 2012. The State was also required to demonstrate that the reduction goal could be achieved in a way that has a positive impact on Maryland's economy, protects existing manufacturing jobs and creates significant new "green" jobs in Maryland. The GGRA can be read in its entirety in Appendix A.

The requirements and content of the GGRA are summarized in Figure 1-1 below:

By 2020, Maryland must reduce statewide GHG emissions by 25 percent from 2006 levels.
By 2011, MDE must develop a Statewide GHG emissions inventory, a "business as usual" emissions projection for 2020 and a proposed GHG emission reduction plan for public comment.
By 2012, Maryland must adopt a final GHG emission reduction plan that includes regulations and a timeline to implement necessary programs. The plan must ensure: <ul style="list-style-type: none">• No loss of manufacturing existing jobs;• A net increase in jobs and a net economic benefit, opportunities for new green jobs in energy and low carbon technology fields, and no adverse impact on the reliability and affordability of electricity and fuel supplies;

<ul style="list-style-type: none"> • Preservation of authority to regulate the manufacturing sector through the expansion of RGGI and, in the absence of a federal program, defers other Maryland regulation of the manufacturing sector until after a 2016 legislative review.
By 2015, an independent study of the economic impact of requiring GHG emission reductions from manufacturing due to the Governor and General Assembly.
In 2015, a report to the Governor and General Assembly assessing the progress toward the 25 percent emissions reduction, benefits to the State’s economy, public health, and the environment, any need for further reductions, and the status of any federal GHG reduction program.
In 2016, the Legislature will review the progress report, the report on economic impacts on the manufacturing sector, the requirements of a federal program, and other information and determine whether to continue, adjust, or eliminate the requirement to achieve a 25 percent reduction by 2020.

Figure 1-1. GGRA Requirements.

The 2012 GGRA Plan

To achieve a 25 percent reduction in Maryland’s GHG emissions from 2006 levels by 2020, the State developed a comprehensive, multi-sector, multi-agency plan with assistance from more than a dozen state agencies and non-governmental organizations. Using Maryland’s 2008 Climate Action Plan as a roadmap, the *2012 GGRA Plan* lays out a blueprint, which if fully implemented, could achieve the 25 percent GHG reduction required by the GGRA, with positive job and other economic benefits. Through implementation, additional environmental benefits could also be achieved through advances in efforts to restore the Chesapeake Bay, improve the State’s air quality, and preserve Maryland’s agricultural and forest lands.

The 2015 GGRA Plan Update

The GGRA requires MDE to submit an updated report to the Governor and General Assembly by October 1, 2015. This report (the *2015 GGRA Plan Update*) updates the information contained within the *2012 GGRA Plan*. The *2015 GGRA Plan Update* is an appropriate appellation, as this report is intended to only provide an update on the contents of the *2012 GGRA Plan*. In considering the impacts of climate change and Maryland’s response as a whole, there is still much work that needs to be done. The programs outlined in the *2015 GGRA Plan Update* can still be modified and improved, and adjustments to the entire plan can still be made if needed.

The *2015 GGRA Plan Update* summarizes the State’s progress toward achieving the 2020 emissions reduction goal established by the GGRA. It also provides a review of the best available science regarding the level and pace of GHG emissions reductions and sequestration needed (Chapter 1), and an update on emerging technologies to reduce GHG emissions (Chapter 7). In reviewing the suite of programs described in Chapter 5, MDE has made recommendations on the need for adjustments to the requirement to reduce statewide GHG emissions by 25 percent

by 2020 (34.66 MMtCO₂e), and has summarized any additional revised regulations/control programs/incentives that are necessary to achieve that goal.

An analysis of the overall economic costs and benefits to the State's economy, environment, and public health of a continuation or modification of the requirements to achieve a 25 percent reduction by 2020 is also required by the GGRA. MDE contracted with RESI to assess, via modeling, the economic effects of various climate action policies and/or programs in development or already enacted by a number of state agencies in Maryland. These policies/programs are being developed or have already been enacted by various state agencies in order to meet the target GHG emission reductions required by the GGRA. This analysis updates the economic and jobs impacts from each program identified in the *2012 GGRA Plan* and can be found in its entirety in Appendix K.

The GGRA also requires an independent study conducted by an institution of higher education in the State to determine the impact of requiring GHG emissions reductions from the State's manufacturing sector. MDE contracted with RESI to assess the impacts of the programs described in the *2012 GGRA Plan* on Maryland's manufacturing sector, a summary of which can be found in Chapter 8. The study can be found in its entirety in Appendix I.

Additionally, the GGRA requires that MDE report on the state of any federal program designed to reduce GHG emissions, an analysis of which can be found in Chapter 9.

The Science of Climate Change in Maryland

Science has demonstrated with a high degree of certainty that Earth's climate is being changed by human activities, particularly the emission of heat-trapping gases, generally called greenhouse gases, including carbon dioxide, methane, and nitrous oxide. Science has also provided a reliable description of (1) how further emissions will warm the Earth, (2) how this will alter the climate and have consequences for human society and the natural systems on which it depends, and (3) the amount and timing of reductions in emissions needed to limit climate change in order to avoid its most harmful consequences.

A comprehensive report on the Science of Climate Change can be found in appendix L.

Maryland's **Greenhouse Gas Reductions Act of 2009** requires the State to reduce Statewide greenhouse gas emissions by 25% from 2006 levels by 2020. The Act further directs the Maryland Department of the Environment to report on "the greenhouse gas emissions reductions needed by 2050 in order to avoid dangerous anthropogenic changes to the Earth's climate system, based on the predominant view of the scientific community" on or before 2020.

The **Maryland Climate Change Commission**, established by Executive Order in 2007, was responsible for laying the groundwork for the Greenhouse Gas Reduction Act by developing a Climate Action Plan in 2008. During the 2015 Session the Maryland General Assembly passed House Bill 514, which codified the Maryland Climate Change Commission. House Bill 514 was

signed into law by Governor Hogan and became effective on June 1, 2015. Among the actions the Commission is charged to undertake include “maintaining a comprehensive action plan, with 5-year benchmarks, to achieve science-based reductions in Maryland’s greenhouse gas emissions.”

Climate Impacts to Maryland

- Maryland will be significantly impacted by changes to the global climate. With thousands of miles of shoreline and a vast and vital resource in the Chesapeake Bay any increases in temperature will have large impacts that reshape our State.
- Realized warming for Maryland will differ from any global averages; in fact, because of our relatively high latitude, it is very likely to be greater.
- Warming in Maryland will be controlled by global emission and not Maryland’s own emissions. Of course, Maryland contributes only a small part of annual global greenhouse gas emissions.
- A full assessment of the impacts to Maryland from climate change can be found in the 2008 Climate Action Plan developed by Maryland at: <http://www.mde.state.md.us/programs/Air/ClimateChange/Pages/Air/climatechange/legislation/index.aspx>. Impacts include changes to temperatures, heat waves, Chesapeake Bay temperatures, precipitation, soils moisture and agriculture, water supply and quality, and coastal vulnerability.

Chapter 2: Climate Change and the Cost of Inaction in Maryland

Frequently Used Abbreviations and Acronyms

NCA: National Climate Assessment

The earth is warming and this is largely the result of human-caused emissions. The [National Climate Assessment](#) (NCA) found that U.S. average temperature has increased by about 1.5°F since 1895 with 80 percent of this increase occurring since 1980. Similarly, the Intergovernmental Panel on Climate Change Fifth Assessment Working Group 1 report (IPCC AR5 WG1), *Climate Change 2013: The Physical Science Basis* came to many of the same conclusions as the NCA, but with a global focus.

The amount of warming that will occur by the end of this century depends on our choices now. If we don't make much progress in curbing emissions, temperatures for the planet could rise between 4.7°F to 8.6°F (2.6°C to 4.8°C) by the end of this century, compared to the average temperature around the end of the 20th century (1986-2005).¹ Warming in the United States is expected to be higher than the global average. Warming averaged across the country could be between 5°F to 10°F, assuming emissions rates continue. Average summer temperatures in Maryland could increase around 9°F by the end of the century, if little is done to reduce emissions.²

Although we have the opportunity to avoid some of this warming, we are still likely to face [a number of impacts](#) arising from climate change in the coming decades. In fact, we are already observing some of these impacts now.

- **Sea level rise** – Sea level has risen about 8 inches in the last 100 years, making coastal storms more damaging and accelerating erosion. Globally, future sea level rise is [likely to range from 1 to 4 feet](#), and could be even higher if glaciers in Greenland or Antarctica melt especially quickly.
- **Polar ice** – [Arctic sea ice during the summer has been shrinking](#), and sometime in the 21st century, perhaps within the next few decades, the Arctic will likely be ice-free in the summer. The ice sheets in Greenland and Antarctica have also been melting more rapidly in recent years, which could increase the rate of global sea level rise.

¹ Intergovernmental Panel on Climate Change, "Climate Change 2013: The Physical Science Basis." Accessed July 15, 2015. Available at: <http://www.ipcc.ch/report/ar5/wg1/>.

² Houser, Trevor et al., "American Climate Prospectus: Economic Risks in the United States." Rhodium Group. June 24, 2014. Available at: <http://rhg.com/reports/climate-prospectus>.

- **More heavy downpours** – More rain is coming in [heavy precipitation events](#) in many parts of the world, including the United States. This may contribute to stronger or more frequent floods.
- **More heat waves** – [Heat waves](#) have become more frequent and intense, threatening human health, stressing water resources, and increasing energy demands.
- **Threats to ecosystems** – [Many plants and animals will be forced to shift their habitats](#) to higher elevations or higher latitudes as warming makes it more difficult to thrive in their current locations.
- **Increased agricultural pests** – With milder winters, many [pests and pathogens that affect plants and livestock have been able to migrate to new areas](#), posing problems to farmers and ranchers.
- **Ocean acidification** – Increased carbon dioxide in the atmosphere has caused [the oceans to become more acidic](#). Further acidification could dissolve the shells of many organisms at the bottom of the food chain, threatening to disrupt the ocean ecosystem.

These impacts pose challenges to infrastructure, businesses, and communities, particularly in countries already struggling to meet the basic food, water, shelter, and security needs of their citizens.

The state of Maryland is presently experiencing some of these types of impacts, which are expected to become more intense and occur more frequently as a result of climate change. No one individual weather event can be attributed directly to climate change; climate is a pattern of events over time. However, it is clear that the costs to property, crops, public health and human life from impacts consistent with climate change are significant (Table 2-1).³

³ National Climatic Data Center, “Storm Events Database.” March 2015. Available at: <http://www.ncdc.noaa.gov/stormevents/>.

Table 2-1. Maryland Impacts from Weather-Related Events, 2012 – 2014.

Date	Event(s)	Damage(s)	Jurisdiction(s)	Comment
Aug 12, 2014	Flash floods from heavy rains	\$4.835M in property damage	Prince George's, Anne Arundel	
Jun – Sep 2014	Rip currents	5 fatalities	Maryland beaches	
Jul 8, 2014	Thunderstorm winds	1 fatality, minor crop damage	Carroll	Tree branches fell at youth campsite
Jul 18, 2013	Heat	4 fatalities	Southern Baltimore, Howard	Heat indices above 105°F, Dew points in the mid-70s
Jan 31, 2013	Flash floods from heavy rains	1 fatality	Anne Arundel	
2013	Flash flood, High Wind, Tornado, Thunderstorm wind, Winter storm, Lightning, Strong wind	\$358.5K in property damage	Statewide	19 counties
Jul 5, 2012	Excessive heat	3 fatalities	Southern Baltimore	Heat indices as high as 112°F
Jul 8, 2012	Heat	1 fatality	Southern Baltimore	Heat indices above 105°F
Oct 28 – 30, 2012	Coastal flood, flood, Strong wind, High wind	\$15.55M in property damage	Caroline, Cecil, Dorchester, Kent, Maryland Beaches, Somerset, Queen Anne's, Talbot, Wicomico, Worcester	Hurricane Sandy
Jun 29, 2012	Thunderstorm wind, Hail	\$1.79M in property damage	Statewide	Derecho
2012	Thunderstorm wind, Tornado (EF1, EF0), Coastal flood, Flash flood, Lightning, Strong wind	\$3.504M in property damage	Statewide	Exclusive of Sandy and Derecho

Source: National Climatic Data Center Storm Events Database

The costs from these recent weather-related events and the scientific assessments remind us of the need to take action to reduce risks from extreme weather related events.

Chapter 3: Adaptation

Frequently Used Abbreviations and Acronyms

ARWG: Adaptation and Response Working Group

CO₂: Carbon Dioxide

DHCD: Maryland Department of Housing and Community Development

DHMH: Maryland Department of Health and Mental Hygiene

DNR: Maryland Department of Natural Resources

EPA: U.S. Environmental Protection Agency

FEMA: Federal Emergency Management Administration

GGRA: Greenhouse Gas Emissions Reduction Act

GHG: Greenhouse Gas

IPAC: Invasive Plant Advisory Committee

MAA: Maryland Aviation Administration

MCCC: Maryland Commission on Climate Change

MDA: Maryland Department of Agriculture

MDE: Maryland Department of the Environment

MDOT: Maryland Department of Transportation

MDP: Maryland Department of Planning

MDTA: Maryland Transportation Administration

MEMA: Maryland Emergency Management Agency

MHT: Maryland Historical Trust

MIA: Maryland Insurance Administration

MPA: Maryland Port Administration

NFIP: National Flood Insurance Program

SDROP: State Disaster Recovery Operations Plan

SHA: Maryland State Highway Administration

TEA: Targeted Ecological Area

UTC: Urban Tree Canopy

Introduction

Climate change will affect Maryland in a variety of ways. More obvious impacts could include an increased risk for extreme events such as drought, storms, flooding, and forest fires; more heat-related stress; the spread of existing or new vector-borne disease; and increased erosion and inundation of low-lying areas along the State's shoreline and coast. In many cases, Maryland is already experiencing these problems to some degree today. Climate change raises the stakes in managing these problems by changing the frequency, intensity, extent, and magnitude of these problems.

Even as the State moves forward with actions that will reduce GHGs and ultimately result in increased energy efficiency, a more sustainable economy, and cleaner air; climate impacts will still be felt into the future. Therefore, adaptation, together with mitigation, is necessary to address climate change. It is noted, however, that these actions are by no means independent of each other and any program or policy to mitigate the effects of climate change will complement steps to reduce the state's risk to climate impacts.

Climate change adaptation is an extremely complex process and there is no single means of response. As stressed in a recent report by the National Academies⁴, climate change adaptation must be a highly integrated process that occurs on a continuum, across all levels of government, involving many internal and external partners and individual actions, and often evolves at different spatial and temporal scales. That said, the State is already taking steps to enhance the resilience of a broad spectrum of natural and human-based systems to the consequences of climate change.

Background

Maryland's Climate Action Plan includes two climate change adaptation strategies that are currently being used to guide state-level adaptation planning efforts. The first strategy (Phase I), released in 2008, addresses the impacts associated with sea level rise and coastal storms. The second strategy (Phase II), released in 2011 as a compendium to the Climate Action Plan, addresses changes in precipitation patterns and increased temperature and the likely impacts to human health, agriculture, forest and terrestrial ecosystems, bay and aquatic environments, water resources, and population growth and infrastructure. Together, the strategies are the product of the work of more than 100 experts from the governmental, nonprofit, and private sectors that held a series of meetings for the purpose of interpreting the most recent climate change literature, evaluating adaptation options, and recommending strategies to reduce Maryland's overall climate change vulnerability.

⁴ National Research Council. 2010. Adapting to the Impacts of Climate Change. National Academies Press, Washington, DC

The strategies provide the basis for guiding and prioritizing state-level activities with respect to both climate science and adaptation policy over the near and longer terms.

Between 2008 – 2015, the State as a whole made substantial progress to implement high-priority elements of Maryland’s Phase I and II Adaptation Strategies. Chapter 8 of the *2012 GGRA Plan*, the [Adaptation Update](#), provided detailed information on state agency implementation efforts to date, along with short, medium and long-term priorities for future action. Summaries of a selection of high priority Phase I and II adaptation strategies, including current and planned near-term implementation efforts are outlined below.

Adaptation Strategy Implementation Update (2008-2015)

Leading by Example

Maryland Department of Natural Resources (DNR)

Initiative: “Lead by Example” Policy: Building Resilience to Climate Change

Description: The DNR has the lead role among state agencies in advancing the scientific understanding of Maryland’s vulnerability to climate change, and advocating for sound planning to avoid or minimize the anticipated impacts. In October 2010, the DNR issued a new policy to direct its investments in and management of land, resources, and assets so as to better understand, mitigate and adapt to climate change. The policy establishes practices and procedures related to new land investments, facility siting and design, habitat restoration, government operations, research and monitoring, and resource planning. The goal of the policy is to lead by example; and along the way, encourage and educate others in the methods for managing natural resources and designing facilities with an understanding of the effects of climate change.

Sea Level Rise and Coastal Storms

Background

The Chesapeake Bay region’s geography and geology make the state one of the three most vulnerable areas of the country to changes resulting from sea level rise – only Louisiana and Southern Florida are more susceptible. Historic tide records show sea level has increased approximately one foot in the Chesapeake Bay over the last 100 years. Estimates provided by the Scientific and Technical Workgroup of the Maryland Commission on Climate Change indicate that Maryland is projected to experience between 2.7 to 3.4 feet of sea level rise over the next century.

The Phase I Strategy, produced by the Maryland Commission on Climate Change's Adaptation and Response Working Group, detailed the actions necessary to protect Maryland's future economic well-being, environmental heritage, and public safety in the face of climate change and sea level rise.

Implementation Status

In 2008, Maryland passed two pieces of key legislation called for in the Strategy: The Living Shoreline Protection Act and amendments to the Chesapeake and Coastal Bays Critical Area Act. Both will reduce Maryland's vulnerability over time and protect natural resources from the impacts of sea level rise by restoring natural shoreline buffers, such as grasses and wetlands, helping to limit new growth in vulnerable areas. In addition to these two pieces of legislation, a variety of other projects designed to implement the Strategy have been completed or are currently underway.

State of Maryland

Initiative/Action: Climate Change and Coast Smart Construction Executive Order

Description: On December 27, 2012, the Climate Change and Coast Smart Construction Executive Order (EO) was signed, enacting a number of policy directives, including directing all State agencies to consider the risk of coastal flooding and sea level rise when they design capital budget projects and charging the Department of General Services with updating its architecture and engineering guidelines to require new and rebuilt State structures be elevated two or more feet above the 100-year base flood level.

The EO also charges the Maryland Department of Natural Resources to work with the Maryland Commission on Climate Change, local governments and other parties as appropriate, to develop additional Coast Smart guidelines within nine months, for the siting and construction of new and rebuilt State structures, as well as other infrastructure improvements such as roads, bridges, sewer and water systems, and other essential public utilities. Recommendations for applying the new construction guidelines to non-state infrastructure projects that are partially or fully funded in the State's capital budget were also developed.

Additionally, the EO requested that the Critical Area Commission for the Chesapeake and Atlantic Coastal Bays evaluate existing regulations and policies for State Agency Actions Resulting in Development on State-Owned Lands and consider the adoption of new or revised provisions that address climate change and the risk of sea level rise and other extreme weather-related impacts.

Lastly, the EO tasked the Scientific and Technical Working Group of the Maryland Commission on Climate Change with providing updated sea level rise projections for Maryland. In 2008, the Scientific and Technical Working Group published sea level rise projections for Maryland, with a high-end range of 3.4 feet by the year 2100. However, considerable new research on sea level rise has since been published requiring the updating of these projections. Updated sea level rise projections were published by the Scientific and Technical Working Group in June 2013 (<http://www.umces.edu/sites/default/files/pdfs/SeaLevelRiseProjections.pdf>). A best estimate of 3.7 feet by 2100 was developed, with a low of 2.1 feet and a high of 5.7 feet.

Department of Natural Resources (DNR)

Initiative/Action: Local Government Technical and Financial Assistance: *Coast Smart Communities*

Description: DNR's Coast-Smart Communities Program supports local level implementation of the adaptation strategy. Under CoastSmart, the DNR administers a competitive grant program to provide financial and technical assistance to local governments looking to reduce their vulnerability to the effects of coastal hazards and sea level rise through planning and permitting activities. Grants of up to \$75,000, drawn from the state's federal Coastal Zone Management Act funds, are awarded on an annual basis and may be renewed for up to three additional years. In coordination with the Coastal Training Program, a training curriculum for local planners and officials is available to complement and inform available technical assistance. Further, CoastSmart developed a self-assessment tool to guide local communities in their understanding of current and future risk and opportunities for increasing resiliency. Attendance of trainings and completion of a Scorecard Self-Assessment exercise will allow for improved targeting of grants. All activities within the CoastSmart Program aim to foster knowledge exchange on coastal hazards among local communities to help integrate hazards planning into a wide range of existing planning processes.

Initiative/Action: Adaptation Toolbox: The Coastal Atlas

Description: Maryland is using the latest technology, and detailed information to undertake state-of-the-art sea level rise mapping and research. Results acquired by both the DNR and individual Maryland counties is housed on the *Coastal Atlas* (<http://dnr2.maryland.gov/ccs/Pages/coastalatl原因.aspx#>), an online toolbox of resources available to assist local governments with becoming ready, adaptive, and resilient to the impacts of sea level rise and coastal storms. Data products and technical tools currently available on the *Coastal Atlas* include: statewide sea level rise vulnerability mapping, historic shoreline position and erosion rate calculations, and the Erosion Vulnerability Assessment Tool. The Coastal Atlas mapping application will be continuously updated as new data becomes available or as updates to existing data are made.

Initiative/Action: Sustainable Shoreline and Buffer Area Management

Description: Through the Shoreline Conservation Services and its Natural Filters Program, DNR is working to implement buffer reforestation, wetland restoration, and shoreline practices to enhance ecosystem resilience to the impacts of climate change. Practices include on-the-ground habitat restoration projects such as stream and shoreline buffer plantings, stream-floodplain reconnection, marsh hydrology restoration, and living shorelines. DNR Staff provide various technical assistance (site visits and evaluations, problem assessments and recommended solutions) for different stakeholders (private citizens, local government, non-profit organizations, state and federal agencies). All of these practices increase ecosystem resiliency by improving water quality, reducing erosion, and enhancing habitat condition and connectivity. Due to the fact that most living shoreline projects involve a channelward encroachment with sand fill, these shoreline restoration techniques provide space for potential marsh migration.

Initiative/Action: Maryland Coastal Resiliency Assessment

Description: The DNR partnered with The Nature Conservancy in 2015 to conduct a "Statewide Coastal Resiliency Assessment." The Assessment will evaluate the risk reduction value of natural infrastructure, assess coastal community vulnerability to coastal hazards, and identify priority conservation areas that currently provide risk-reduction benefits to vulnerable human communities. The Assessment will also identify priority restoration areas or opportunities where natural features could provide future risk reduction benefits. The Assessment considers a wide range of natural features such as tidal wetlands and marshes, vegetated buffers, oyster reefs, submerged aquatic vegetation, Bay islands, beaches, and dunes. These features buffer coastal communities from the impacts of coastal hazards through wave attenuation, infiltration, sediment stabilization, and other risk-reduction benefits. The purpose of this project is to establish state priorities for natural infrastructure solutions within tidal regions of the coastal zone. The priorities established through this project will be integrated into Maryland's "Blue Infrastructure" framework and a parcel-level scorecard used to review land acquisition projects. Following completion in 2016, trainings will be held with state land managers, conservation planners, restoration specialists, and local partners to share the Assessment datasets and integrate results into current land conservation and restoration targeting efforts.

Maryland Department of Transportation (MDOT)

The MDOT is working to assess Maryland's critical transportation facilities and systems' vulnerability to projected sea level rise and extreme weather damage. This assessment provides the information necessary to evaluate options for dealing with potential impacts to infrastructure and connectivity, as well as aid in the development of adaptation policies for existing and planned transportation facilities. The assessment will ultimately influence long-term strategic planning for system adaptation that can account for the uncertainty of future climactic conditions.

Initiative/Action: Maryland State Highway Administration (SHA) Transportation Vulnerability Assessment

Description: Among Maryland agencies, SHA has the largest and most geographically dispersed network of facilities requiring the most complex long-term action plan. SHA is studying the effects of severe weather and climate change to the infrastructure on the highway system. SHA with Maryland Transportation Administration (MDTA) developed a climate change adaptation strategy and implementation plan to address severe weather and climate change impacts to the state maintained highway network. This plan provides a foundation for strategies and priorities actions by near-, mid-, and long-term actions. In order to implement the strategies, SHA needs more specific information on vulnerable assets. SHA completed the FHWA funded 18-month pilot project for the Climate Adaptation and Vulnerability Framework. The study was completed in October 2014 and includes a detailed Vulnerability Assessment for two pilot counties (Anne Arundel & Somerset). SHA continues to develop vulnerability assessments that utilize tools from the pilot study to further analyze additional counties vulnerable to intense storms or sea-level rise. The vulnerability assessments are very detailed and require time to develop. Completion of a vulnerability assessment for all tidal counties is anticipated in 2017.

Initiative/Action: Maryland Port Administration (MPA) Climate Change Vulnerability Assessment and Recommendations

Description: As a component of the overall Maryland Transportation Initiative described above, the Maryland Port Administration prepared the report, “Climate Change Vulnerability Assessment and Recommendations” in 2010. The report provides recommendations for future capital investments based on the findings of the vulnerability assessment, and identifies the need for the MPA to make infrastructure and facility improvement decisions that consider climate change and sea level rise. In response, the MPA implemented a policy of migrating facilities out of the flood plain if possible, or elevating in place if relocation is not possible, or mitigating for saltwater inundation if the facility cannot be relocated or elevated for operational reasons (i.e. build stronger to withstand wave action, and with corrosion resistant material, etc.). As the MPA reviews its Dredged Material Management Plan and Marine Terminal Development Plans, it plans to factor sea level rise and potential storm surge inundation into its evaluation of proposed projects. Additionally, the MPA works with its partners in the Maryland and Federal Dredge Material Management Programs to incorporate climate change vulnerability analysis into decision-making processes.

Initiative/Action: Maryland Transit Administration (MTA) Climate Change Vulnerability Assessment

Description: The MTA Climate Change Vulnerability Assessment is being developed in response to Maryland’s Climate Action Plan, produced by the Maryland Climate Change Commission, and to the Climate Change and Coast Smart Construction Executive Order (2012) as well as MTA’s climate change policy. The purpose of the study is to identify MTA assets that are vulnerable to three expected results of global climate change: sea level rise; storm surge; and flooding due to major rain events.

MTA has completed the vulnerability mapping and are currently underway with the risk assessment. The risk assessment, scheduled to be completed in December 2015, will evaluate the likelihood and consequences of climate-related impacts on MTA assets and identify adaptation strategies for priority assets. A stakeholder meeting is scheduled for July 2015 with a follow-up workshop in Fall 2015.

Initiative/Action: Maryland Aviation Administration (MAA) Airport Layout Plan Vulnerability Assessments

Description: The MAA conducted a review of the Airport Layout Plans (ALPs) for five airports that were identified to be potentially affected by projected sea level rise/inundation. The ALP is a Plan that shows all existing and planned airport improvements, including runways, taxiways, terminals, and other structures. The airports in the State of Maryland that are potentially affected by projected sea level rise/inundation are Martin State Airport, Bay Bridge Airport, Essex Skypark, Ocean City Municipal Airport, and Crisfield Airport. The projected 2-foot, 5-foot, and 10-foot sea level rise contours, as developed by Maryland Department of Natural Resources (DNR) were overlaid onto the ALPs of each of the five airports. At Martin State Airport (MTN), planned future improvements were eliminated from the projected sea level rise contour areas,

resulting in a reduction in potential adverse effects of inundation, and a lessening of potential conflicts with emerging Maryland "Coast Smart" construction policies. The MAA Office of Regional Aviation Assistance is working with the other four airports in an advisory role to support continued airport layout planning to reduce or eliminate potential conflicts to aviation facilities from projected sea level rise/inundation effects.

Maryland Department of Planning (MDP), Maryland Historical Trust (MHT)

Initiative/Action: Historical, Archaeological, and Cultural Resources Vulnerability Study

Description: Rising sea levels, erosion, and major storms all pose a significant threat to historic and archeological sites, districts, and landscapes. In 2010, the MHT completed a preliminary vulnerability assessment of historical and cultural resources in Maryland. The study was completed using inundation level data from the DNR. Sea-level rise was raised by local governments and advocates through the *PreserveMaryland* planning process and included as a regional issue of concern in the statewide preservation plan for 2014-2018. As a first step, MDP produced an interactive online map, based on data used in the preliminary vulnerability assessment, to help local preservation planners and raise public awareness.

In 2011-2012, MHT was awarded a Coastal Zone Management Grant, through DNR, to complete a pilot project focusing on the Choptank River watershed in Dorchester County to develop a methodology for an in-depth analysis of vulnerable sites that provides details for management prioritization. In the first phase, sea level rise layers and additional shoreline data from DNR and their partners were incorporated, including erosion rates and other shoreline risk data. These layers were used to construct a general model of areas within the pilot project zone, which are subject to various levels of impact from coastal hazards and sea level rise. MHT then analyzed the recorded historic buildings and districts located in the pilot area impact zone. A methodology was developed to characterize each resource according to its level of recordation, extent of survey, extent and nature of potential impact, and the property's significance. This analysis allowed MHT to identify and prioritize high-value historic resources that are most threatened in the pilot area for documentation and/or mitigation. During the second phase of the project, MHT undertook documentation of 35 endangered sites within the watershed, including fieldwork, documentary research and Maryland Inventory of Historic Properties forms.

Initiative/Action: Cultural Resources Hazard Mitigation Planning Program

Description: With funding from the National Park Service, MHT has launched a two-year Cultural Resources Hazard Mitigation Planning Program aimed at protecting historic places, archeological sites, and cultural landscapes from the effects of natural hazards, such as flooding, wind and coastal erosion. Partnering with MEMA, DNR, MDE and others, MHT is currently developing trainings, model guidance and educational materials to help local governments create hazard mitigation plans for their cultural resources. MHT promotes a planning framework based on *FEMA's Integrating Historic Property and Cultural Resources Considerations into Hazard Mitigation Planning*, which is currently being tested in Annapolis. MHT also offers one-on-one technical assistance to aid local governments in plan development and mitigation projects involving cultural resources.

Initiative/Action: Local Government Technical and Financial Assistance: Greater Crisfield Long-Term Recovery Project

Description: The Greater Crisfield Long-Term Recovery Project primarily focuses on rehabilitation of homes and infrastructure damaged by Hurricane Sandy, along with economic development and some limited new home construction. In addition to serving as a State climate change and technical/financial assistance liaison to the local Somerset County Long Term Recovery Committee (LTRC), which provides new housing and housing rehabilitation services, MDP leads the interagency State Recovery Committee, which has worked to determine how best to assist the Greater Crisfield area while also implementing State climate change adaptation strategies. This has included the use of federal community development block grant (CDBG) disaster recovery funds available for Sandy recovery, as well as planning and community visioning assistance. One such visioning project, The Smith Island Vision Plan, jointly funded by DHCD and DNR, committed grant funds to Somerset County to work with a local citizens group, Smith Island United, to develop a Vision Plan for Smith Island. Members of the State Recovery Committee have served on the Steering Committee for this year-long process, which was just recently endorsed by Smith Island in the summer of 2015. The Smith Island Vision Plan will be adopted as an addendum to the Somerset County Comprehensive Plan and will serve as a key document for future infrastructure projects, as well as climate change adaptation strategies. The Greater Crisfield Project can serve as a model to improve Maryland's short-term and long-term hazard response approach.

Initiative/Action: Pre-Planning Assistance to Local Governments

Description: MDP offers assistance to local governments prior to the beginning of the local comprehensive planning process. This includes facilitating access to DNR maps of areas vulnerable to coastal hazards to inform local government decision-making related to land use and infrastructure.

Maryland Insurance Administration (MIA)

Initiative/Action: Climate Change Insurance Advisory Committee

Description: In the fall of 2008, the Maryland Insurance Commissioner convened a Climate Change Insurance Advisory Committee. The committee was charged with:

- Reviewing the adequacy of the data available to insurers to assess the risk imposed by climate change;
- Examining whether adaptive options are available to help mitigate losses and whether rating can be structured to provide an incentive for these options; and
- Reviewing ways to promote partnerships with policyholders for loss mitigation.

The committee released its final report in December 2010.

Maryland Department of the Environment (MDE)

Initiative/Action: Living Shoreline Regulation Development

Description: In 2008, the Maryland legislature enacted the Living Shoreline Protection Act. The Act requires riparian property owners to rely upon "living shorelines" defined as nonstructural shoreline stabilization measures such as marsh creation, whenever feasible, to protect shorelines from erosion while also providing critical wildlife habitat. A variety of state agencies are involved in implementing the program and related efforts. MDE issued draft implementing regulations on November 7, 2012. Final regulations went into effect in February 2013.

Initiative/Action: Higher Regulatory Standards for Floodplain Management
Description: Flood Insurance Rate Maps (FIRMs) are being updated throughout Maryland by the Federal Emergency Management Agency (FEMA). Part of this process requires communities that currently participate in the National Flood Insurance Program (NFIP) to update their local floodplain management regulations by the map effective date. At a minimum, these regulations must be consistent with federal regulatory requirements, but communities can choose to adopt higher regulatory standards. As the State Coordinating Office for the NFIP, MDE is assisting communities with this by providing a Maryland Model Floodplain Management Ordinance as a template containing higher regulatory standards such as a 2' freeboard requirement. Freeboard can be a community tool to respond to sea level rise, and to achieve lower flood insurance premiums for property owners. Many communities are implementing these higher regulatory standards in order to gain additional points for the Community Rating System (CRS), a flood insurance discount program for communities that go beyond the minimum NFIP requirements.

Department of Housing and Community Development (DHCD)

Initiative/Action: Review of Current Statewide Building Codes and Recommendations for Enhancement in Coastal Regions of Maryland

Description: As required under Section 2 of the Omnibus Coastal Property Insurance Reform Act of 2009 (Act), Chapter 540 (House Bill 1353), DHCD conducted reviews and prepared a report to members of the Senate Finance Committee and House Economic Matters Committee on "...enhanced building codes for coastal regions of the State that promote disaster-resistant construction in the coastal regions of the State...". The report was delivered to Members in October 2010. The report was also provided to planning boards of the counties in the coastal areas of the State.

Maryland Emergency Management Agency (MEMA)

Initiative/Action: State Hazard Mitigation Plan

Description: Maryland's 2011 State Hazard Mitigation Plan was approved in September 2011. Vulnerability to climate change, coastal hazards and sea level rise issues was evaluated as part of the State risk assessment and specific adaptation strategies were included in the overall mitigation plan. The 2016 update of the State Hazard Mitigation Plan are expected to include risks associated with non-coastal impacts of climate change as prioritized in the mitigation plan, the 2015 DNR Coast Smart Construction guidelines and the results Maryland Coastal Resilience Assessment.

Initiative/Action: State Disaster Recovery Operations Plan (SDROP)

Description: The Maryland SDROP has been developed by the Recovery Support Function Leadership Group in order to ensure the ability of the State of Maryland to recover from a catastrophic incident that overwhelms the State or any local jurisdictions by coordinating support and engaging all necessary State, local, federal, private sector, voluntary, faith-based, and nongovernmental agencies to address the needs of Maryland residents, visitors, and communities following a disaster. The SDROP is an all-hazards, capabilities based, state-level plan that outlines how agencies will coordinate support to and interact with local and community constructs during the recovery process. The first final draft was completed in June 2015. A statewide tabletop exercise to test the plan was held in July 2014.

Human Health

Background

Climate change poses serious health risks to people in Maryland, including increases in heat-related injuries, cardiovascular mortality and morbidity, respiratory illness, changes in infectious disease patterns (vector-borne, food-borne, and water-borne diseases), impacts to water supply and quality, and both direct and stress-related injuries from extreme storm events and flooding. The role of the public health system is to anticipate and manage these risks, in partnership with other agencies and institutions.

The health impacts of climate change will be influenced by other societal changes, including changes in health care and health care delivery, public health capacity, and many other factors. One challenge will be to focus the attention of institutions and agencies used to planning cycles of months to a year, on climate forecasts of fifteen to thirty years. However, the public health strategy for climate change in Maryland has been developing tools and case studies to assist local health departments and other agencies in considering health impacts in their planning processes.

Implementation Status

Maryland Department of Health and Mental Hygiene (DHMH)

Initiative/Action: State Climate Change Environmental Health Capacity Building

Description: To ensure that risks, costs, and benefits are evaluated in a systematic manner, Maryland successfully competed for and was awarded a 2012 capacity building cooperative agreement from the U.S. Centers for Disease Control and Prevention (CDC) Climate Ready Cities and States Initiative. The cooperative agreement, “Building Resilience Against Climate Effects (BRACE),” was implemented in Maryland as the Maryland Public Health Strategy for Climate Change. The four-year award is enabling DHMH to identify and address needs in the areas of: (1) epidemiologic capacity in injuries/disasters and vector-borne disease; (2) short, intermediate, and long-term climate change modeling and integration capacity; (3) training in health impact assessment (HIA); and (4) integration of information management tools related to disasters with routine DHMH functions. The strategy is outlined in Figure 3-1, below.

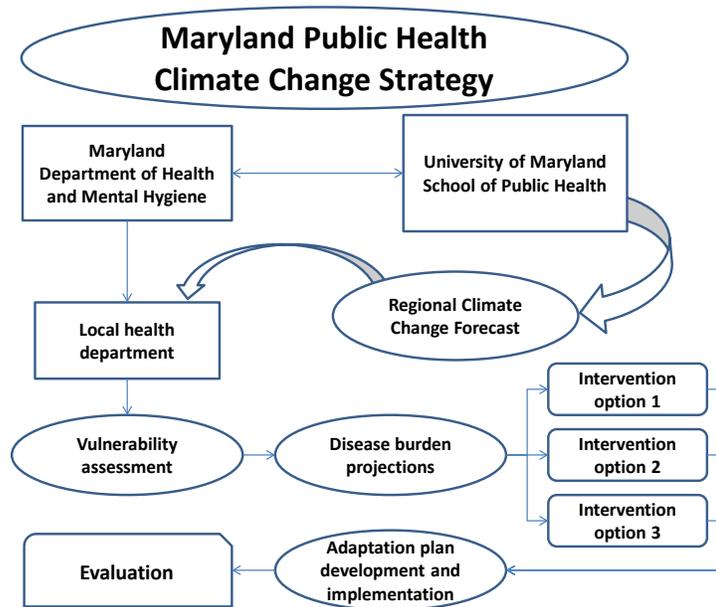


Figure 3-1. Overall framework of proposed Maryland project on public health and climate change.

Initiative/Action: Enhanced Environmental Public Health Tracking infrastructure

Description: A combined effort is needed in order to minimize the public health risks of climate change. Through continued coordination between the DHMH and other state agencies, preemptive measures can be taken to both prevent and minimize the impact of climate change on public health. In 2002, the DHMH received Center for Disease Control funding to plan for a statewide Environmental Public Health Tracking Network that will be part of the national tracking network. Maryland used the funding to build capacity and enhance infrastructure. The results range from starting or improving surveillance to enabling faster responses to environmental public health questions and faster action to prevent disease. These enhancements will be achieved through the CDC project on capacity building, integrating them with the environmental public health tracking project.

Initiative/Action: Development of Climate Health Indicators

Description: The DHMH is working with the Commission on Environmental Justice and Sustainable Communities, the MDE, and the MDP on the selection of health indicators that could be used by the MDP and other agencies to evaluate the potential impacts of climate change adaptation or mitigation strategies, as well as the potential health consequences of projects related to adaptation to sea level rise. The DHMH has strengthened its coordination with the DNR and the MDE related to monitoring and reporting of Chesapeake Bay-related health concerns, specifically with respect to harmful algal blooms.

Initiative/Action: State Heat Plan

Description: In May, 2012, DHMH released the Maryland State Heat Emergency Plan which guides state actions during an Extreme Heat Event: a weather condition with excessive heat and/or humidity that has the potential to cause heat-related illnesses. An Extreme Heat Event is defined as a day or series of days when:

- The heat index is forecasted to be approximately 105 degrees or higher, or;
- The National Weather Service has issued a Heat Advisory, or;
- Weather or environmental conditions are such that a high incidence of heat-related illnesses can reasonably be expected.

DHMH has also activated the State Heat Emergency web site (<http://dhmh.maryland.gov/extremeheat>), which includes links to the State Heat Plan, Facts about Heat Related Illness, and weekly Heat Reports that provide guidance and information about deaths and illness caused by extreme heat in the region.

Agriculture

Background

Agriculture is the largest commercial industry in Maryland, employing about 350,000 people, primarily in the north-central and Eastern Shore regions. Farms occupy about two million acres, or about one-third of the State's land, though individually the farms are, on average, much smaller than those in other states. Maryland's agriculture is diverse, including nursery plants, dairy products, beef cattle, vegetables, wheat, horses, and fruit. Poultry, fed by largely locally produced corn and soybeans, represents the largest market value. Projected increases in temperature, precipitation variability, and frequency of extreme events associated with climate change are likely to affect the conditions upon which farming has been established. Many of the stressors farms already face are likely to intensify or become less predictable: drought frequency, winter flooding, pests and disease, and ozone levels. These changes occur in the current context of the high economic uncertainty and small profit margins, and are likely to result in increased costs to both farmers and consumers.

To adapt to a changing climate, farmers will require guidance on climate smart crop species and strategies to reduce poultry and livestock loss and stress associated with heat. More intense water management will be needed to offset the impacts of growth and uncertainty in water supplies on agricultural production and water resources.

It is the broad goal of these strategies to help reduce stress on agricultural operations and to build the resilience of Maryland farms, despite changes they may face in the future, and to improve the quality of the Chesapeake Bay and its watershed. As climate change may affect the intensity of how farmers manage, alter effectiveness of agricultural BMPs, and affect the implementation of relevant regulations, farmers need to be prepared and supported for adjustments that may be required.

Implementation Status

Maryland Department of Agriculture (MDA)

Initiative/Action: Exposure to and spread of damaging insects and disease, especially invasive species

Description: MDA conducts regulatory and integrated pest management programs to help prevent the introduction and mitigate the impacts of invasive species in Maryland. A list of pests of concern, including the Emerald Ash Borer, which is an exotic currently under quarantine in Maryland, can be found on MDA's website. Maryland's Invasive Plant Advisory Committee (IPAC) was established by legislative mandate in October 2011. The IPAC's primary responsibility is to advise the Secretary of Agriculture on regulating the sale of invasive plants, and preventing them from entering Maryland or from spreading further in the state. Using a scientific weed risk assessment protocol, IPAC will classify invasive plants as Tier 1 or Tier 2 and recommend regulations to reduce the risk of invasive plants in Maryland. Initial regulations were promulgated in January of 2013. The remaining regulations, including proposed Tier 1 and Tier 2 plant lists were written in May of 2015 and are in the process of being finalized. There are currently six weed assessments available online.

Maryland Department of Health and Mental Hygiene (DHMH)/DNR/MDA

Initiative/Action: Vector-borne disease surveillance and control

Description: Maryland State officials continue to track the spread of WNV and other arboviral activity in the State in vector species, host animals, and humans. This allows for ongoing enhancement and deployment of effective tools to support surveillance, prevention, and control of West Nile virus and other arthropod-borne viruses, including novel or emerging pathogens that threaten the health of Maryland residents. In addition, the Mid-Atlantic Zoonotic and Vector Borne Disease Inter-Agency Workgroup (MAZV), a collaboration between DHMH, DNR, MDA, and researchers, practitioners, and federal agency partners meets regularly to monitor and discuss vector-borne disease activities in Maryland and the surrounding regions.

Forests and Terrestrial Ecosystems

Background

The diversity of Maryland's forests and terrestrial ecosystems reflects the wide variety of environmental conditions found across the State's five major physiographic provinces. Not only do forested systems regulate climate and sequester carbon, but they play a major role in any adaptation plan to reduce the impacts of urban heat, enhance migration corridors, mitigate flooding, protect drinking water supplies, and reduce nutrient and sediment runoff. From the mountains to the sea, one can hike through western Maryland's thick groves of hemlock lining deep gorges, across grassy serpentine barrens supporting the unique purple-flowered fringed gentian, by vernal pools inhabited by salamanders, and through the pine forests and hardwood swamps of the Eastern Shore. The State's forests are mostly privately owned and only 27% are permanently protected from development. These habitats and their plant and animal communities

are shaped mainly by geology, climate, and interactions with other species. They also are subject to many existing stressors such as development, pests, and pollution, limiting their capacity to adapt.

Forests and terrestrial ecosystems contribute an estimated \$2.2 billion to Maryland's economy and \$24 billion in ecological services. The condition of these ecosystems and the services they provide is likely to be altered by climate change. Climate change will alter distributions of species and habitats and exacerbate existing stressors at an uncertain rate and degree. Native species populations may decline, increase, or migrate from the State while new species may migrate in due to habitat shifts. Services provided by forests such as temperature regulation, water filtration, aesthetic value, and habitat may be altered. Existing stressors on species and habitats may be exacerbated by climate change.

Implementation Status

Maryland Department of Natural Resources (DNR)

Initiative/Action: GreenPrint Update

Description: Maryland's GreenPrint initiative identifies the most ecologically valuable areas in the State and designates these lands and waters as "Targeted Ecological Areas (TEAs)". TEAs are the "best of the best" natural resources across the State. TEAs were first defined in 2008 and included the most ecologically important large blocks of forests and wetlands; wildlife and rare species habitats; aquatic biodiversity areas; and forests for protecting water quality. In 2011, DNR updated the TEA designations to include coastal ecosystems; habitats for climate change adaptation and marsh migration, and areas for supporting commercial and recreational fisheries. Together, these areas are identified as conservation priorities for natural resources protection. DNR is now using these updated conservation priorities to target Stateside Program Open Space land conservation projects.

Initiative/Action: Wildlife Vulnerability Assessment

Description: The DNR has conducted a vulnerability assessment of GCN species using Nature Serve's Climate Change Vulnerability Index. The DNR is also participating in an expert panel effort in the northeast headed by the Manomet Center for Conservation Science to assess the likely impacts of climate change on northeastern fish and wildlife habitats and species of greatest conservation need. All of this information is planned for incorporation into the next version of the Maryland's State Wildlife Action Plan. The DNR's Natural Heritage Program is currently updating the State Wildlife Action Plan, which includes Maryland's analysis of selected Species of Greatest Conservation Need and their vulnerability to climate change. This report will be published in October 2015.

Initiative/Action: Forest Management Plans

Description: In 2011 DNR's Forest Service included climate change and adaptation information as a required element in forest management plans. These plans are required by any forest landowner who participates in State property tax abatement programs or USDA forestry

programs and thus will reach a wide audience.

Initiative/Action: Maryland Forest Resource Assessment and Strategy

Description: The DNR Forest Service has incorporated climate change into their 2010 Forest Resource Assessments as an additional stressor. Climate change was also identified as one of the top five areas for action in their five-year strategy. As part of this, the Forest Service is working with other local, state, and federal agencies to incorporate adaptation into existing forestry programs.

Initiative/Action: Urban Tree Canopy Assessment

Description: DNR is currently working to maintain and improve the health and longevity of trees in urban areas and increase the urban tree canopy cover throughout Maryland. Urban trees shield buildings from cold winds, lower ambient summertime temperatures, reduce heating and cooling costs, decrease the demand for energy production and reduce vulnerability to the effects of heat waves on at risk populations. Reduced heat slows the formation of ground level ozone as well as the evaporation of fuel from motor vehicles. Thirty-seven communities in Maryland have committed to participation in the UTC Goal effort to date. Baltimore City, Annapolis, and the Frederick County Board of Education have already adopted goals; the other communities are in the process of assessing their existing and potential UTC. Communities like Baltimore City have also begun to prioritize plantings for urban heat reduction and water quality improvement.

Bay and Aquatic Ecosystems

Background

The Chesapeake Bay is the largest estuary in the United States, fed by a watershed that stretches from mountains to sea, across 64,000 square miles (166,000 square kilometers), spanning six states - Maryland, Delaware, Virginia, West Virginia, Pennsylvania, New York, and the District of Columbia. Within its watersheds and oceanfront, Maryland's extensive aquatic ecosystems range from freshwater swamps and bogs, tidal and non-tidal freshwater rivers and marshes, tidal brackish and saline rivers and marshes, and coastal bays. These ecosystems are influenced by precipitation, temperature, tropical storms, and human activity. Currently, the services provided by the Bay are estimated to be approximately \$1 trillion, annually. However, human development and pollution have degraded their natural resilience, leaving them more vulnerable to extreme events. Climate change will likely exacerbate this problem, creating a greater threat to these ecosystems. The Bay has already warmed by 3 degrees Fahrenheit and additional temperature increases could change the composition of commercial fisheries and increase anoxia in the Bay (Prasad et al 2011). To protect its marine, estuarine and aquatic ecosystems against future damage, the action is needed to alleviate existing stressors and to strategically conserve and restore critical bay and aquatic habitats.

Implementation Status

Maryland Department of Natural Resources (DNR)

Initiative/Action: Climate Change Criteria for Conservation

Description: The DNR completed a project, “Coastal Land Conservation in Maryland: Targeting Tools and Techniques for Sea Level Rise Adaptation and Response.” The purpose of the project was to develop new conservation criteria to identify coastal habitats that may help Maryland proactively adapt to sea level rise and increased storm events associated with climate change. Climate change targeting criteria resulting from this project was used to develop new conservation areas for “GreenPrint” and a parcel-level scorecard used to review land acquisition projects. Trainings have been held with state land managers and conservation planners to share the new tools and datasets, and to implement them into current land conservation targeting and review processes.

Initiative/Action: Coastal Resilience Conservation Easements

Description: The DNR has developed a new conservation easement focused on increasing the resilience of coastal ecosystems and reducing the vulnerability of landowners to climate change. This tool has been shared with county conservation planners, local land trusts, the Maryland Department of Agriculture, and other conservation partners.

Initiative/Action: Temperature Sensitive Stream Regulations

Description: In 2011, the DNR and the MDE collaborated to create an update to Use Class III (naturally-reproducing trout) streams. Future coldwater protections are being assessed for contributing watersheds to these streams and for the protection of streams that harbor coldwater dependent invertebrate species. Future models may address those streams that will be most sensitive to climate change and those that will remain coldwater systems.

Initiative/Action: Guidelines and mapping for vulnerable ephemeral and headwater systems

Description: The DNR has identified ephemeral and intermittent freshwater habitats that are highly sensitive to changes in precipitation regimes and ultimately climate change. These habitats include ephemeral, intermittent, and headwater stream systems and vernal pools. Headwater streams support rare and endangered species, serve as migratory corridors, and process and store proportionally larger amounts of nutrients and sediment than larger streams. Mechanisms are now being explored to increase mapping of these systems, to develop model ordinances, and develop model field protocol for their identification and protection by local governments and organizations.

Initiative/Action: Bay Acidification Task Force

Description: Maryland General Assembly passed House Bill 118 creating a Task Force to Study the Impact of Ocean Acidification on State Waters during the 2014 legislative session.

The Task Force issued a report in January 2015 calling for monitoring, industry partnerships and collaboration with federal agencies. Maryland is one of the first East Coast states to take action on ocean acidification, and these proactive efforts will help the state reduce potential impacts and its coastal businesses prepare for a changing ocean. The report is a much-needed first step to protect Maryland’s \$1.65 billion blue crab, oyster and striped bass seafood industry.

Key findings from Maryland’s Task Force focus on seven areas that should be addressed in order to enhance acidification understanding, recognize its impacts on Maryland aquatic industries, and leverage resources to capitalize on federal and other state acidification research and monitoring programs. Key areas include:

- Enhancing monitoring of State waters to quantify scale
- Patterns and trends of ocean acidification
- Establishing additional research priorities in estuarine and coastal waters
- Improving coordination with other state and federal resource managers
- Focusing on impacts to key species and associated activities
- Providing direct support to affected industries
- Pursuing legislative action
- Improving communications and outreach

Addressing the above seven issue areas identified by the Task Force will position Maryland in both the short- and long-term to leverage existing monitoring, research and programmatic assets; collect the information necessary to assess the impacts of acidification on our aquatic resources; communicate the results to various stakeholders to meet the demands of our expanding aquatic industries; and mitigate the impacts of rising CO2 emissions.

Initiative/Action: DNR Stream Restoration Policy

Description: In June 2015, the DNR developed criteria to guide its actions to review, support, fund, and/or construct stream restoration projects, in order to evaluate the merits or proposed stream restoration actions using the best available science to support recommendations from the Department’s review of proposals and projects. The policy requires the assessment of long-term benefits, which, in many cases, includes adaptation to climate change. Stream restoration projects can lessen the impacts of climate change impacts by improving resilience of streams to flooding, protecting and restoring aquatic habitats, and preventing degradation.

Initiative/Action: Chesapeake Bay Agreement – Climate Resiliency Management Strategy

Description: In June 2014, representatives from across the region signed the *Chesapeake Bay Watershed Agreement*, with the vision of fostering an environmentally and economically sustainable watershed with clean water, abundant life, conserved lands and access to the water, a vibrant cultural heritage, and a diversity of engaged citizens and stakeholders. Signatories include the governors of Delaware, Maryland, New York, Pennsylvania, Virginia and West Virginia; the mayor of the District of Columbia; the chair of the Chesapeake Bay Commission; and the administrator of the U.S. Environmental Protection Agency (EPA). This agreement marked the first time a “climate resiliency” goal and associated outcomes were included in the Partnership’s guiding principles. To guide implementation of the Agreement, the Chesapeake Bay Program Partnership formally released a Climate Resiliency Management Strategy in July 2015. The Strategy lays out the management approach for assessing climate impacts and vulnerabilities, increasing the capacity of the Bay Program to prepare for and respond to climate change, implementing adaptation projects, and tracking the effectiveness of and ecological response to adaptation efforts. A biennial work pan for the Management Strategy will be

developed by the Bay Program's Climate Resiliency Work Group on or before April 2016.

Water Resources

Background

Maryland is fortunate to have an abundance of water sources that have historically been adequate for meeting the drinking water needs, as well as the needs for commercial, industrial, and agricultural use. However, during recent droughts, many of the previously believed reliable sources have experienced difficulties impacting a number of users who are dependent on them. The vulnerability of our resources due to variability in weather patterns combined with population growth, development, and pollution from manmade contaminants, pose a risk to sustainability of our water resources as well as Maryland's future economy and public health.

In the past 30 years, Maryland's climate has become wetter and hotter, resulting in more runoff and longer heat waves. Variability in weather patterns can cause either drought or flooding, threatening the reliability of our State's water resources. As a continued consequence of climate change, every area of Maryland could be impacted by increased flooding, more frequent and longer droughts, more intense storms and greater water demand. The Chesapeake Bay region is ranked the third most vulnerable area to sea level rise in the nation behind Louisiana and southern Florida. Current projections indicate that flooding will increase: 100-year floods will increase by 10-20 % and 10-year storms will increase by 16-30%. There is a greater likelihood that more powerful rain and windstorms will strike Maryland as ocean waters warm, accompanied by higher storm surges and rainfall. These variations in weather patterns and sea level rise have the potential to cause water infrastructure damage, flooding of water supply wells and salt water intrusion, bacteriological and chemical contamination of water sources, algal blooms, increased demand for irrigation and ultimately decrease in availability of water for Marylanders. Our water resources are finite, and we should be aware of the fragility of our State's water resources, and challenges that threatens their sustainability. We must develop and implement plans to meet the upcoming challenges.

Implementation Status

Maryland Department of the Environment (MDE)

Initiative/Action: Coastal Plain and Fractured Rock Studies

Description: The MDE has two long-term water supply studies that have been initiated in partnership with the Maryland Geological Survey, the U.S. Geological Survey, and the DNR Monitoring and Non-Tidal Assessment Division. The Coastal Plain and Fractured Rock studies were initiated in 2006 and 2009, respectively. These studies will develop information and tools to help the MDE make sound science-based decisions about water allocations, ensure ongoing sustainability of the resource, and evaluate the potential impacts of withdrawals on aquatic habitat. In addition, the studies will provide valuable information to assist local governments as they plan for future growth and water use needs.

The Coastal Plain study involves a complex aquifer model, which will be capable of modeling various management scenarios as well as potential impacts of climate change. The MDE is already using two important tools developed as part of these studies known as the Coastal Plain and Fractured Rock Aquifer Information Systems. These geographically-referenced tools provide MDE's permit project managers with up-to-date and easily accessible data, including geophysical logs, aquifer test information, water levels, well locations, and selected water quality data. Funding to continue the studies beyond SFY 2012 has not been identified to date.

Initiative/Action: Developing source water protection implementation measures for vulnerable communities

Description: The MDE has delineated areas around each public water supply well or intake where measures should be taken to protect the water supplies from water quality impacts. More than three hundred communities around the State have adopted land use ordinances or other measures to protect their water sources. In 2011, MDE contracted with two private consultants to assist twenty vulnerable groundwater communities in developing and implementing protection measures. This project was completed in 2013.

Initiative/Action: Tools for water utilities

Description: The MDE has produced a publication for public drinking water systems that provides the systems with information about the possible impacts of climate change on utilities and recommends a variety of adaptation measures to help water systems prepare for and/or avoid these impacts. The publication has been distributed by mail to all community water systems in the State.

Initiative/Action: Environmental Site Design

Description: Current Maryland law and regulations require that Environmental Site Design (ESD) be used to the maximum extent practicable (MEP) to control stormwater from new development and redevelopment. The goal is that ESD planning techniques and practices are to be implemented to replicate runoff characteristics similar to “woods in good condition.” These practices reduce runoff and improve water quality and ultimately help buffer communities from the impacts of rain events.

Population Growth and Infrastructure

Background

Maryland's growing population lives and works primarily in a built environment and is reliant on transportation, water, and communication and energy networks, spanning a wide range of landscapes, from cooler Appalachian Mountains in the west, to low-lying areas of the Eastern Shore. These systems are regulated in part at the state level, but are more directly influenced by local decision-making. The systems are subject to the pressures of shifting population and often have unreliable sources of funding required for needed maintenance, planning and upgrades. The projected effects of climate change, including increases in precipitation variability and extremes,

and winter precipitation and temperature, are likely to affect the frequency, severity and timing of many existing problems, such as stormwater overflows, buckling of roads, and malfunctioning train systems due to heat waves. Historical and current climate conditions will no longer be adequate to guide planning, design, operation and maintenance decisions.

For sustainable development, planning efforts must reflect and address projections for both population growth and the effects of climate change. Many areas in Maryland are expected to experience increased growth and development. Decisions about growth need to factor in climate impact projections. Temperature and precipitation extremes will likely harm infrastructure and affect human health. Increases in precipitation and the intensity of storm events will likely exacerbate existing problems, particularly in urban areas. Problems associated with stormwater, flooding, heat stress and air quality will likely worsen. Building codes, infrastructure design, emergency management and planned development should be oriented to reduce impacts caused by increased climate variability and extremes. Maryland's built environment needs to be reinforced to prepare for new temperature and precipitation regimes. Over time, changes to the system including the operation, maintenance, design and management of much of the State's built infrastructure may become necessary.

Implementation Status

Maryland Department of Planning (MDP)

Initiative/Action: Local & State Targeted Growth and Conservation Areas

Description: Climate Change Impact Areas were identified as one of the Local and State Targeted Growth and Conservation Areas that warrant special attention. Climate Change Impact Areas include: projected 50 and 100-year Sea Level Rise Inundation Zones, 50-Year Erosion Vulnerable Zones, Category 2 Storm Surge Inundation Zones, Marsh Transition Zones, Temperature Sensitive Streams, Drought Hazard, and Wildfire Risk Areas. The intent of identifying these areas is to ensure that the State and local governments make wise decisions about how to protect our natural resources, and where and how to develop and redevelop in light of climate change induced hazards and risks. State capital investments consider Climate Impact Areas during the identification of potential sites and the scope of the work associated with the capital investment. Local governments also are educated on how to use the maps and encouraged to utilize them in capital improvement planning. Guidelines for reducing climate change impacts within these areas include:

- Promoting the safety and well-being of Maryland's citizens by avoiding infrastructure capacity improvements that increase human exposure to natural disasters;
- Avoiding assumption of the financial risk of development and redevelopment in vulnerable or hazardous coastal areas;
- Ensuring wise and sound public investments in Maryland's sea level rise inundation zone. However, appropriate conservation efforts along Maryland's shorelines should not preclude important investment in the State's water-dependent infrastructure, such as our seaports;

- Analyzing climate change impacts on historical and cultural resources and prioritizing necessary recovery, documentation, and protection efforts; and
- Protecting critical natural environments from impacts of climate change (i.e., sea level rise, temperature increase, precipitation change) and climate-induced natural hazards.

Department of Natural Resources (DNR)

Initiative/Action: Community Connections Protocol Development

Description: DNR has developed an additional protocol for assessing land conservation projects based on their value and ability to connect people to the land. The assessment includes a Climate Change Resilience component, which considers on-site adaptation benefits including community storm surge protection, shoreline stabilization and restoration, urban tree canopy protection, and future planned abandonment and relocation facilitation. The community connections protocol and scorecard will be used for appropriate proposed projects to be funded by Program Open Space.

Initiative/Action: State-wide Land Preservation and Recreation Plan

Description: DNR developed the 2014 State-wide Land Preservation and Recreation Plan (LPRP) in coordination with the Maryland Department of Planning, local governments, a wide range of stakeholders, and public input. This was the first iteration of the LPRP to provide an analysis of how climate change may impact Maryland’s natural and cultural resources, open space, recreation and tourism, as well as provide strategies for ensuring sustainability and increasing resilience. The LPRP is a working resource and tool for Statewide outdoor recreation and open space planning.

Tools, Research and Education to Inform Sound Decisions

Background

Maryland managers and decision-makers need the right tools to anticipate and plan for climate change. Long-term monitoring and research efforts are critical. As Maryland experiences new hydrologic and temperature conditions, the State will need to gain a better understanding of these conditions. Financial, educational, scientific and political support will also be necessary in order to assess conditions and to research new ways to build up the resilience of natural and built infrastructure to the impending impacts of climate change.

Investment in education is also essential to teach public officials, planners, and other decision makers how to use the tools to formulate and implement specific actions. Coordination with the public is necessary, particularly those most vulnerable and without the necessary resources to respond. In the short-term, there is a critical need to establish and disseminate state-specific climate data and information in order to develop a common understanding of future planning needs at both state and local scales. This is an important first step to ensure climate issues are considered during infrastructure planning, design, construction, and budget processes.

Implementation Status

Maryland Department of Natural Resources (DNR)/University of Maryland Center for Environmental Science (UMCES)

Initiative/Action: Information Dissemination

Description: Information on both the Phase I and II adaptation strategies have been widely disseminated and presented at a variety of conferences, workshop and stakeholder events. Topic and sector-based fact sheets have been developed and are available online (<http://www.dnr.maryland.gov/climatechange/>). DNR and UMCES are both working to widely disseminate climate change-related data and information to agencies, stakeholders, and the public via existing networks and social media outlets.

University of Maryland, Maryland State Department of Education

Initiative/Action: MADE-CLEAR

Description: The recently funded Maryland and Delaware Climate Change Education, Assessment and Research (MADE CLEAR) program will bring together university faculty, middle school and high school teachers and informal educators to develop training opportunities in climate education across Maryland and Delaware. The goal will be to ensure that students graduating from Maryland schools understand the science behind climate change, the choices available to mitigate and adapt to a changing climate, and professional opportunities related to the green job market. For more information on MADE-CLEAR, visit: <http://www.madeclear.org/>

Department of Natural Resources (DNR)

Initiative/Action: Incorporation of climate change into education initiatives

Description: In 2011, the DNR assembled a series of talking points on climate impacts in Maryland to be utilized by its education staff. As a next step, DNR is including K12 teacher and informal science educator professional development that incorporates climate change into existing education and outreach programs. DNR is also supporting climate change interpretation and communication at Maryland State Parks through park ranger and seasonal staff professional development in climate change communication techniques. Messages of most relevance to citizens will be used as appropriate in outreach programs aiming to encourage stewardship actions; while more direct coastal education programs and materials are being developed for use in classroom settings.

Initiative/Action: Climate Change Adaptation Needs Assessment, Training and Technical Assistance

Description: The Maryland Chesapeake and Coastal Service (CoastSmart Communities Program & the Coastal Training Program) and its Partners continue to use the outcomes of the formal needs assessment conducted in 2012 to guide programming and routinely conduct informal need assessments of local government staff to continue to understand the evolving needs. Since 2012

there has been a series of targeted trainings and courses offered through the Chesapeake and Coastal Service and Partners. A sample of courses offered includes: Introduction to the Community Rating System Part I & II, Climate Adaptation for Coastal Communities, CoastSmart Communities Scorecard Facilitation, Be Flood Ready, Conducting Local Governments to Share Ideas to Reduce Flooding, and FEMA's Managing Floodplain Development through the National Flood Insurance Program, in addition to others. An updated needs assessment is being considered in 2016 to further understand the information/technical assistance needs so that CCS and its partners can meet those in the most efficient way possible.

Strengthening Climate Action in Maryland

On November 19, 2014, Executive Order 01.01.2014.14 (EO) was issued to expand the membership, mission and work of the Maryland Commission on Climate Change (MCCC). As one of four working groups organized under the MCCC, the EO establishes the following charge for the Adaptation and Response Working Group (ARWG):

- Strengthen and maintain existing State action plans to further address, prepare for and adapt to the consequences of climate change;
- Reestablish the Adaptation and Response Working Group, as needed;
- Convene regular Working Group meetings to ensure that sufficient progress is being made across all sectors and communities in Maryland; and
- Establish a comprehensive and accountable annual work plan that set annual goals and performance benchmarks, and prioritizes new and existing climate change adaptation actions and initiatives.

Under the umbrella of the MCCC, the efforts of the ARWG will be undertaken in conjunction with the efforts of the MCCC's Mitigation (MWG), Scientific and Technical (STWG), and Education, Communication and Outreach (ECO) Working Groups.

Prioritizing New and Existing Climate Change Adaptation Actions and Initiatives

Table 3-1. Sea Level Rise and Coastal Storms

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (C, O, S, M, L, TBD)
Reduce Impact to Existing and Future Growth and Development					
Take action now to protect human habitat and infrastructure from future risks	Strongly encourage the integration of coastal erosion, coastal storm, and sea level rise adaptation and response strategies into existing state and local policies and programs.	DNR/MDP	MDA, MDE, MDOT, DHCD, local governments	High	Ongoing
	Develop and implement State and local adaptation policies (i.e., protect, retreat, abandon) for vulnerable public and private sector infrastructure.	DNR	MDP, MDE, MDOT, local governments	High	Ongoing
	Strengthen building codes and construction techniques for new infrastructure and buildings in vulnerable coastal areas.	DHCD/DNR	MDP, MDOT, MDE, local governments	High	Ongoing
Financial and Economic Well-Being					

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (C, O, S, M, L, TBD)
Minimize risks and shift to sustainable economies and investments	Develop and implement long-range plans to minimize the economic impacts of sea level rise to natural resource-based industries.	COMMERCE	DNR	Medium	Long
	Establish an independent Blue Ribbon Advisory Committee to advise the State of the risks that climate change poses to the availability and affordability of insurance.	MIA	DNR	High	Complete
	Recruit, foster, and promote market opportunities related to climate change adaptation and response.	COMMERCE	DNR	Low	Long
Protection of Human Health, Safety and Welfare					
Maximize the safety and well-being of Maryland's citizens in times of foreseen and unforeseen risk	Strengthen coordination and management across Agencies responsible for human and animal health and safety.	DHMH	MDA/DNR	High	Ongoing
	Conduct Health Impact Assessments to evaluate the public health consequences of climate change and sea level rise-related projects and/or policies.	DHMH	MDA/ MDE/ DNR/MDP	High	Medium

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (C, O, S, M, L, TBD)
	Develop a coordinated plan to assure adequacy of Vector-borne Surveillance and Control Programs.	DHMH/ MDA	DNR/MDE	High	Medium
Natural Resource Protection					
Retain and expand forests, wetlands and beaches for protection against coastal flooding	Identify high priority protection areas and strategically and cost-effectively direct protection and restoration actions.	DNR	MDE	High	Ongoing
	Develop and implement a package of appropriate regulations, financial incentives, educational, outreach, and enforcement approaches to retain and expand forests and wetlands in areas suitable for long-term survival.	DNR	MDE, MDA	High	Ongoing
	Promote and support sustainable shoreline and buffer area management practices.	DNR	MDE, MDA	High	Ongoing
Adaptation and Response Toolbox					

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (C, O, S, M, L, TBD)
Provide State and local governments the tools to anticipate and plan for sea level rise and climate change	Strengthen federal, state, local, and regional observation systems to improve the detection of biological, physical, and chemical responses to climate change and sea level rise.	DNR/UMD	NOAA/ EPA	High	Ongoing
	Update and maintain state-wide sea level rise mapping, modeling, and monitoring products.	DNR	NOAA	High	Ongoing
	Utilize new and existing educational, outreach, training and capacity building programs to disseminate information and resources related to climate change and sea level rise.	DNR/UMD	MDE/MDP	High	Ongoing
Future Steps and Directions					
State and local governments' commitment of resources and time to assure progress	Develop state-wide sea level rise planning guidance to advise adaptation and response planning at the local level.	DNR	MDP, local governments	High	Ongoing

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (C, O, S, M, L, TBD)
	Develop and implement a system of performance measures to track Maryland's success at reducing its vulnerability to climate change and sea level rise.	DNR	Other State agencies	Medium	Ongoing
	Pursue the development of adaptation strategies to reduce climate change vulnerability among affected sectors, including agriculture, forestry, water resources, aquatic and terrestrial ecosystems, and human health.	DNR/UMD	Other State agencies	High	Ongoing

Table 3-2. PHASE II: Building Societal, Economic and Ecological Resilience Implementation Guidance Table.

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
HUMAN HEALTH						
Conduct vulnerability assessments to gain a better understanding of risk and inform preventative measures.	Assess potential health threats and the sufficiency of Maryland’s response capacity.	DHMH	MEMA	TBD	TBD	
	Evaluate impacts to food safety and availability.	DHMH	MDA	Medium	Medium-Term	TBD
	Assess the vulnerability of Maryland’s populations and communities to changing health threats.	DHMH	MDP, MDE	Medium	Long-Term	TBD
	Identify potential barriers to effective emergency response.	DHMH	MEMA	High	Medium-Term	TBD
Integrate impact reduction strategies into State and local planning	Improve response capacity through the development of new or expanded programs.	DHMH	MEMA	Medium	Long-Term	High
	Address climate-related health risks in hazard mitigation and emergency response plans.	DHMH	MEMA	Medium	TBD	TBD

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
practices.	Support community engagement in planning and emergency response decisions.	DHMH	MEMA	Medium	Long-Term	TBD
	Pursue opportunities to enhance protection of Maryland’s “green infrastructure.”	DNR	DHMH, MDP	TBD	TBD	TBD
Streamline and revise data collection and information dissemination channels.	Improve the resolution and availability of health and population data.	DHMH	UMD, MDP, CDC, EPA	High	Ongoing	High
	Analyze health and population data along with other spatially explicit information (e.g., land use, air quality, water quality).	DHMH	DNR, MDP, MDE, EPA, CDC	High	Ongoing	High
AGRICULTURE						
Increase crop diversity, protect against pests and disease, and intensify water	Promote diversification of crop species and varieties.	MDA	UMD-Extension (UME), Local Agricultural Producers	Low	Ongoing	TBD

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
management.	Intensify water management and conservation through research, funding and incentives.	MDA	UME, MDE, DNR, USDA, EPA, Bay Trust	High	Ongoing	High
	Protect against incoming pests, weeds and disease.	MDA	UME	Low	Ongoing	TBD
	Support innovative solutions that foster adaptation and also reduce energy costs and carbon footprints.	MDA	UME, MEA	Medium	Ongoing	TBD
Strengthen applied research, risk communication and technical support.	Enhance dissemination channels to improve the relay of climate information.	MDA	UME, SCDs, NRCS, NGOs, commodity orgs.	Low	Ongoing	TBD
	Identify opportunities to support the transition of farm and agricultural practices.	MDA	UME, NRCS, Farm Credit, Insurance Industry	Low	Long-Term	TBD

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	Enhance emergency response and risk management.	MDA	UME, Farm Credit, Insurance Industry	Low	Ongoing	TBD
Enhance existing Best Management Practices and land conservation targets.	Evaluate the effectiveness of BMPs under future climate change scenarios	MDA	UMD, DNR, MDE	Medium	Ongoing	TBD
	Assess and revise targets for agricultural land preservation.	MDA	Local and Regional Land Trusts	Low	Ongoing	TBD
FORESTS & TERRESTRIAL ECOSYSTEMS						
Expand land protection and restoration and revise targeting priorities.	Integrate climate data and models into existing resource assessments and spatial planning frameworks.	DNR	EPA, CBP, USDOJ, USFWS, NGOs, NASA, NOAA	High	Medium-Term	Medium

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	Incorporate climate change adaptation strategies into state resource management plans.	DNR	MDP, EPA, CBP, USDOL, USFWS, NOAA USFS NGOs	High	Medium-Term	Low
	Collaborate with federal partners to support regional and national adaptation planning.	DNR	EPA, CBP, USDOL, USFWS, NOAA USFS NGOs	Medium	Medium-Term	Low
	Update existing land protection targeting programs and project evaluation protocols.	DNR	EPA, CBP, USDOL, USFWS, NOAA USFS NGOs	High	Ongoing	Low

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	Develop climate change adaptation guidance and technical tools that local governments could consider as part of its local planning.	DNR	MDP, UMD Cooperative Extension	High	Ongoing	Medium
Adjust management practices and reduce existing stressors.	Strengthen State and local programs to slow the loss and fragmentation of forest and terrestrial ecosystems to new development.	DNR	MDP, MDE MDOT USFWS, USFS, EPA, CBP, NGOs	High	Ongoing	Medium
	Review and revise best forestry management practices.	DNR	UMD-Cooperative Extension	Medium	Medium-Term	Medium
	Continue to support incorporation of the policies and strategies of <i>Maryland's Sustainable Forestry Act of 2009</i> into state and local planning decisions.	DNR	State Forest Conservancy District Boards	High	Ongoing	Low

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	Evaluate sustainable forestry certification programs for opportunities to enhance climate resiliency.	DNR	Sustainable Forestry Initiative, Forestry Boards, Forest Stewardship Councils	Medium	Medium-Term	Medium
	Improve capacity to manage and respond to stressors exacerbated by climate change.	DNR	MDA, Maryland Invasive Species Council, Forest Health Emergency Contingency Program	Medium	Short-Term	High

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
Foster stewardship on private lands.	Develop new tools to guide adaptation stewardship activities on private lands.	DNR	Forest Stewardship Councils, UMD-Cooperative Extension	High	Short-Term	Medium
	Integrate adaptation strategies into existing programs.	DNR	USFS, Forest Stewardship Councils, UMD-Cooperative Extension	High	Short-Term	Medium

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	Develop new conservation easement mechanisms to promote adaptation stewardship activities on private lands.	DNR	USFS, Forest Stewardship Councils, UMD-Cooperative Extension MDA	High	Short-Term	Medium
BAY AND AQUATIC ECOSYSTEMS						
Advance protection of at-risk species and habitats.	Revise state-level protection targeting programs to reflect climate change adaptation priorities.	DNR	UMD, USACE, USGS, USFWS, NOAA, NGO's	High	Ongoing	Low
	Develop new protection and conservation mechanisms to promote adaptation stewardship activities on private lands.	DNR	UMD, USACE, USGS, USDO, USFWS, NOAA, NGOs	Medium	Medium-Term	Medium

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	Amend legal mechanisms to designate and protect temperature-sensitive streams.	DNR	MDE, EPA	High	Ongoing	Medium
	Implement an adaptive management approach.	DNR	MDE, MDOT, MDA, MDP, Federal Partners, NGOs	High	Medium-Term	Low
Restore critical bay & aquatic habitats to enhance resilience.	Proactively pursue, design and construct habitat restoration projects to enhance the resilience of bay, aquatic and terrestrial ecosystems.	DNR	USACE, USGS, USFWS, NOAA, EPA, CBP, NGOs	High	Long-Term	High
	Conduct an audit of state-owned lands to identify habitat restoration potential for enhancing ecosystem resilience and increasing on-site carbon sequestration.	DNR		Medium	Short-Term	Low

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	Increase on-the-ground implementation of existing stream restoration practices.	DNR	USGS, EPA, CBP, USFWS	High	Short-Term	High
Reduce existing stressors.	Remove barriers to habitat connectivity.	DNR	MDE, USFWS, NOAA	High	Ongoing	High
	Explore ways to reduce impervious surface cover.	DNR, MDE	MDP	High	Ongoing	High
	Prepare for new or expanding ranges of invasive species.	DNR	MDA, Maryland Invasive Species Council, USFWS	High	Ongoing	Medium
Foster a collective response to climate change.	Adjust bay and watershed restoration priorities in light of a changing climate.	DNR	MDE, UMD, NOAA, USGS, EPA, Penn State, USFWS	Medium	Ongoing in Coastal Plain	Medium

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	Integrate both adaptation and mitigation reduction strategies into natural resource management plans and programs.	DNR	USFWS, NOAA, NGOs	High	Short-Term	Low
	Revise fishery and wildlife management to build climate resilient safeguards.	DNR	USFWS, NOAA, NGOs	High	Long-Term	Medium
	Increase collaboration between federal, state, local and regional climate change adaptation partners.	DNR	UMD, NOAA, USGS, EPA, NGOs	High	Short-Term	Low
WATER RESOURCES						
Ensure long-term safe and adequate water supply for humans and ecosystems.	Pursue examination and implementation of the recommendations of the 2008 “Wolman Committee” report.	MDE	DNR, MDP, local govts., federal partners	High	Ongoing	High
	Manage water supply, considering future climate and population.	MDE	MDP, DNR, local govts.	High	Ongoing	TBD

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	Enhance planning and coordination within the water resource community.	MDE	MDP, local govts.	High	Long-Term	TBD
	Encourage water suppliers to evaluate and improve their resilience.	MDE	Water utilities, Local govts., MEMA, EPA	High	Long-Term	TBD
	Promote demand management and water conservation practices.	MDE	Local govts., MDA, Business community	Medium	Ongoing	TBD
	Assess, target and protect high-quality water recharge areas.	MDE	DNR, MDP	Medium	Long-Term	TBD
Reduce the impacts of flooding and stormwater.	Encourage the removal of vulnerable or high-hazard water supply and treatment infrastructure.	MDE	Water utilities, local govts.	Low	Long-Term	TBD
	Prevent inundation and overflow of on-site disposal systems.	MDE	Local govts.	Medium	Long-Term	TBD

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	Revise Clean Water Revolving Fund criteria.	MDE		Low	Short-Term	Low
	Invest in an improved understanding and communication of flood probabilities and hazards.	MDE	DNR	Medium	Long-Term	TBD
POPULATION GROWTH & INFRASTRUCTURE						
Ensure safety, clean water, clean air and sufficient infrastructure.	Determine funding needed for future infrastructure needs.	MDOT, MDE	MEMA, DGS, Utilities, Local Govts.	Medium	Ongoing	TBD
	Conduct a comprehensive analysis of the vulnerability of Maryland's infrastructure.	MDOT, MDE	MEMA, DGS, Utilities, Local Govts.	Medium	Ongoing	High
	Develop a "lead by example" investment policy to guide state investments.	DNR	All State Agencies	High	Short-Term	Low
	Reduce regional air quality impacts in Maryland.	MDE	MEA, MDOT, EPA, MPOs, Other states	High	Medium-Term	High

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
Plan for precipitation-related weather extremes and increase resilience to rising temperatures.	Assess the economic costs resulting from severe weather events.	MDOT, MEMA	DHMH Utility Providers, Local Govts.	Low	TBD	TBD
	Identify state investment needs to prepare for future weather emergencies.	MDOT, MEMA	Utility Providers, Local Govts.	Low	TBD	TBD
	Accelerate use of improved stormwater management strategies and environmental site design (ESD).	MDE	DGS, DNR, MDOT, UMD, Local Govts.	High	Ongoing	High
	Enhance the preparedness of transportation system and utility providers.	MDOT, MEMA	PSC, MEA, Utility Providers, MPOs,	Low	TBD	TBD
	Develop operation contingency plans for critical infrastructure.	MDOT, MEMA	Utility Providers	Medium	Ongoing	TBD
	Increase urban tree canopy.	DNR	Local Govts.	High	Ongoing	High
	Strengthen building and	DHCD	Local	High	Ongoing	TBD

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	infrastructure design standards.		Govts., MDOT, MEA, MDE, MEMA			
Institutionalize consideration of climate change.	Support the integration of climate change adaptation strategies into state and local policies and programs.	MDP	DNR, MEMA, MDE	High	Long-term	Medium
	Provide technical assistance to jurisdictions that want to integrate climate vulnerability data into state and local spatial planning frameworks.	MDP	DNR	High	Long-term	Medium
	Assist local governments considering climate change issues in combination with ongoing growth and development planning efforts.	MDP	Sustainable Growth Commission, Local Govts.	High	Short-term	Low
	Explore incentives to promote sound planning practices	MDP	MEA, UMD	High	Medium-term	TBD

Priority Recommendations	Action Strategies	Lead Agency (suggested)	Key Partners (suggested)	Implementation Priority (L, M, H, TBD)	Implementation Timeframe (O, S, M, L, TBD)	Potential Implementation Cost (L, M, H, TBD)
	Investigate the impacts of climate change on future energy needs.	DNR	MDE, MEA, MDA, COMMERCE, MDP, MDOT	High	Ongoing	Medium
	Create a framework and standards for the placement and use of alternative energy.	DNR, MEA	MDE, MDA, COMMERCE, MDP, MDOT, Critical Area Commission, UMD	High	Ongoing	Medium

Implementation Priority: L (Low); M (Medium); H (High – Needs Immediate Action); TBD (To Be Determined)

Implementation Timeframe: Ongoing (a component of an existing program); Short (1 -3 years); Medium (3 – 5 years); Long-Term (5 + years); TBD (To Be Determined)

Implementation Cost: Low (\$0 - \$100,000); Medium (\$100,000 - \$200,000); High (\$200,000 +); TBD (To Be Determined)

Recommending Short- and Longer-Term Strategies and Initiatives to Better Address the Consequences of Climate Change

1. *Developing broader public and private and federal, state and local partnerships*
 - From 2007-2014, the ARWG has primarily been comprised of representatives of the following state agencies: DNR, MDE, MDP, MHT, DHCD, DoIT, MES, MEMA, DBM, DHMH, MDOT, MPA, SHA, MDA, MIA, MEA, DGS and the University System of Maryland. The ARWG has also formed a number of sector-based working groups to assist with implementation of specific action items, including the development of the Phase I and II Adaptation Strategies. Both state agency and stakeholder representatives have participated on each of the ARWG's underlying working groups. ARWG members will engage in broadening stakeholder representation to include business and industry representatives with specific expertise in the areas of the ARWG.
2. *Addressing the challenge that low income and otherwise vulnerable communities will likely be disproportionately impacted by climate change (EO Task E(3)c)*
 - Climate change poses unique and often more devastating impacts to vulnerable and low-income communities. These communities already face challenges such as outdated infrastructure, poor healthcare, and lack of resources, which are then exacerbated by the effects of climate change. The ARWG will work with vulnerable and low-income communities in Maryland, the Commission on Environmental Justice and Sustainable Communities, and the Education and Outreach Working Group to help these communities better adapt to the impacts of climate change.
3. *Assessing the impacts that climate change will likely have on the State's economy, revenues and investment decisions (EO Task E(3) d)*
 - The ARWG will work to explore what impacts that climate change will likely have on the State's economy, revenues, and investment decisions (EO Task E(3)d) by utilizing Maryland's Greenhouse Gas Reduction Act Plan Report (2013), which addresses the cost of inaction. The report focuses on five major areas of economic loss if no climate measures are implemented: 1) coastal lands, infrastructures and ecosystems, 2) tourism, 3) agriculture, 4) public health and 5) energy. Additionally, the ARWG will look to integrate, where appropriate, topics or concepts from other states' reports (i.e., New York, Florida, and Washington) into Maryland's purview.
4. *Delivering Tools and Assistance for Local Governments (EO Task E(3)(f))*
 - ARWG members will assess the delivery of tools and assistance to local governments to support community-scale climate vulnerability assessments and the development and integration of specific strategies for enhancing resilience to the impacts of climate change into local plans and ordinances. The ARWG will explore introducing programs, similar to CoastSmart, to non-coastal communities

to address issues such as the intersection of climate and stormwater, as well as riverine and nuisance flooding.

State Enhancement Actions

1. Maryland Environmental Policy Act Guidelines

- In November 2014, Executive Order 01.01.2014.14 tasked the DNR to issue Maryland Environmental Policy Act (MEPA) guidelines that require the consideration of climate change factors, including both mitigation and adaptation. DNR is working to incorporate these changes into the MEPA guidelines by integrating climate change mitigation and adaptation into the consideration of environmental effects and alternatives of proposed state actions. In addition to revising the guidelines, DNR will consider adding adaptation and mitigation questions to the Environmental Assessment Form for proposed state actions.

2. State Planning, Regulatory and Fiscal Program Analysis

- Executive Order 01.01.2014.14 tasked all state agencies to “review State planning, regulatory and fiscal programs to identify and recommend actions to more fully integrate the consideration of Maryland’s GHG reduction goal and the impacts of climate change.” State agencies will analyze state funded programs to determine whether additional executive, legislative or administrative requirements will be necessary to incorporate consideration of climate change adaptation measures.

Conclusions

The information presented in this chapter is not intended to be a final work product or strategy on climate change adaptation for the State of Maryland. It should be viewed as “living document” that provides a snapshot of where the State currently stands in terms of implementing its broad scale climate change adaptation planning efforts. The chapter is intended to provide the basis for guiding and prioritizing future state-level activities with respect to both climate science and adaptation policy within short to medium-term timeframes (i.e., 1 – 5 years). It is envisioned that the information in this chapter will also serve as a framework not only to direct state-action, but also to engage policy-makers and stakeholders, and facilitate collaboration among federal, regional and local partners.

Adaptation planning efforts at the state-level will be routinely reviewed and updated as new climate science and information becomes available and we gain a better understanding of how to adapt to climate change. State agencies leads, as well as internal and external partners, will remain a key part of advancing climate change adaptation planning in Maryland. In closing, it goes without saying that further detailed planning, stakeholder engagement, and funding will be required to build Maryland’s ecological, societal and economic resilience to the impacts of climate change.

Chapter 4: Inventory and Forecast

Frequently Used Abbreviations and Acronyms

CAMD: Clean Air Markets Division

CO₂e: Carbon Dioxide Equivalent

EPA: U.S. Environmental Protection Agency

GGRA: Greenhouse Gas Emissions Reduction Act

GHG: Greenhouse Gas

MDE: Maryland Department of the Environment

RCI: Residential, Commercial and Industrial Building Fossil Fuel Combustion

The Inventory and Forecast Process Overview

The Greenhouse Gas Emissions Reduction Act of 2009 (GGRA) required the State to develop and implement the *2012 GGRA Plan* to achieve a 25 percent reduction in greenhouse gas (GHG) emissions from a 2006 baseline by the year 2020. The GGRA specifically requires the development of a baseline inventory for 2006. This inventory was developed based on six categories of heat retaining gases: carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons and perfluorocarbon. Collectively, these gases are referred to as carbon dioxide equivalent, or CO₂e. The 25 percent reduction is subtracted from the baseline to create a target level of emissions for 2020.

To calculate the reductions needed to achieve the target, a projected inventory for the year 2020 was developed to estimate emissions due to growth from “business-as-usual” activities (i.e. estimated emissions in the absence of any climate control programs). The growth emissions added to the emissions needed to achieve the 25 percent reduction are the total emission reductions needed for success of the *2012 GGRA Plan*. The emissions estimates, assumptions, and methodologies are explained further in this chapter. The full report and emissions inventory, is located on the MDE web page at:

<http://www.mde.state.md.us/programs/Air/ClimateChange/Pages/GreenhouseGasInventory.aspx>.

Emissions inventories are the foundation of air quality decisions; it is essential the data be as accurate as possible. Inventory quality is critical since the inventory assists decision makers in defining realistic regulations and reduction strategies.

GHG Emissions Reporting Requirements in Maryland

Federal regulations established under the U.S. Environmental Protection Agency's (EPA) Acid Rain program require large sources of air pollutants to report carbon dioxide emissions data quarterly to EPA's Clean Air Markets Division (CAMD) public access database. These sources are mainly electric generating units. The data reported is obtained through direct measurement of carbon dioxide emissions by monitors located in the exhaust stacks of the sources. These instruments collect data continuously. In the absence of a monitoring system, sources calculate the amount of carbon dioxide using an accepted methodology and then report this into CAMD. These regulations include standards for monitoring, recordkeeping, and reporting.

The GGRA Inventory and Forecast

Emissions inventories are essential to developing environmental policies. The quality of a state-specific inventory is vital to the process if Maryland expects to set and achieve realistic pollution reduction goals. A baseline GHG inventory will pinpoint the business sectors that contribute to Maryland's GHG emissions, identifying where priorities should be placed in the development of climate policies. It also is necessary to determine what Maryland's future GHG emissions will be through the use of a forecast and modeling. Since GHG emissions may increase in the future, Maryland can take advantage of any cost-effective opportunities for early GHG reductions that may exist.

The Maryland General Assembly passed the GGRA in 2009.⁵ The GGRA requires MDE to prepare and publish an updated inventory of statewide GHG emissions for calendar year 2006 and develop a projected business-as-usual inventory for calendar year 2020 on or before June 1, 2011.⁶ This GGRA requirement was met and can be found on the MDE web page. The GGRA also requires an updated inventory every three years, starting in 2011. These periodic inventories are the primary tool that MDE will use to track emission reduction progress. MDE will complete the 2014 inventory by the end of this year.

The GGRA identified 2006 as the base year for Maryland's process and as the year for the first compliance-quality inventory. Since Maryland GHG data existed for 2006, using 2006 as the base year for Maryland's GHG inventory made sense from a resource perspective

Steps to Conducting a GHG Inventory

To comply with this mandate, MDE prepared a report that estimates the statewide emissions of GHGs for calendar year 2006 and a business-as-usual projected inventory for calendar year 2020. The report and the emissions inventory is divided into seven major source categories that contribute to GHGs emissions in Maryland and can be found in its entirety on the MDE web page. The seven major source categories are:

- Electricity use and supply

⁵ Environment Article, Title 2, Subtitle 12, "Greenhouse Gas Emissions Reductions", §§2-1201 – 2-1211, Annotated Code of Maryland.

⁶ *Id.*, §2-1203.

- Residential, commercial and industrial buildings fossil fuel combustion (RCI)
- Transportation
- Industrial processes
- Fossil fuel industry, including fugitive emissions from GHGs released from leakage
- Waste management
- Agriculture

The inventory also includes forestry and land use as a “sink” category based on its carbon sequestration.⁷

Maryland’s man-made GHG emissions and terrestrial sinks for carbon storage were estimated for the base year 2006 using a set of generally accepted principles and guidelines for State GHG emissions, relying to the extent possible on Maryland-specific input data. The projections are based on the application of appropriate growth factors to the base year GHG emission inventory. Growth factors associated with the emissions projections are described in detail in the report. The projected inventories were based on a business-as-usual forecast as required in GGRA; therefore, to the extent possible, no control or reduction programs were taken into consideration in the estimation. Programs like RGGI and EmPOWER Maryland that were implemented after the 2006 base year are credited toward the 25 percent reduction requirement.

The inventory and forecast cover the six types of gases included in the U.S. Greenhouse Gas Inventory for 2006: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. A scale has been developed to allow the comparison of all the GHGs on an equivalent basis. Carbon dioxide was selected as the compound to which all others would be equated since carbon dioxide is by far the most prevalent GHG and has been identified as having the Global Warming Potential of 1. The goals, inventory and reductions in the 2012 GGRA Plan are expressed as CO₂e based on the conversions below.

Maryland has used the global warming potentials for the GHG pollutants established by the Intergovernmental Panel on Climate Change.

Table 4-1. Global Warming Potentials of GGRA Gases

GHG Pollutant	Global Warming Potential
Carbon Dioxide	1
Methane	21
Nitrous Oxide	310

⁷ As defined by EPA, terrestrial carbon sequestration is “... the process through which CO₂ from the atmosphere is absorbed by trees, plants and crops through photosynthesis, and stored as carbon in biomass (tree trunks, branches, foliage and roots) and soils. The term "sinks" is also used to refer to forests, croplands, and grazing lands, and their ability to sequester carbon. Agriculture and forestry activities can also release CO₂ to the atmosphere. Therefore, a carbon sink occurs when carbon sequestration is greater than carbon releases over some time period.”

www.epa.gov/sequestration/faq.html

Sulfur Hexafluoride	23,900
Perfluorocarbons	9,200
Hydro Chlorofluorocarbons	11,700

Figures 4-1 and 4-2 provide a graphic representation of the relative proportions of the major sectors of the GHG inventory for the 2006 base year and the 2020 projection year respectively. Table 4-2 provides a summary of the base year and projection year GHG emissions for Maryland for the years 2006, 2010, 2015, and 2020. Activities in Maryland accounted for approximately 107.2 million metric tons of *gross*⁸ CO₂e emissions (consumption basis) in 2006, an amount equal to about 1.5 percent of total U.S. gross GHG emissions (7,054.2 million metric tons of CO₂e).⁹

Emission Summaries

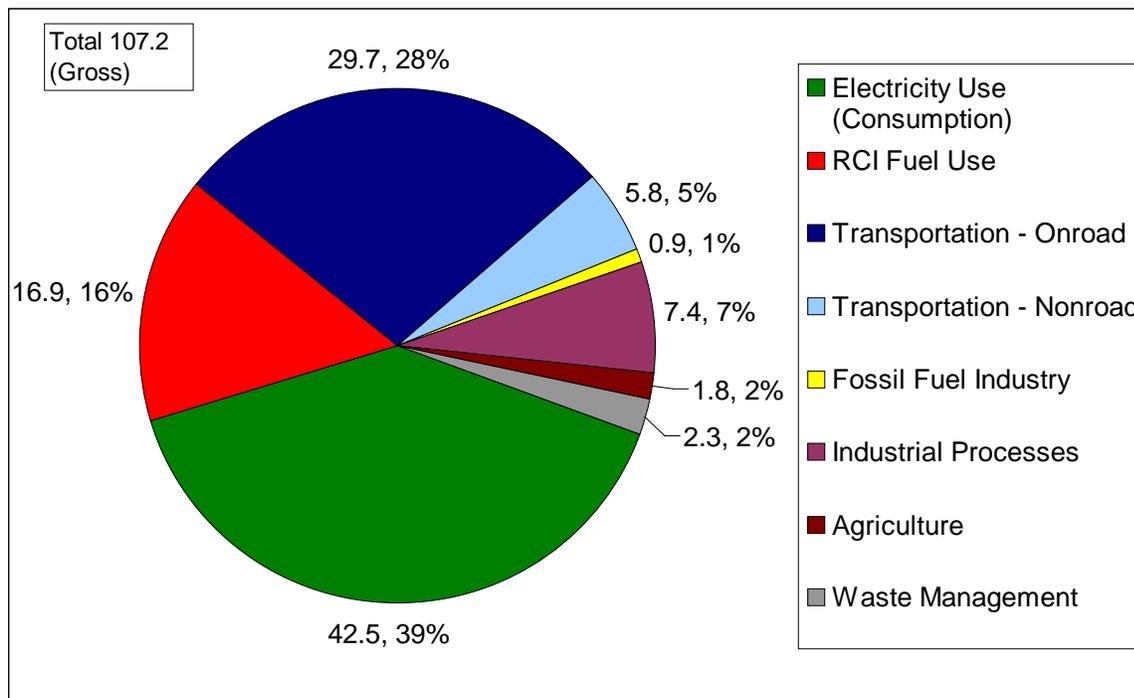


Figure 4-1. Baseline 2006 CO₂e Emissions by Activity (in million metric tons of CO₂e and percentage)

⁸ Excluding GHG emissions removed due to forestry and other land uses.

⁹ The national emissions used for these comparisons are based on 2006 emissions from *Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2006*, April 15, 2008, US EPA # 430-R-08-005, <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>.

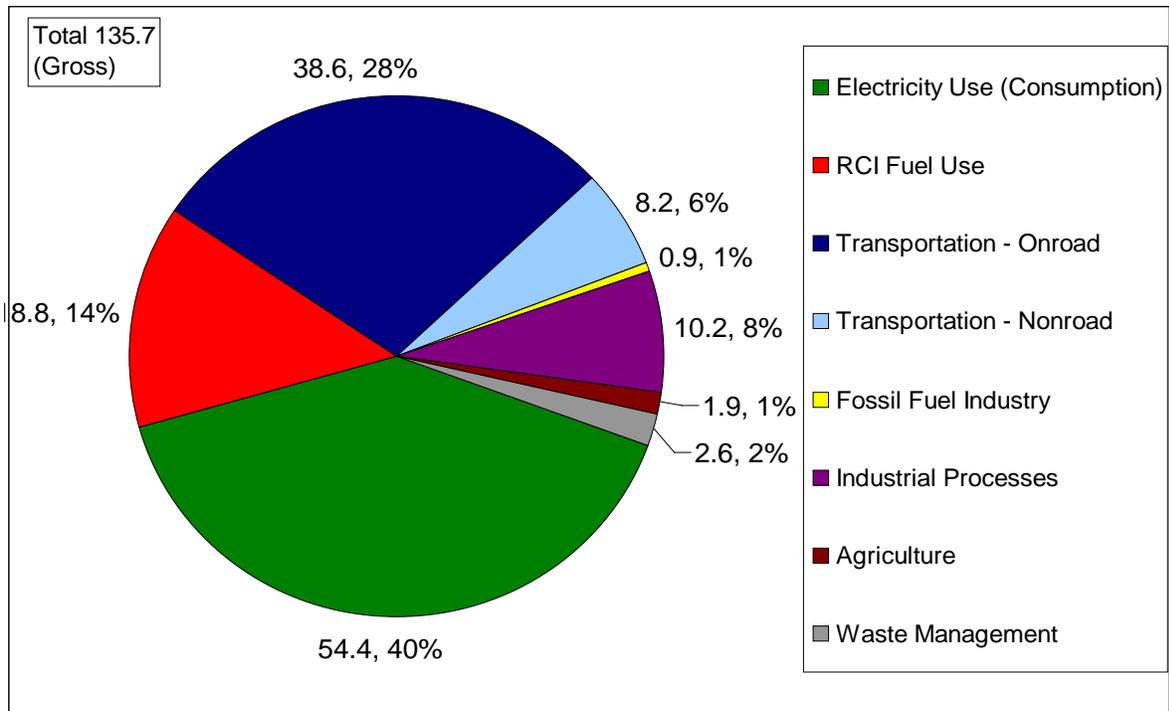


Figure 4-2. Projected "Business As Usual" CO₂e Emissions by Activity (2020) (in million metric tons of CO₂e and percentage)

Table 4-2. Maryland 2006 Base Year and Projected 2020 GHG Emissions, by Sector¹⁰

MMtCO ₂ e	2006	2010	2011	2015	2020	Explanatory Notes for Projections
Energy Use (CO₂, CH₄, N₂O)	95.76	103.35	90.97	111.78	120.97	
Electricity Use (Consumption)^b	42.48	46.63	37.86	50.16	54.42	PSC Projections
Electricity Production (in-state)	32.16	34.04	24.55	35.91	37.78	MEA Statistical Analysis
<i>Coal</i>	28.28	28.85	21.93	29.57	30.29	MEA Statistical Analysis
<i>Natural Gas</i>	3.65	4.55	2.42	5.70	6.85	Output Optimization.
<i>Oil</i>	0.24	0.64	0.20	0.64	0.64	Output Optimization.
<i>Wood</i>	0.00	0.00	0.00	0.00	0.00	Population growth
<i>MSW/LFG</i>	0.00	0.00	0.00	0.00	0.00	Population growth
Net Imported Electricity	10.31	12.59	13.31	14.25	16.65	Power Balance
Residential/Commercial/Industrial	16.87	17.24	17.00	18.07	18.84	

¹⁰ Totals may not equal sum of subtotals shown in this table due to independent rounding.

(RCI) Fuel Use						
Coal	3.00	3.17	2.96	3.68	4.20	Household growth
Natural Gas & LPG	9.21	9.42	9.98	9.72	10.00	Household growth
Petroleum	4.58	4.57	3.95	4.57	4.56	Household growth
Wood	0.09	0.09	0.11	0.09	0.09	Household growth
Transportation	35.47	38.66	35.27	42.68	46.78	
Onroad Gasoline	23.76	25.75	22.53	28.23	30.71	MOVES Modeling
Nonroad Gasoline	1.04	1.05	2.74	1.06	1.06	Various
Onroad Diesel	5.91	6.47	5.72	7.18	7.88	MOVES Modeling
Nonroad Diesel	1.50	1.60	2.16	1.73	1.85	Various
Rail	0.24	0.25	0.19	0.27	0.30	EPA RIA
Marine Vessels (Gas & Oil)	1.00	1.21	0.35	1.48	1.75	EPA RIA
Lubricants, Natural Gas, and LPG	0.30	0.34	0.46	0.40	0.47	Industrial Employment.
Jet Fuel and Aviation Gasoline	1.72	1.98	1.13	2.34	2.76	Aircraft Operations
Fossil Fuel Industry	0.94	0.82	0.84	0.87	0.92	
Natural Gas Industry	0.81	0.69	0.69	0.74	0.79	Industrial Employment.
Oil Industry	0.00	0.00	0.00	0.00	0.00	Industrial Employment.
Coal Mining	0.13	0.13	0.14	0.13	0.13	Production growth
Industrial Processes	7.44	8.21	4.40	9.21	10.24	
Cement Manufacture	1.48	1.57	0.92	1.83	2.09	Production growth
Limestone and Dolomite	0.11	0.15	0.09	0.18	0.21	Production growth
Soda Ash	0.05	0.05	0.04	0.05	0.05	Production growth
Iron and Steel	3.60	3.65	0.91	3.75	3.85	Production growth
ODS Substitutes	1.97	2.65	2.28	3.35	4.04	Population growth
Electricity Transmission and Dist.	0.23	0.14	0.17	0.05	0.00	Population growth
Semiconductor Manufacturing	0.00	0.00	0.00	0.00	0.00	Industrial Employment.
Ammonia and Urea Production	0.00	0.00	0.00	0.00	0.00	Industrial Employment.
Aluminum Production	0.00	0.00	0.00	0.00	0.00	Industrial Employment.
Agriculture	1.77	1.85	1.66	1.79	1.86	
Enteric Fermentation	0.42	0.44	0.37	0.42	0.51	Population growth
Manure Management	0.32	0.32	0.32	0.30	0.29	Population growth
Agricultural Soils	1.02	1.08	0.95	1.06	1.05	Population growth

Agricultural Burning	0.01	0.01	0.01	0.01	0.01	Population growth
Urea Fertilizer Usage	0.01	0.01	0.01	0.01	0.01	No Growth
Waste Management	2.26	2.34	2.26	2.48	2.60	
Waste Combustion	1.29	1.34	1.43	1.42	1.49	Population growth
Landfills	0.39	0.40	0.56	0.43	0.45	Population growth
Wastewater Management	0.54	0.56	0.56	0.59	0.62	Population growth
Residential Open Burning	0.03	0.03	0.03	0.04	0.04	Household growth
Gross Emissions (Consumption Basis, Excludes Sinks)	107.23	115.75	99.28	125.26	135.68	
<i>Increase gross emissions relative to 2006</i>		7.95%	-7.41%	16.82%	26.53%	
Emissions Sinks	-11.79	-11.8	-11.85	-11.8	-11.8	
Forested Landscape	-10.45	-10.45	-10.45	-10.45	-10.45	
Urban Forestry and Land Use	-1.33	-1.33	-1.43	-1.33	-1.33	
Agricultural Soils (Cultivation Practices)	-0.05	-0.05	-0.02	-0.05	-0.05	
Forest Fires	0.05	0.04	0.05	0.04	0.04	
Net Emissions (Consumptions Basis) (Including forestry, land use, and agric sinks)	95.44	104.00	87.44	113.51	123.93	
<i>Increase net emissions relative to 2006</i>		8.97%	-8.38%	18.94%	29.85%	

Estimates of carbon sinks within Maryland's forests, including urban forests and land use changes, are also included in the inventory and projection. Current estimates indicate that about 11.8 million metric tons of CO₂e were stored in Maryland forest biomass and agricultural soils in 2006. This leads to *net* emissions of 95.4 million metric tons of CO₂e in Maryland in 2006.

There were three principal sources of GHG emissions in Maryland in 2006: electricity consumption, transportation, and RCI fossil fuel use. Electricity consumption accounted for 43 percent of gross GHG emissions, transportation for 30 percent and RCI fuel use accounted for 17 percent.

Under the reference case projections, Maryland's gross GHG emissions continue to grow and are projected to climb to about 135 million metric tons of CO₂e by 2020. This is approximately 27 percent above 2006 levels.¹¹ Maryland's electricity consumption sector is projected to be the largest contributor to future GHG emissions growth in Maryland, followed by the transportation sector and RCI fossil fuel use.

Some data gaps exist in this analysis, particularly for the reference case projections. Key refinements include review and revision of key emissions drivers that will be major determinants of Maryland's future GHG emissions (such as the growth rate assumptions for electricity

¹¹ Note that electricity sector emission reductions attributable to the Maryland CO₂ Budget Trading Program are not included in the reference case emissions inventory.

generation and consumption, transportation fuel use, and RCI fuel use). The full report provides the detailed methods, data sources, and assumptions for each GHG sector. Also included are descriptions of significant uncertainties in emission estimates or methods, and suggested next steps for refinement of the inventory.

Source and Sink Categories

The full inventory and forecast report describes the inventory procedures MDE used to compile the 2006 base year emissions inventory of the six GHG pollutants. The emission sources are divided into the following seven source categories:

- Electricity Supply
- Residential, Commercial, and Industrial Buildings (RCI) Fuel Combustion
- Transportation Energy Use
- Industrial Processes
- Fossil Fuel Production Industry
- Agriculture
- Waste Management

As noted earlier, the inventory also includes forestry and land use as a sink category based on its carbon sequestration.

The inventory has been calculated on a statewide basis and has not been allocated to the county level unless otherwise stated. Brief descriptions of each emission source and sink category are presented in the following paragraphs:

Electricity Supply

The electricity supply sector accounts for GHG emissions occurring as a result of the combustion of fossil fuel at electricity-generating facilities located both in and outside of the State. Carbon dioxide represented more than 99.5 percent of total sector emissions, with methane and nitrous oxide CO₂e emissions comprising the balance.

Maryland is a net importer of electricity, meaning that the State consumes more electricity than is produced here.¹² For this analysis, it was assumed that all power generated in Maryland was

¹² The geographic boundary of the inventory is identical with the borders of Maryland except for a single category: electricity consumption. As part of the 2006 baseline, the GGRA requires Maryland to include GHG emissions from electricity consumed by its citizens whether that electricity is generated within Maryland or imported into Maryland from outside the state. Several factors contributed to the decision to use a consumption-based approach to electricity emissions rather than just include emissions from electricity generated in Maryland. Data is available to estimate both categories of emissions with reasonable accuracy. Historically 30 percent of the electricity consumed by Marylanders is generated outside Maryland. Since electricity consumption is a very large portion of the GHG emissions generated by Marylanders, excluding 30 percent of those emissions would reduce the effectiveness of the *2012 GGRA Plan*. Some of the early reduction strategies, like the EmPOWER Maryland goals, are based on consumption of electricity not generation of electricity. While other sectors such as transportation also produce

consumed in Maryland, and that remaining electricity demand was met by imported power. Sales associated with imported power accounted for 28 percent of the electricity consumed in Maryland in 2006.¹³ GHG emissions from electricity produced in-state are dominated by the combustion of coal, followed by emissions from the use of oil and natural gas. As shown previously in Figure 4-1, electricity consumption accounted for about 39 percent of Maryland's gross GHG emissions in 2006 (about 43 million metric tons of CO₂e), which was higher than the national average share of emissions from electricity consumption (34 percent).¹⁴ Nuclear energy is also a significant contributor to Maryland's power supply system at 38% of Maryland's overall in state generation, second only to coal. Nuclear energy is a carbon neutral energy source.

In 2006, emissions associated with Maryland's electricity consumption (43 million metric tons of CO₂e) were about 10 million metric tons of CO₂e higher than those associated with electricity production (32 million metric tons of CO₂e). In 2011, emissions associated with Maryland's electricity consumption (38 million metric tons of CO₂e) were about 13 million metric tons of CO₂e higher than those associated with electricity production (25 million metric tons of CO₂e). The higher level for consumption-based emissions reflects GHG emissions associated with net imports of electricity to meet Maryland's electricity demand.¹⁵ Projections of electricity sales for 2006 through 2020 indicate that Maryland will remain a net importer of electricity. The 2020 business-as-usual forecast assumes that in-state production-based emissions will increase by about 10 million metric tons of CO₂e. In addition, consumption-based emissions associated with imported electricity will increase by about 6 million metric tons of CO₂e.

The consumption-based approach better reflects GHG emissions and emissions reductions occurring in Maryland, particularly with respect to electricity use and energy efficiency improvements. This is particularly useful for policy-making.

RCI Fuel Combustion

The full report and inventory discusses emissions associated with direct fossil fuel used in the residential, commercial and the industrial buildings sector to provide space and process heating. In 2011, emissions associated with Maryland's RCI fuel combustion were 17 million metric tons of CO₂e.

Transportation Energy Use

emissions from GHG sources originating outside Maryland (e.g. out-of-state vehicles traveling through Maryland), these emissions are not included in the inventory. This is in part because these emissions are quite variable and also because a good source of accurate data for these emissions is not available.

¹³ In 2006, total Maryland retail sales were 63,173 gigawatt-hours, of which 17,643 (i.e., 28 percent) were estimated to be from imports.

¹⁴ For the U.S. as a whole, there is relatively little difference between the emissions from electricity use and emissions from electricity production, as the U.S. imports only about 1 percent of its electricity, and exports even less. Maryland's situation is different, since it is a net electricity importer.

¹⁵ Estimating the emissions associated with electricity use requires an understanding of the electricity sources (both in-state and out-of-state) used by utilities to meet consumer demand.

Emissions estimated for this business sector are the result of the combustion of fossil-fuel primarily for transportation purposes. Sources include:

- Cars
- Light-duty trucks
- Vans
- Buses
- Other diesel vehicles

The majority of CO₂e emissions in the transportation sector relate to onroad gasoline, with onroad diesel accounting for a significant percentage.

Other modes of transportation, such as airplanes, trains and commercial marine vessels are included under the general category of nonroad mobile sources. It is often difficult identifying the actual end-use for nonroad gasoline and diesel fuels (other than marine use). Natural gas and liquified petroleum gas used as transportation fuel are easily broken out. Also, jet fuel and aviation gasoline are discrete products that are treated as a separate sector.

Nonroad mobile sources are motorized vehicles and equipment not normally operated on public roadways. These include:

- Lawn and garden equipment
- Agricultural or farm equipment
- Logging equipment
- Industrial equipment
- Construction equipment
- Airport service equipment
- Recreational land vehicles or equipment
- Recreational marine equipment
- Locomotives
- Commercial aviation
- Air taxis
- General aviation
- Military aviation
- Commercial Marine Vessels

As shown previously in Figure 4-1, the transportation sector accounted for about 33 percent of Maryland's gross GHG emissions in 2006 (about 35.5 million metric tons of CO₂e), which was higher than the national average share of emissions from transportation fuel consumption (27 percent). In 2011, Maryland's gross GHG emissions were about 35.3 million metric tons of CO₂e.

For 2006, onroad gasoline vehicles accounted for about 65 percent of transportation GHG emissions. Onroad diesel vehicles accounted for another 17 percent of emissions, and air travel for roughly 6 percent. Marine vessels, rail, and other sources, such as natural gas- and liquefied petroleum gas-fueled vehicles used in transport applications accounted for the remaining 12 percent of transportation emissions.

In 2011, onroad gasoline vehicles accounted for about 64 percent of transportation GHG emissions. Onroad diesel vehicles accounted for another 16 percent of emissions, and air travel for roughly 3 percent. Marine vessels, rail, and other sources, such as natural gas- and liquefied petroleum gas-fueled vehicles used in transport applications accounted for the remaining 17 percent of transportation emissions.

Industrial Processes

Emissions estimated in the industrial sector account for process-related GHG emissions resulting from the four main industrial processes that occurs in the State:

- (1) Carbon dioxide emissions from cement production, soda ash, dolomite and lime/limestone consumption;
- (2) Carbon dioxide emissions from iron and steel production;
- (3) Sulfur hexafluoride emissions from electric power transmission and distribution system transformer use; and
- (4) Hydrofluorocarbon and perfluorocarbon emissions resulting from the consumption of substitutes for ozone-depleting substances used in cooling and refrigeration equipment.

Industrial process CO₂e emissions are estimated to increase in the projected 2020 business-as-usual forecast, although not uniformly across sectors. Several sectors have values that are not visible due to the scale of the chart, but the GHG emissions have been calculated and do change between the 2006 baseline and 2020 business-as-usual forecast.

In 2006, the GHG emissions from industrial processes were about 7 million metric tons of CO₂e. In the 2020 business-as-usual forecast, the GHG emissions from industrial processes are projected to be about 10 million metric tons of CO₂e. In the 2011 inventory, the GHG emissions from industrial processes showed a decrease to about 4 million metric tons of CO₂e.

Fossil Fuel Production Industry

This section reports GHG emissions that are released during the production, processing, transmission, and distribution of fossil fuels (primarily natural gas and coal) in the State. Methane emissions released via leakage and venting from oil and gas fields, processing facilities and natural gas pipelines, and fugitive methane emissions during coal mining, are estimated in this section, as well as carbon dioxide emissions associated with the combustion of natural gas in compressor engines.

Fossil fuel production emissions are projected to drop in the 2020 business-as-usual forecast. In 2006, GHG emissions from the fossil fuel production industry were about 0.94 million metric tons of CO₂e. In the 2020 business-as-usual forecast, GHG emissions from the fossil fuel production industry are projected to be about 0.92 million metric tons of CO₂e. In the 2011 inventory, GHG emissions from the fossil fuel production industry decreased to about 0.84 million metric tons of CO₂e. This is attributable to a decrease in emissions in the fossil fuel and natural gas industries. Coal mining emissions are expected to remain constant between the 2006 baseline and the 2020 "Business-As-Usual" forecast.

Agriculture

The emissions estimated in this section refer to non-energy generating methane and nitrous oxide emissions from enteric fermentation¹⁶, manure management, and agricultural soils. Emissions and sinks of carbon in agricultural soils also are estimated in this section. Energy emissions, such as combustion of fossil fuels in agricultural equipment, are not included in this section, but are already accounted for under the RCI and nonroad transportation sectors.

Agriculture CO₂e emissions are projected to increase from the 2006 baseline under the 2020 business-as-usual forecast. The growth is different by type of emission source, some going down and some going up at different rates. Enteric fermentation shows the largest percentage of growth. However, the 2011 inventory shows a decrease in agriculture CO₂e emissions from the 2006 baseline. In 2006, GHG emissions from agriculture were about 1.77 million metric tons of CO₂e. In 2011, GHG emissions from agriculture were about 1.66 million metric tons of CO₂e.

Waste Management

This section estimates all GHG emissions from Maryland's waste management practices based on the three main classes of waste management in the state:

- (1) Solid waste management
- (2) Wastewater management
- (3) Solid municipal waste incinerations

Waste CO₂e emissions are projected to increase from the 2006 baseline.

WTE Emissions and Biomass

MDE chose to include WTE biogenic emissions in the GHG emissions inventory because the inventory is combustion-based, the carbon released from combusted biogenic materials is

¹⁶ Enteric fermentation is a natural part of the digestive process of cattle, sheep, and other ruminants, which produces methane emissions as a byproduct. Most of the methane is belched by the animal. A small percentage of methane is also produced in the large intestine and passed out as flatulence. www.epa.gov/ttnchie1/ap42/ch14/final/c14s04.pdf; <http://www.c2es.org/technology/factsheet/EntericFermentation>

occurring now over a much shorter period of time and some portion of the emissions are not carbon neutral. Moreover, EPA is commencing a comprehensive review of how biomass emissions should be treated in conjunction with development of GHG emissions inventories. Maryland is continuing to review the science with interested parties and may make different recommendations in the future.

Forestry and Land Use

This section provides an assessment of the net GHG flux resulting from land uses, land-use changes, and forest management activities in Maryland. The balance between the emission and uptake of GHGs is known as GHG flux.¹⁷ The GHG emissions estimated in this section include carbon dioxide emissions from urea fertilizer use, methane and nitrous oxide emissions from wildfires and prescribed forest burns, and nitrous oxide emissions from synthetic fertilizers application to settlement soils. Carbon sequestration pathways estimated in this section include:

- Above and below ground biomass
- Dead wood and forest litters
- Landfilled yard trimmings and food scraps
- Harvested wood product
- Wood products in landfills
- Urban trees

Net forestry emissions remain basically constant from the 2006 baseline to the forecasted 2020 business-as-usual.

Hydraulic Fracturing in Maryland

The recent increased of hydraulic fracturing “fracking” drilling operations in the United States has fundamentally changed the fossil fuel markets. The subsequent decrease in natural gas prices has lead natural gas to be the current fuel of choice for electrical generation units (EGUs). Current research seems to suggest that fracking produces more emissions than conventional natural gas drilling techniques. This is especially important because these emissions are predominately Methane (CH₄), which has a higher GWP potential than CO₂. MDE recognizes that methane emissions are something that needs to be studied further.

2020 Goal: How much do we need to reduce?

To calculate a specific 2020 emissions reduction goal for Maryland, two key pieces of information are needed: the 2006 statewide GHG emissions baseline and the 2020 statewide business-as-usual forecast (anticipated emissions in the absence of any climate control

¹⁷ The term “flux” is used here to encompass both emissions of GHGs to the atmosphere and removal, or “uptake”, of carbon from the atmosphere (carbon sequestration).

programs). The growth in emissions is the difference between these two numbers. The total GHG emissions reduction needed under GGRA must not only offset this growth; it must also reduce emissions 25 percent below the 2006 baseline. This is the same methodology that MDE uses for reduction efforts for criteria pollutants, such as precursors of ozone.

Maryland's 2006 baseline GHG emissions are confirmed at 107.23 million metric tons of CO₂e. A 25 percent reduction from this equals 80.42 million metric tons of CO₂e (a reduction of 26.81 million metric tons). Another way to think about this is that the GGRA climate strategies should lead Maryland down to a 2020 actual statewide emissions profile of 80.42 million metric tons of CO₂e (107.23 minus 26.81).

Maryland's 2020 business-as-usual GHG emissions forecast is 135.68 million metric tons of CO₂e. This represents a 27 percent increase over the 2006 actual baseline. This forecast does not include any measures to reduce GHG emissions that were implemented after 2006.

The 2020 GHG reduction target is calculated by subtracting where we need to be in 2020 (25 percent below the 2006 baseline, or 80.42 million metric tons of CO₂e) from the 2020 business-as-usual forecast (135.68 million metric tons of CO₂e). Therefore, the 2020 reduction target required under GGRA and as outlined in the *2012 GGRA Plan* is 55.26 million metric tons of CO₂e.

2020 Goal Revision

The *2015 GGRA Plan Update* quantifies and includes reductions attributable to market forces. These non-programmatic reductions include six sources of emissions that are constantly fluctuating (Table 4-3). Since the 2006 baseline year, CO₂ emissions in Maryland have decreased because electricity generation and industrial sources are using more natural gas instead of coal (natural gas emits half the amount of CO₂ as coal when used to make electricity). The sluggish U.S. economy also contributed to the decline in CO₂ emissions from transportation, manufacturing, and electricity generation. Further, predictions of vehicle miles traveled (VMT) for Marylanders corrected through the use of the updated Motor Vehicle Emission Simulator (MOVES) modeling tool, and the forecasted per-capita waste generation rate was determined to be over-estimated in 2012, with the emissions benefits from increased recycling and reuse being adjusted for 2015.

Table 4-3. Market Force Reductions.

Market Force	Potential GHG Emission Reductions (MMtCO₂e) Revised for 2015
PJM Fuel Mix Changes	3.06
Other Electricity Sales Reductions	4.59
New Maryland Natural Gas Plants	4.04
Maryland Coal Retirements	2.19

Source (Solid Waste) Reductions	3.60
Forecasted VMT Related Reduction (True-Up)	3.12
Total	20.60

In accounting for these market force reductions, the 2020 GGRA goal has been revised for the *2015 GGRA Plan Update* to be **34.66 MMtCO₂e** as described in Table 4-4.

Table 4-4. 2020 GGRA Goal Revision.

	Potential GHG Emission Reductions (MMtCO₂e) Revised for 2015
2020 Goal described in <i>2012 GGRA Plan</i>	55.26
Market Force Reductions described in <i>2015 GGRA Plan Update</i>	20.60
Revised 2020 Goal	34.66

Chapter 5: Summary of Reduction Programs

Frequently Used Abbreviations and Acronyms

BWI: Baltimore Washington International Airport

CO₂-equivalent: Carbon Dioxide Equivalent

DGS: Maryland Department of General Services

DHCD: Maryland Department of Housing and Community Development

DNR: Maryland Department of Natural Resources

COMMERCE: Maryland Department of Commerce

EPA: U.S. Environmental Protection Agency

GGRA: Greenhouse Gas Emissions Reduction Act of 2009

GHG: Greenhouse Gas

HVAC: Heating, Ventilation and Air Conditioning

MACT: Maximum Achievable Control Technology

MARC: Maryland Area Regional Commuter

MDA: Maryland Department of Agriculture

MDE: Maryland Department of the Environment

MDP: Maryland Department of Planning

MDOT: Maryland Department of Transportation

MEA: Maryland Energy Administration

MIA: Maryland Insurance Administration

MMtCO₂e: Million Metric Tons of CO₂-equivalent

PJM: Pennsylvania Jersey Maryland Interconnection, LLC

PSC: Maryland Public Service Commission

REC: Renewable Energy Credit

RGGI: Regional Greenhouse Gas Initiative

RPS: Maryland Renewable Energy Portfolio Standard

VMT: Vehicle Miles Traveled

Strategies, Programs and Initiatives

This chapter summarizes the various strategies, programs and initiatives that the State is developing and implementing to meet the GGRA's GHG emissions reductions and economic benefits goals. Some of the *2015 GGRA Plan Update*'s strategies are already being implemented in full, while others are in an earlier phase of the implementation process. The suite of programs encompass eight sectors and each program has been updated for 2015 to include any enhancements from the *2012 GGRA Plan* that have been achieved, revised estimated emissions reductions, revised estimated economic and job benefits, summaries of progress including current implementation efforts and concerns, and, where applicable, recommendations for additional enhancements to the program by the lead agency.

Through the emissions inventory and forecast analysis, the 25 percent reduction in Statewide GHG emissions from 2006 levels by 2020 goal of the GGRA has been calculated to be 34.66 MMtCO₂e. The combined emissions reductions of all programs in the *2015 GGRA Plan Update* will yield a total of 38.37 MMtCO₂e in emissions reductions. This will exceed the GGRA 2020 goal by 3.71 MMtCO₂e. Table 5-1, Strategy Assigned Reductions, summarizes the Plan's strategies and programs and their associated GHG emissions reductions benefits.

Notes on Specific Facets of the 2015 GGRA Plan Update

Uncertainties in Emission Quantification: Overlapping Programs and Evolving Quantification Techniques

In determining the estimated emissions reduction benefit of each of the programs in this report, overlap of program reductions and emission quantification uncertainties were taken into consideration. For example, the benefits of a recycling program overlap with the benefits of a heavy-duty truck program as both programs have an impact on truck traffic. As an example of other uncertainties, the report estimates how natural resources such as forests, other vegetation and geological formations act as sinks. Several ideas were considered in estimating the emission reduction potential from the geological opportunities to store carbon in Maryland. Analyzing the uncertainty of carbon sinks on GHG concentrations included a close look at the location and size of forested properties, species composition, forest age, estimates of forest cover; and any forest management practices currently employed. Given that this emerging practice has no formal guidelines, best practices were used. A detailed inventory of forested land in Maryland was used along with current sequestration rates and emission sinks calculations. For these reasons, 30 percent of the emission reduction benefits from many of the programs in this plan have been discounted or removed to ensure double counting did not occur and that uncertainties in emission reduction quantification are considered.

However, this percent reduction was made based on the best estimates available when calculating individual program reductions and is by no means the result of an exact science. As such, MDE has examined overlap issues and other uncertainties and believes a more appropriate

approach for dealing with uncertainty is to continue to use the conservative 30 percent reduction benefit discount, but to also show reductions using a less conservative uncertainty factor of 10 percent. MDE believes this approach is the best way to convey this important, but largely unknown issue. MDE has not applied the uncertainty factors to the estimated reduction benefits for programs that are part of the Energy and Transportation sectors. These sectors already have substantial overlap and uncertainty analyses included as part of their methodologies, so the overlap range discussed above has been applied to programs within the other sectors described in this plan.

Table 5-1 provides an overall summary of GGRA programs, emission reductions by 2020 and which State Agency is responsible for implementation.

Table 5-1. GGRA Programs and 2020 Emission Reductions.

Program I.D.	Program	Lead Agency	Potential GHG Emission Reductions (MMtCO₂e) Revised for 2015
ENERGY			
A	EmPOWER Maryland	-	7.24
A.1	EmPOWER Maryland: Energy Efficiency in the Residential Sector	MEA	Included in A
A.2	EmPOWER Maryland: Energy Efficiency in the Commercial and Industrial Sectors	MEA	Included in A
A.3	EmPOWER Maryland: Energy Efficiency in Appliances and Other Products	MEA	Included in A
A.4	EmPOWER Maryland: Utility Responsibility	MEA	Included in A
A.5	Combined Heat and Power	MEA	Included in A
B	The Maryland Renewable Energy Portfolio Standard (RPS)	-	4.13
B.1	The Maryland Renewable Energy Portfolio Standard (RPS) Program	MEA	4.13
B.2	Fuel Switching	MEA	Included in B
B.3	Incentives and Grant Programs to Support Renewable Energy	MEA	Included in B
B.4	Offshore Wind Initiatives to Support Renewable Energy	MEA	Included in B
C	The Regional Greenhouse Gas	MDE	3.60

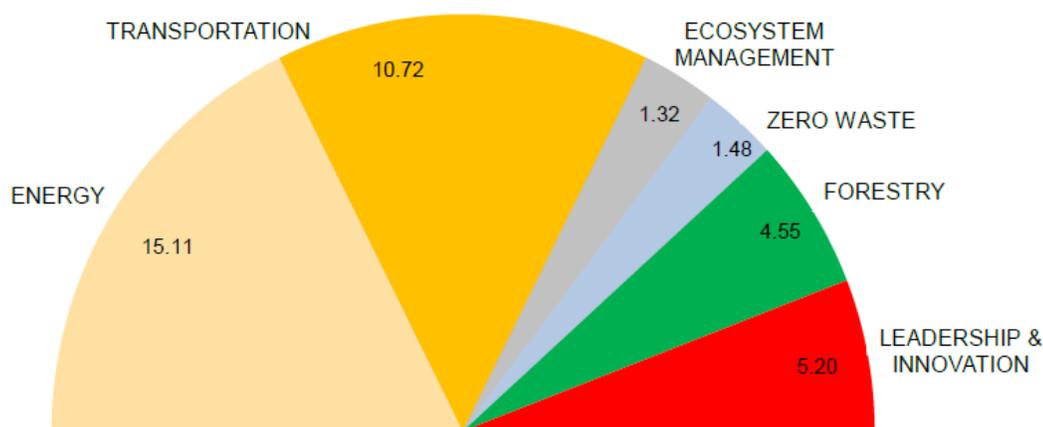
	Initiative (RGGI)		
D	Other Energy Programs	-	0.14
D.1	GHG Power Plant Emission Reductions from Federal Programs	-	-
D.1.A	Boiler Maximum Achievable Control Technology (MACT)	MDE	0.07
D.1.B	GHG New Source Performance Standard	MDE	Included in D.1
D.1.C	GHG Prevention of Significant Deterioration Permitting Program	MDE	Included in D.1
D.2	Main Street Initiatives	DHCD	0.05
D.3	Energy Efficiency for Affordable Housing	DHCD	0.02
TRANSPORTATION			
E	Transportation Technologies	-	6.88
E.1	Motor Vehicle Emission and Fuel Standards	-	5.57
E.1.A	Maryland Clean Cars Program	MDE	Included in E.1
E.1.B	Corporate Average Fuel Economy Standards (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
F	Public Transportation	-	1.85
F.1	Public Transportation Initiatives	MDOT	1.85
F.2	Intercity Transportation Initiatives	MDOT	Included in F.1
G	Pricing Initiatives	MDOT	1.99
H	Other Innovative Transportation Strategies/Programs	-	Included in F.1
H.1	Evaluating the GHG Emissions	MDE	Included in F.1

	Impact of Major New Transportation Projects		
H.2	Bike and Pedestrian Initiatives	MDOT	Included in F.1
AGRICULTURE AND FORESTRY			
I	Forestry and Sequestration	-	4.55
I.1	Managing Forests to Capture Carbon	DNR	1.80
I.2	Planting Forests in Maryland	DNR	1.79
I.3	Creating and Protecting Wetlands and Waterway Borders to Capture Carbon	DNR	0.43
I.4	Biomass for Energy Production	DNR	0.33
I.5	Conservation of Agricultural Land for GHG Benefits	MDA	0.18
I.6	Increasing Urban Trees to Capture Carbon	DNR	0.02
I.7	Geological Opportunities to Store Carbon	DNR	Included in I
J	Ecosystems Markets	-	0.68
J.1	Creating Ecosystems Markets to Encourage GHG Emission Reductions	DNR	0.11
J.2	Nutrient Trading for GHG Benefits	MDA	0.57
BUILDING			
K	Building and Trade Codes in Maryland	DHCD	3.15
RECYCLING			
L	Zero Waste	MDE	1.48
MARYLAND'S INNOVATIVE INITIATIVES			
M	Leadership-By-Example	-	1.78
M.1	Leadership-By-Example: State of Maryland Initiatives	DGS	0.56
M.2	Leadership-By-Example: Maryland Colleges and Universities	MDE	0.56
M.3	Leadership-By-Example: Federal Government	MDE	0.41

M.4	Leadership-By-Example: Local Government	MDE	0.25
N	Maryland's Innovative Initiatives	-	0.21
N.1	Voluntary Stationary Source Reductions	MDE	0.17
N.2	Buy Local for GHG Benefits	MDA	0.02
N.3	Pay-As-You-Drive® Insurance in Maryland	MIA	0.02
N.4	Job Creation and Economic Development Initiatives Related to Climate Change	COMMERCE	Included in N
O	Future or Developing Programs	-	0.02
O.1	The Transportation and Climate Initiative	MDE/ MDOT	0.02
O.2	Clean Fuels Standard	MDE	0.00
LAND USE			
P	Land Use Programs	-	0.64
P.1	Reducing Emissions through Smart Growth and Land Use/Location Efficiency	MDP	Included in P
P.2	Priority Funding Area (Growth Boundary) Related Benefits	MDP	Included in P
PUBLIC			
Q	Outreach and Public Education	MDE	0.03
TOTAL EMISSIONS REDUCTIONS			
TOTAL			38.37
GGRA 2020 GOAL			34.66
2020 REDUCTIONS OVER GGRA GOAL			3.71

Note: Only bolded numbers are used in the calculation of totals.

Figure 5-1 illustrates the 2015 GGRA Plan Update's emissions reductions in a dashboard format grouped by sector.



MMt CO₂e Reduction from 2006 Baseline

Figure 5-1. GHG Emission Reduction Dashboard.

Key Strategies and Programs

A handful of key strategies and programs will drive the majority of Maryland's GHG emissions reductions:

1. EmPOWER Maryland:

Enacted in 2008, the EmPOWER Maryland Energy Efficiency Act (EmPOWER) set a target to reduce both Maryland's per capita total electricity consumption and peak load demand by 15 percent below 2007 levels by 2015. EmPOWER includes numerous State and utility managed energy efficiency and conservations programs. By 2020, EmPOWER programs should contribute 7.24 MMtCO₂e in emissions reductions.

2. Maryland Clean Cars Program:

Enacted into law on November 19, 2007, the Maryland Clean Cars Program adopted California's stricter vehicle emission standards, the first program in the nation to directly regulate CO₂ emissions from motor vehicles. These standards became effective in Maryland for model year 2011 vehicles, significantly reducing a number of emissions including volatile organic compounds (VOCs) and nitrogen oxides (NO_x). By adopting the more stringent California standards, significant reductions in both localized pollution and greenhouse gases will be achieved. GHG emissions from the Maryland Clean Cars Program have been aggregated with the calculations for the Motor Vehicle Emission and Fuel Standards program group, which should reduce the State's GHG emissions by 5.57 MMtCO₂e by 2020.

3. Corporate Average Fuel Economy (CAFE) Standards, Model Years 2008-2011: First enacted by Congress in 1975, the purpose of the CAFE standard is to reduce energy consumption

by increasing the fuel economy of cars and light trucks. Since introduction in 1975, CAFE standards have increased from the initial 18 miles per gallon standard to 35 miles per gallon by 2020, as established in the federal Energy Independence and Security Act of 2007. GHG emissions reductions from projected CAFE increases have been aggregated with the calculations for the Motor Vehicle Emission and Fuel Standards program group, which should reduce the State's GHG emissions by 5.57 MMtCO₂e by 2020.

4. The Maryland Renewable Energy Portfolio Standard (RPS) Program:

Maryland became one of the first states to adopt a Renewable Energy Portfolio Standard (RPS) in 2004. Requiring that power providers buy a growing portion of electricity supplied from renewable sources, the intent of this law is to establish a market for new sources of mostly in-state renewable electricity generation and to recognize the economic, environmental, fuel diversity, and security benefits of renewable energy resources. In 2020 the law requires that Maryland attain 18 percent of its electricity from renewable sources, increasing to 20 percent renewables by 2022. By 2020, Maryland's RPS program should contribute 4.13 MMtCO₂e in emissions reductions.

5. The Regional Greenhouse Gas Initiative (RGGI):

The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort by nine Northeast and Mid-Atlantic States to design and implement a regional cap-and-trade program to reduce carbon dioxide emissions from power plants in the region. RGGI serves as the framework program by which the EmPOWER and RPS programs are implemented. With efforts to strengthen RGGI already implemented, the RGGI program should reduce Maryland's GHG emissions by 3.60 MMtCO₂e by 2020.

6. Building and Trade Codes in Maryland:

Given the long life of most buildings, upgrading State and local building codes to include minimum energy efficiency requirements provides long-term GHG savings. Maryland's Building Performance Standards are updated by regulation every three years following the three-year cycle of the International Code Council. Progressive building and trade codes adjustment in Maryland should contribute to a 3.15 MMtCO₂e reduction in the State's GHG emissions by 2020.

7. Public Transportation Initiatives:

For several decades, vehicle miles traveled has risen faster than the increase in population in Maryland and nationwide, and land use development over the past 40 to 50 years has put more people living beyond the reach of easy access to transit facilities. By 2020, public transportation initiatives in Maryland should contribute 1.85 MMtCO₂e in emissions reductions.

8. Managing Forests to Capture Carbon:

Managing forests to capture carbon will promote sustainable forestry management practices in existing Maryland forests on both public and private lands. The enhanced productivity resulting from enrolling unmanaged forests into management regimes will increase rates of carbon dioxide sequestration in forest biomass, increase amounts of carbon stored in harvested, durable wood

products which will result in economic benefits, and increased availability of renewable biomass for energy production. Enhanced forestry management in Maryland should contribute to a 1.80 MMtCO₂e reduction in the State's GHG emissions by 2020.

9. Planting Forests in Maryland:

Planting trees expands forest cover and associated carbon stocks by regenerating or establishing healthy, functional forests through practices such as soil preparation, erosion control, and supplemental planting, to ensure optimum conditions to support forest growth. By 2020, the implementation goal is to achieve the afforestation and/or reforestation of 43,030 acres in Maryland by 2020. Achieving the 43,030 acre target should reduce GHG emissions in the State by 1.79 MMtCO₂e by 2020.

10. Zero Waste:

Zero Waste is a concept that calls for the near complete elimination of solid waste sent to landfills or incinerators for disposal, and where, instead, the vast majority of Maryland's solid waste is reused, recycled, composted, or prevented through source reduction. By 2020, Maryland's zero waste efforts should contribute 1.48 MMtCO₂e in emissions reductions.

The Energy Sector

Table 5-2. Energy Sector GHG Reduction Programs.

ENERGY		
Program I.D.	Program	Potential GHG Emission Reductions (MMtCO₂e) Revised for 2015
A	EmPOWER Maryland	7.24
B	The Maryland Renewable Energy Portfolio Standard (RPS)	4.13
C	The Regional Greenhouse Gas Initiative (RGGI)	3.60
D	Other Energy Programs	0.14
Total		15.11

A. EmPOWER Maryland

Program Description

Created by a 2007 Executive Order and codified by the General Assembly during the 2008 Session, EmPOWER Maryland is designed to reduce per capita electricity consumption and peak demand by Maryland consumers by 15 percent by 2015. While the EmPOWER Maryland suite of energy efficiency programs is funded in part with revenue paid into the Strategic Energy Investment Fund (SEIF) from the auction of RGGI allowances, the vast majority of programmatic savings and revenues come from monies collected by the utilities on ratepayers' bills.

Maryland's EmPOWER statute requires that at least 10 percent of the 2015 consumption target come from utility programs, which must be approved in advance by the Public Service Commission (PSC). In addition to these utility managed programs, MEA's programs and other State efforts are intended to close the gap towards the overall program goal.¹⁸ MEA works

¹⁸ The SEIF fund was created by legislative act of the General Assembly, "Regional Greenhouse Gas Initiative – Maryland Strategic Energy Investment Program", Public Utility Companies Article, § 7-701 et seq., Annotated Code of Maryland (Senate Bill 268/House Bill 368, General Assembly 2008). A portion of the fund is allocated to the MEA to administer programs in the residential, commercial and industrial sectors to reduce consumer demand for electricity and natural gas by five percent by 2015 through energy efficiency measures. The utility-run EmPOWER programs are mandated by "EmPOWER Maryland Energy Efficiency Act of 2008", Public Utility Companies Article, § 7-211, Annotated Code of Maryland (House Bill 374, General Assembly 2008). The law requires utilities to reduce per capita electricity consumption in Maryland by 10 percent by 2015 and per capita peak demand by 15

closely with the State’s electric utilities and the PSC in program design. While MEA is the lead State agency responsible for non-utility EmPOWER programs, the PSC is responsible for ensuring the utilities meet their goal.

In July 2015, the PSC issued an order directing the continuation of utility programs supporting EmPOWER Maryland energy reduction policy and set new savings targets that will extend beyond the original 2015 goals in the EmPOWER Maryland statute. In its order, the PSC directed utilities to ramp up electricity savings to 2% of gross sales¹⁹ for as long as cost-effective savings continue to be available. The PSC also directed workgroups to recommend by February 1, 2016, separate goals for natural gas savings and limited-income programs savings. Savings can come from a variety of sources, including traditional equipment-based measures, “smart meter” enabled analytics, and more efficient distribution grid hardware. Utilities will be reviewing their current plans and proposing modifications as needed to meet the new goals.

While the PSC order does not specifically contemplate a separate savings goal for non-utility entities, MEA and other state agencies will continue to work closely with the PSC and Maryland utilities to ensure that programs are effectively designed and implemented. Additionally, MEA and DGS continue to work on efforts to reduce energy use in State buildings.

More detail on EmPOWER Maryland’s programs is provided below. The methodology for estimating the reduction in GHG emissions from the programs is in Appendix C of this report.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the EmPOWER programs in 2020 are estimated to be 7.24 MMtCO₂e. Because these programs are all related, MEA has aggregated the potential emission reductions from the full set of programs. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI’s 2015 Study estimated that the EmPOWER Maryland programs, once fully operational, would support an aggregated total of 7,551 to 7,666 jobs by 2020, \$5,646,584,190 to

percent by 2015 by implementing energy efficiency programs targeted to consumers. Together, the EmPOWER Maryland law and the law creating the SEIF fund target a 15 percent reduction in per capita electricity consumption and per capita peak demand by 2015.

¹⁹ This is not equivalent to requiring that total electricity sales decrease by 2% a year. Instead, it requires verified savings to be equivalent to 2% of the most recent baseline year’s weather-normalized gross sales. For example, if a utility’s most recently baseline year’s weather-normalized gross sales were 1,000,000 MWh, their electricity savings target would be 20,000 MWh (2% of 1,000,000).

\$6,217,799,076 in net economic output and \$2,673,446,659 to \$2,697,771,512 in wages over the lifetime of the programs. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with the EmPOWER Maryland programs.

Implementation

The underlying authority for the PSC to order cost-effective and appropriate energy efficiency and conservation programs is found in Public Utilities Article §7-211 of the Annotated Code of Maryland. Additionally, SEIF funding for energy efficiency programs is mandated in State law, specifically State Government Article, §9-20B of the Annotated Code of Maryland.

As of the end of 2014, programs supporting energy efficiency and demand response in Maryland have resulted in:

- 4.4 million MWh of annual savings
- 1,700 MW of demand reduction capability
- Over 1.7 million measures for residential customers (excluding light bulbs)
- 34 million efficient light bulbs rebated

Opportunities:

- C&I performance has historically lagged residential performance, but a renewed focus by utilities provides a good opportunity for highly cost-effective savings
- Financing programs that allow customers to pay back over time are showing early promise
- Natural gas programs are still in very early stages and have greater potential in the future
- 2015-2017 programs continue to be very highly cost effective, indicating that considerable future savings exist
 - Delivering lifecycle savings at around 3.5-4.5 cents/kWh, compared to supply costs in the 8.0-10.0 cents/kWh range
 - TRC in the 1.7-1.9 range
- AMI will enable new, data-driven savings programs
 - Building analytics, new behavioral programs, etc.

Challenges:

- The bulk of program savings are driven by the efficacy of utility implementation and are subject to PSC budget approval
- While programs are required to be collectively cost-effective, the EmPOWER surcharge has increased over time
 - That said, rate impacts and bill impacts are not equivalent and both need to be monitored closely
- Stricter federal standards erode attributable savings in the cost effectiveness testing methodology
- Efficient Lighting (CFL/LED) saturation is increasing
- Electrification of transportation may provide headwind

- GHG savings offset in Transportation module, and effect likely small in the near term

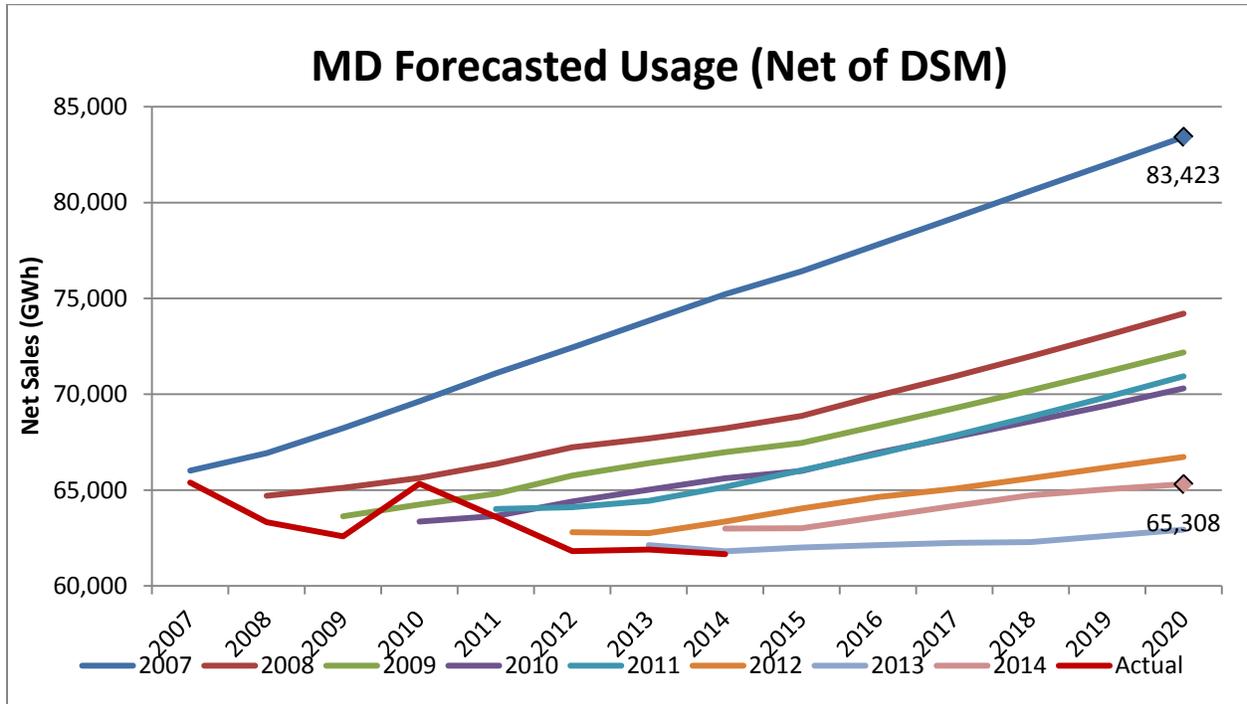


Figure 5-2. GGRA Plan Projections – EmPOWER. Recession/EmPOWER flattened and lowered forecasts. Over 18,000 GWh by 2020 between 2007 and 2014* forecast. 2015-2017 programs not fully incorporated into 2014 forecast.

* Listed year indicates version of PSC Ten Year Plan. Actual sales from EIA.

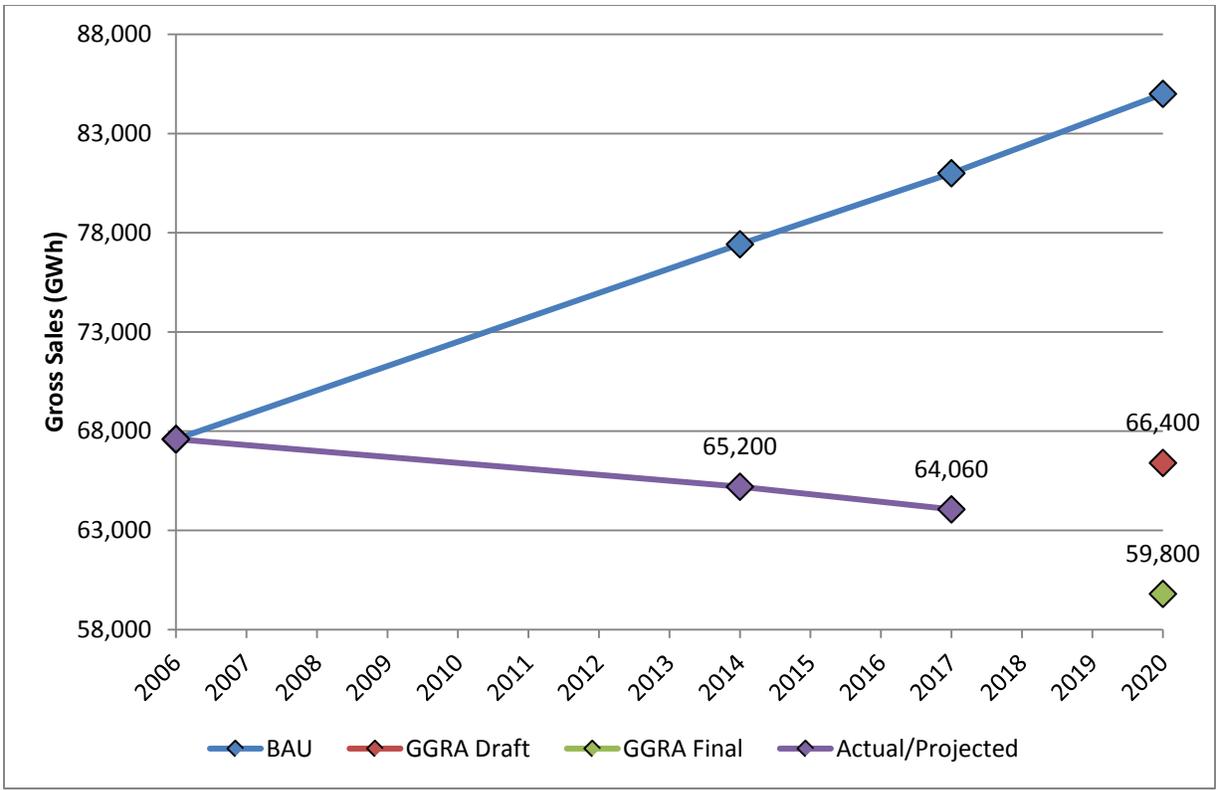


Figure 5-3. GGRA Plan Projections – EmPOWER.

A.1. EmPOWER Maryland: Energy Efficiency in the Residential Sector

Lead Agency: MEA

Program Description

The State’s residential energy efficiency initiatives are part of the EmPOWER Maryland suite of energy efficiency programs and are administered primarily by MEA using SEIF revenues. Programs funded and administered through other State agencies, including the DHCD, and federally-funded energy efficiency programs contribute to the 2015 EmPOWER goal. Together with programs implemented by the utilities, the State’s programs in all sectors, including residential, commercial and industrial, are intended to help achieve the EmPOWER Maryland goal of a 15 percent reduction in per capita energy use by 2015 and to contribute to continued reductions in energy use and GHG beyond 2015.

More information about these programs can be found at:

<http://energy.maryland.gov/Residential/index.html>

A.2. EmPOWER Maryland: Energy Efficiency in the Commercial and Industrial Sectors

Lead Agency: MEA

Program Description

MEA's commercial and industrial energy efficiency programs support or compliment the EmPOWER Maryland suite of energy efficiency programs. MEA administers four programs that target energy efficiency improvements in the commercial and industrial sectors, which represent approximately 58 percent of electricity consumption in Maryland. These programs offer incentives for energy audits and funding for upgrades. The four programs are: 1) DOE Save Energy Now; 2) the Lawton Loan Program; 3) C/I Deep Retrofits; and 4) the State Agencies Loan Program.

A.3. EmPOWER Maryland: Energy Efficiency in Appliances and Other Products

Lead Agency: MEA

Program Description

While MEA no longer runs appliance and equipment rebate programs for homeowners, it does administer low-interest loans for residential and commercial energy efficiency improvements, which may include appliances, equipment and lighting.

A.4. EmPOWER Maryland: Utility Responsibility

Lead Agency: MEA

Program Description

EmPOWER Maryland mandated that the PSC require each utility to propose cost-effective energy efficiency, conservation, and demand response programs designed to achieve targeted per capita energy reductions of at least five percent by the end of 2011 and at least 10 percent by the end of 2015, in addition to a 15 percent per capita peak demand reduction.

In July 2015, the PSC issued an order directing the continuation of utility programs supporting EmPOWER Maryland and set new savings targets that will extend beyond the original 2015 goals in the EmPOWER Maryland statute. In its order, the PSC directed utilities to ramp up

electricity savings to 2% of gross sales²⁰ as long as cost-effective savings continue to be available. The PSC also directed workgroups to recommend by February 1, 2016, separate goals for natural gas savings and low- and moderate-income sector savings. Savings can come from a variety of sources, including traditional equipment-based measures, “smart meter” enabled analytics, and more efficient distribution grid hardware. Utilities will be reviewing their current plans and proposing modifications as needed to meet the new goals.

The six participating utilities are Potomac Edison (formerly known as Allegheny Power); Baltimore Gas and Electric (BGE); Delmarva Power and Light; Potomac Electric Power Company (Pepco); and Southern Maryland Electric Cooperative (SMECO). These utilities are responsible for two thirds of the 2015 EmPOWER 15 percent energy consumption reduction goal and all of the peak demand reduction goal, as well as the total post-2015 goals established by the PSC in July 2015. Energy savings targets are spread amongst all customer classes, including low-to-moderate income customers.

A.5. Combined Heat and Power

Lead Agency: MEA and MDE, in coordination with other State agencies

Program Description

Combined heat and power, also called co-generation, is a technology designed to generate both power and thermal energy from a single fuel source. A combined heat and power system recovers waste heat from thermal energy used in industrial processes and electricity generation and uses it for heating or cooling, achieving thermal efficiency levels of up to 80 percent. The increased efficiency means more useful energy is generated from a single fuel source. Therefore, GHG emissions from a combined heat and power system are less than from a typical system which produces electric and thermal energy separately. Expanding the use of these systems can greatly increase a facility’s level of energy efficiency and decrease energy costs. Moreover, combined heat and power is an efficient, clean, and reliable approach to generating power while also reducing GHG emissions. The five EmPOWER utilities received approval from the PSC to run combined heat and power programs in the spring of 2012. Several new projects are underway and efforts continue to recruit new potential customers.

This is a voluntary program.

B. The Maryland Renewable Energy Portfolio Standard (RPS)

Program Description

²⁰ This is not equivalent to requiring that total electricity sales decrease by 2% a year. Instead, it requires verified savings to be equivalent to 2% of the most recent baseline year’s weather-normalized gross sales. For example, if a utility’s most recently baseline year’s weather-normalized gross sales were 1,000,000 MWh, their electricity savings target would be 20,000 MWh (2% of 1,000,000).

The Maryland Renewable Energy Portfolio Standard (RPS) is a law that requires Maryland to obtain 20 percent of its electricity from renewable sources, as defined by statute, by 2022, with a solar carve-out which requires that two percent be obtained from solar energy generation by 2020. The RPS incentivizes the development of renewable energy by requiring electricity suppliers to meet a prescribed portion of their energy supply needs using renewable energy sources. Energy suppliers are required to purchase Renewable Energy Credits (RECs) to demonstrate compliance with the RPS. The State also runs a number of other incentive programs to support renewable energy and achieve the RPS goal. Collectively, the RPS compliance program and the State incentive programs constitute the RPS bundle of programs. The State recognizes the significant environmental and consumer benefits associated with renewable energy and is facilitating development of a diversity of renewable energy sources.

The original RPS legislation was adopted in 2004 and has been amended a number of times, in 2007, 2008, 2010, 2011 and 2012.²¹

²¹ Original 2004 RPS legislation:

- “Electricity Regulation - Renewable Energy Portfolio Standard and Credit Trading - Maryland Renewable Energy Fund” (SB869/HB 1308, 2004 Session).

Subsequent legislation amending the RPS law:

- “Net Energy Metering - Renewable Energy Portfolio Standard - Solar Energy” ([SB595](#), 2007 Session) added a provision requiring electricity suppliers to derive 2% of electricity sales from solar energy in addition to the 7.5% renewables derived from other Tier 1 resources as outlined in the initial RPS law.
- “Renewable Portfolio Standard Percentage Requirements – Acceleration” (SB209/HB375, 2008 Session) increased Maryland’s RPS percentage requirements to 20 percent by 2022, including a two percent level for solar, restricted the geographic scope in which renewable resources can be obtained for compliance, and increased the fee charged to electric suppliers for shortfalls.
- “Renewable Energy Portfolio Standard – Tier 1 Renewable Source – Poultry Litter” (SB348/HB1166, 2008 Session) added poultry litter to the list of Tier 1 renewable energy sources eligible for inclusion in meeting the State’s RPS.
- “Renewable Energy Portfolio Standard - Solar Energy” (HB 471/SB 277, 2010 Session) accelerated Maryland’s RPS requirements for solar energy in the early years (2011 – 2017), while leaving unchanged the RPS’s 2022 goal of two percent for solar.
- “Renewable Energy Portfolio - Waste-to-Energy and Refuse-Derived Fuel” (SB690/HB1121, 2011 Session) added waste-to-energy and refuse-derived fuel to the list of Tier 1 renewable energy sources eligible for inclusion in meeting the State’s RPS, provided the source is connected with the distribution grid serving Maryland.
- “Renewable Energy Portfolio Standard - Renewable Energy Credits Solar Water Heating Systems” (SB717/HB 933, 2011 Session) added solar hot water systems to the list of Tier 1 renewable energy sources eligible for inclusion in meeting the State’s RPS.
- “Renewable Energy Portfolio Standard – Solar Energy and Solar Water Heating Systems” (SB791/HB1187, 2012 Session) accelerated the two percent solar carve-out compliance schedule and moved up the final target date for achieving the solar carve-out from 2022 to 2020.
- “Renewable Energy Portfolio Standard - Renewable Energy Credits - Geothermal Heating and Cooling” (SB652/HB1186, 2012 Session) added geothermal heating and cooling systems that meet certain standards systems to the list of Tier 1 renewable energy sources eligible for inclusion in meeting the State’s RPS.
- “Renewable Energy Portfolio Standard - Renewable Energy Credits - Thermal Biomass Systems” (SB 1004/HB 1339, 2012 Session) added thermal energy associated with biomass systems that primarily use animal waste (possibly supplemented by other biomass resources) to the list of Tier 1 renewable energy sources eligible for inclusion in meeting the State’s RPS.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the current RPS programs in 2020 are estimated to be 4.13 MMtCO₂e. Because these programs are all related, MEA has aggregated the potential emission reductions from the full set of programs. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Maryland RPS programs, once fully operational, would support an aggregated total of 3,549 to 3,642 jobs by 2020, \$6,427,048,459 to \$6,588,698,029 in net economic output and \$4,236,359,157 to \$4,340,264,666 in wages over the lifetime of the programs. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with the Maryland RPS programs.

Implementation

The RPS is mandated by §§7-701 through §7-713 of the Public Utilities Article of the Annotated Code of Maryland. MEA is the lead State agency on implementation of RPS programs.

As of the end of 2014:

- 7.8 million RECs retired (12.8% of sales)
- 240 MW of solar in Maryland

Opportunities:

- GHG emission reductions will need to be updated if REC purchases exceed imported electricity and should reflect the contractual rather than physical nature of RECs
- Wind and solar continue to come down in overall price
 - New wind turbine technology is better suited to lower wind areas, expanding the potential sites that could be developed economically
 - Solar prices continue to fall at rapid pace, and consumers continue to show growing interest in local solar electricity
- Oversupply of PJM RECs is being absorbed, so the increase in Maryland's RPS is driving new projects and affecting CO₂ intensity in PJM
- EPA's Clean Power Plan 111(d) is likely to be an additional driver of renewable energy in Maryland and beyond

Challenges:

- RPS GHG reduction is a function of quantity (% of sales) and composition (carbon intensity of RECs)
 - Changes in either would require legislation
- EPA Biogenic Carbon Accounting Framework not finalized
 - Considerable debate amongst academics/policy makers how to treat biomass emissions
 - Agreed that timescale of emissions source/sink is critical
 - MDE has chosen to include biogenic emissions at point of consumption
- Expiration of federal PTC for wind and reduction of ITC for solar may present short-term obstacles for the continued deployment of new facilities
- Integrating increasing penetration of solar becomes more technically challenging

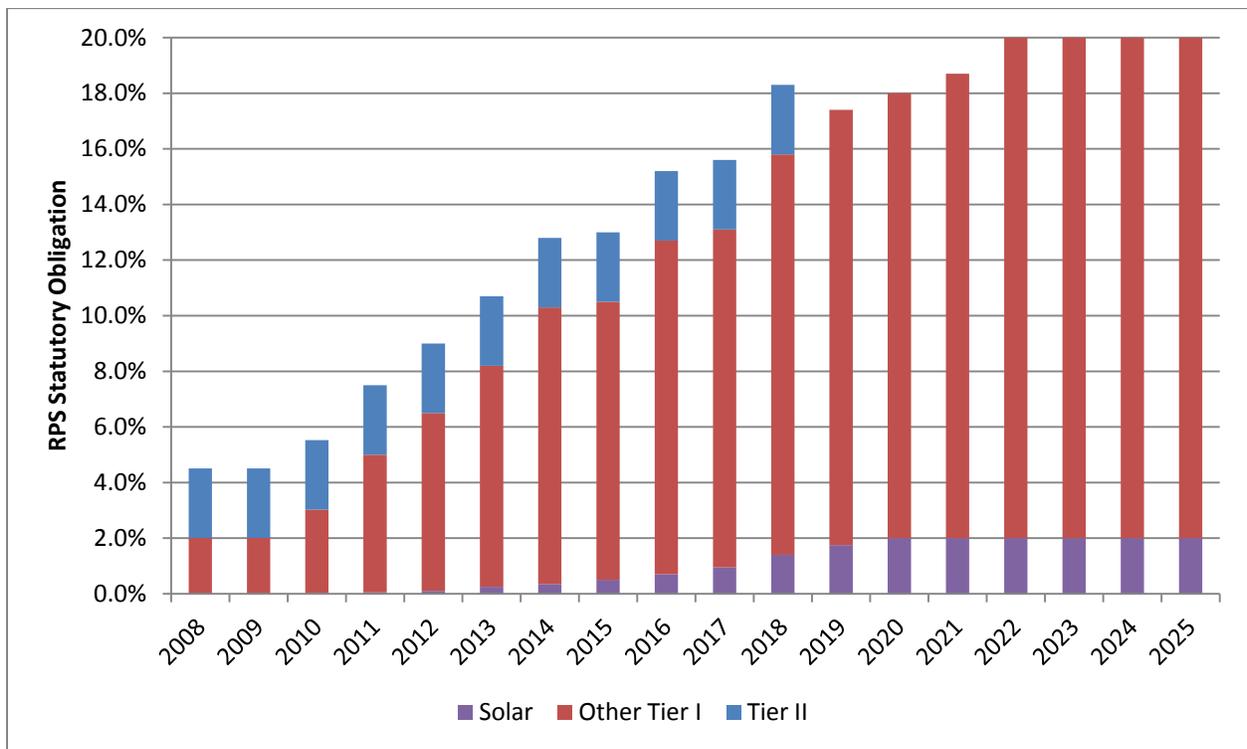


Figure 5-4. Statutory RPS Obligation.

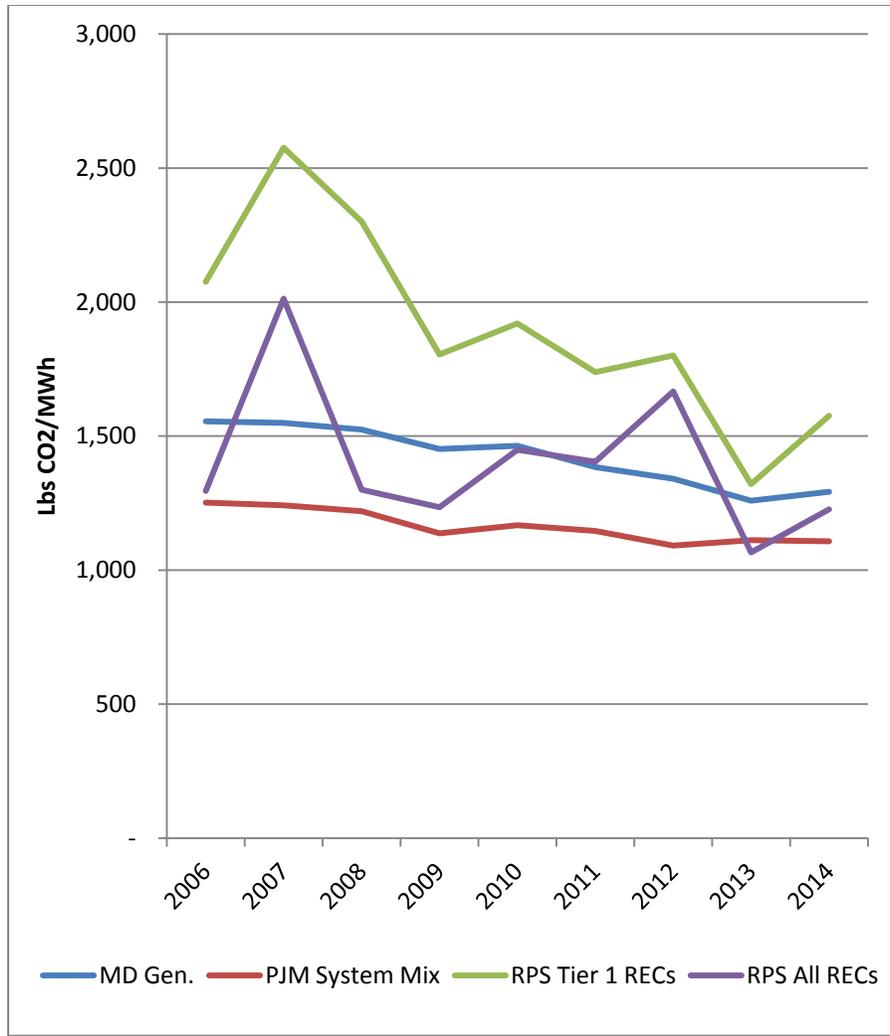


Figure 5-5. Carbon Intensity of Electricity Sources. MD has substantial coal generation, but market factors have affected how they are dispatched. PJM intensity declined even as more coal-intense areas added (Ohio, Kentucky). RPS calculation based on retired REC mix (includes emissions for biomass and WTE). MD Generation from EIA/EPA with WTE emissions added and does not reflect formal GGRA methodology. PJM and RPS from PJM-GATS with EPA emission factors and updated heat rates from prior analysis.

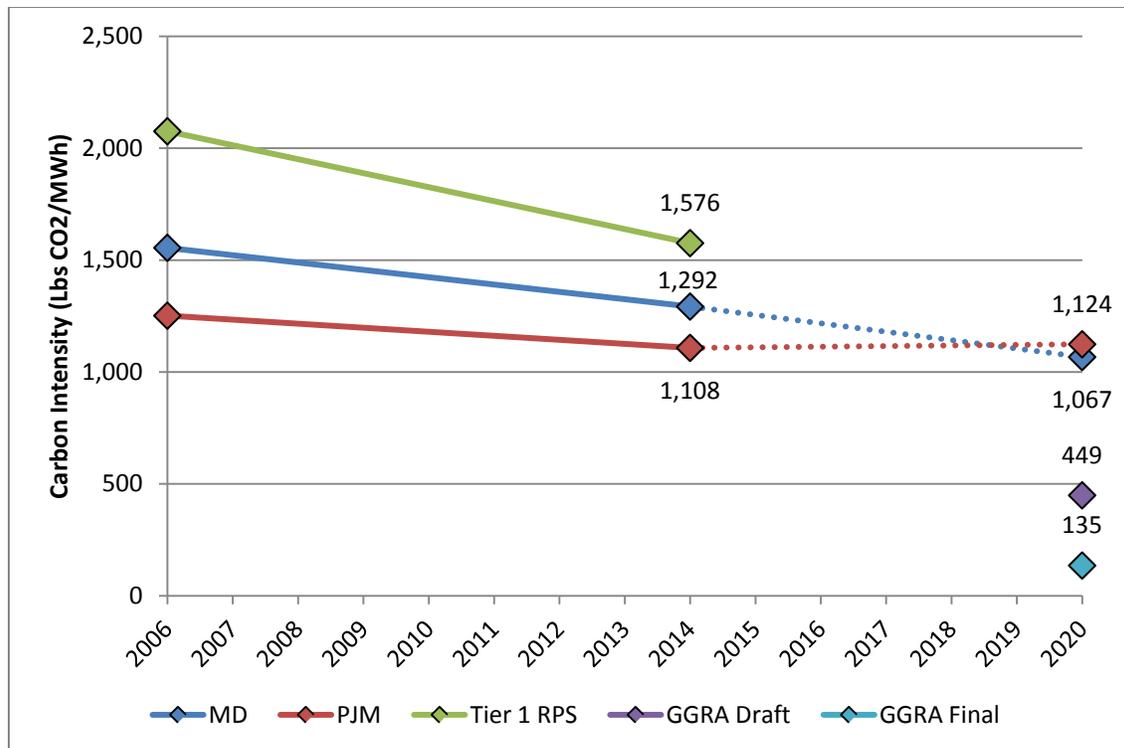


Figure 5-6. GGRA Plan Projections – RPS.

B.1. The Maryland Renewable Energy Portfolio Standard (RPS) Program

Lead Agency: MEA

Program Description

The RPS is implemented through the creation, sale and transfer of RECs. Each REC represents one megawatt of renewably generated electricity. Electricity suppliers are required to purchase RECs to demonstrate they have obtained specified percentages of their energy supply from renewable resources. Sources are classified as Tier 1 and Tier 2. Tier 1 sources consist of: solar, wind, qualifying biomass, qualifying methane, geothermal, ocean, qualifying fuel cell, qualifying hydroelectric power, poultry litter-to-energy, waste-to-energy, and refuse-derived fuel. Non-solar Tier 1 requirements gradually increase to 18 percent in 2020, and then peak in 2022 at 20 percent and are subsequently maintained at that level. Tier 1 includes a solar set-aside requirement that gradually increases until it peaks at 2 percent in 2020. Maryland’s Tier 2 source (eligible hydroelectric power) requirement remains constant at 2.5 percent through 2018, after which it sunsets. The development of renewable energy sources is further promoted by requiring electricity suppliers to pay a financial penalty for failing to acquire sufficient RECs to satisfy the RPS. The penalty is used to support the development of new Tier 1 renewable sources in the State.

The RPS is designed to create a stable and predictable market for renewable energy and to foster additional development and growth in the renewable energy industry.

B.2. Fuel Switching

Lead Agency: MEA

Program Description

For more information on fuel switching, please refer to the introductory section of this chapter. In state fuel switching GHG emissions reductions have been accounted for through Maryland's New Source Performance Standard program, Boiler Maximum Available Control Technology program, and GHG Prevention of Significant Deterioration Permitting Program. Out of state fuel switching GHG emission reductions have been estimated to account for approximately 1 MMtCO₂e.

B.3. Incentives and Grant Programs to Support Renewable Energy

Lead Agency: MEA

Program Description

MEA administers a number of incentives and grant programs to promote and accelerate the development of renewable energy production in Maryland, from utility scale facilities to on-site distributed generation.

These are voluntary incentive based programs. Funding for the incentive and grant programs comes from the Strategic Energy Investment Fund.

B.4. Offshore Wind Initiatives to Support Renewable Energy

Lead Agency: MEA

Program Description

Maryland waters are part of the Mid-Atlantic Bight region, a coastal area spanning from North Carolina to Massachusetts with substantial wind resources located in close proximity to coastal population centers. In fact, this area has the greatest renewable energy potential relative to other U.S. offshore regions in the Gulf of Mexico, Pacific, and Alaska. Research indicates that the potential power supply available from offshore wind substantially exceeds the region's current energy use. Maryland, therefore, has the potential to access large energy resources off the coast that could contribute to meeting future energy demands while simultaneously displacing fossil fuel generation.

Maryland has taken a lead among Mid-Atlantic States working to harness offshore wind resources. The State is moving forward expeditiously to put in place financial support, regulatory parameters, lease conditions, and data-gathering initiatives to support the deployment of a first-phase major offshore wind project in the Maryland Wind Energy Area (WEA).

C. The Regional Greenhouse Gas Initiative (RGGI)

Lead Agency: MDE

Program Description

Maryland is one of nine Northeast and Mid-Atlantic States that participate in the Regional Greenhouse Gas Initiative (RGGI) – a regional market-based cap-and-trade program to reduce CO₂ emissions from fossil-fuel fired power plants in the region.²² RGGI reduces emissions through an emissions cap applied to the nine-state geographic region. Under the initiative, the participating states issue “allowances” equal to the number of tons of CO₂ emissions allowed under the regional cap. A single allowance permits a source to emit one ton of carbon dioxide.

The enhancement to the RGGI program that was proposed in the *2012 GGRA Plan* is now fully adopted as part of the implementing regulations for RGGI.

GHG Emission Reductions in 2020

Revised 2015 Estimate

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 MMtCO₂e.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI’s 2015 Study estimated that RGGI, once fully operational, would support a total of 96 to 1,015 jobs by 2020, \$94,970,706 to \$322,862,295 in net economic output and \$117,721,558 to \$770,226,749 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

²² Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont currently participate in RGGI.

Implementation

The RGGI program is mandated by State law and is fully implemented and enforceable through regulations (COMAR 26.09) adopted and enforced by MDE.

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

Program Description

GHG emissions from the energy supply sector in Maryland include emissions from fossil fuel-fired electricity generation and represent a substantial portion of the State's overall GHG emissions. Electricity demand in Maryland is expected to increase over time and thus, if unmitigated, GHG emissions will also likely increase. Because approximately 40 percent of electricity consumption in Maryland is generated out-of-state in the surrounding Pennsylvania Jersey Maryland Interconnection LLC (PJM) electricity grid region, State programs alone cannot effectively control GHG emissions from power consumed in Maryland.

Existing and proposed federal rules summarized in this section (D.1.A. GHG New Source Performance Standard; D.1.B. Boiler Maximum Achievable Control Technology; and D.1.C. GHG Prevention of Significant Deterioration Permitting Program) are expected to reduce GHG emissions from Maryland and out-of-state power generators.

D.1.A. Boiler Maximum Achievable Control Technology (MACT)

Lead Agency: MDE

Program Description

EPA has adopted new air emissions requirements for industrial, commercial, and institutional boilers under two separate rulemakings.²³ The first, which took effect January 31, 2013, establishes national emission standards for Hazardous Air Pollutants (HAPs) for major sources.²⁴

²³ Boilers burn fuel, including natural gas, fuel oil, coal, biomass (e.g., wood), or other gas to produce steam or hot water. The steam is used to produce electricity, drive an industrial process, or provide heat. Emissions from burning the fuel can include toxic air pollutants like mercury, lead and particle pollution.

²⁴ "National Emission Standards for Hazardous Air Pollutants for Major sources: Industrial, Commercial, and Institutional Boilers and Process Heaters", 78 Fed. Reg. 7138 (January 31, 2103).

The rule affects thousands of boilers and process heaters at facilities nationwide which are considered as major sources of HAPs. These facilities also emit GHGs.

The Boiler MACT rule applies to any stationary source with a boiler or group of stationary sources with boilers that emit 10 tons per year of any single HAP or 25 tons per year of any combination of HAPs. The rule requires each boiler to meet pollution emission limits on an annual and continuous basis.

EPA also issued a Boiler MACT rule for smaller “area sources”, which took effect February 1, 2013.²⁵

Among other things, the Boiler MACT rules require operators to conduct a boiler tune-up to improve efficiency, minimize fuel consumption and reduce emissions. EPA estimates there will be a one percent fuel savings due to the tune-ups, which equates to an equivalent one percent reduction in GHG emissions.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Boiler MACT program in 2020 are estimated to be 0.07 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI’s 2015 Study estimated that the Boiler MACT program, once fully operational, would support a total of 89 jobs by 2020, \$76,106,574 in net economic output and \$86,578,365 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

MDE will adopt State regulations to implement the federal requirements.

D.1.B. GHG New Source Performance Standard

Lead Agency: MDE

²⁵ “National Emission Standards for Hazardous Air Pollutants for Area Sources: Industrial, commercial, and Institutional Boilers”. 78 Fed. Reg. 7488 (February 1, 2013).

Program Description

The U.S. Environmental Protection Agency (EPA) is using the New Source Performance Standard authority under the federal Clean Air Act to promulgate new regulations to reduce GHG emissions from fossil fuel-fired power plants. The performance standards, which are expected to become final in early 2013, will apply to new electric generating units and will be based on existing technologies. EPA is coordinating this action on GHGs with a number of other required regulatory actions for other pollutants, thereby enabling electric generating units to develop multi-pollutant strategies to reduce pollutants in a more efficient and cost-effective way than would be possible by addressing multiple pollutants separately.

GHG Emission Reductions in 2020

Revised 2015 Estimate

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.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the GHG New Source Performance Standard program, once fully operational, would support a total of 40 jobs by 2020, \$33,142,090 in net economic output and \$13,839,722 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

After EPA adopts the new federal GHG New Source Performance Standard, MDE and other State agencies will implement the federal standard through State regulations. EPA is required to implement and enforce the new requirements in any state that does not implement the federal standards.

D.1.C. GHG Prevention of Significant Deterioration Permitting Program

Lead Agency: MDE

Program Description

The Prevention of Significant Deterioration (PSD) program is a federal preconstruction review and permitting program applicable to new major stationary sources and major modifications at existing major stationary sources. It requires the application of Best Available Control Technology (BACT) to control emissions of certain pollutants, which now include GHGs. A BACT determination is based on consideration of a number of factors, including the cost-effectiveness of the controls and the energy and environmental impacts. The BACT requirements apply to all new major sources of GHG emissions and major modifications at GHG emitting facilities. This means that GHG sources subject to the requirements must evaluate and apply currently available measures (and later technology as it develops) to reduce GHG emissions.

GHG Emission Reductions in 2020

Revised 2015 Estimate

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.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the GHG Prevention of Significant Deterioration Permitting Program, once fully operational, would support a total of 3 jobs by 2020, \$4,669,183 in net economic output and \$4,455,563 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

MDE has adopted regulations to implement and enforce the federal PSD program in Maryland, and has issued several PSD approvals requiring the regulated sources to implement BACTs for GHGs.

D.2. Main Street Initiatives

Lead Agency: DHCD

Program Description

The Department of Housing and Community Development (DHCD) has pursued new opportunities to help people and communities through energy efficiency retrofits for homes and

small businesses. With a “Main Street” approach, DHCD competed for and won an award of \$20 million from the U.S. Department of Energy’s (DOE) Better Buildings/EECBG program. This Recovery Act-funded award was a three-year commitment that funded energy efficiency retrofits through a new DHCD program called BeSMART. The BeSMART investments and initiatives subsequently provided the foundation for DHCD’s newly created Housing and Building Energy Programs (HBEP) unit, which was launched in 2012.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Main Street Initiatives program in 2020 are estimated to be 0.05 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI’s 2015 Study estimated that the Main Street Initiatives/ BeSMART program, once fully operational, would support a total of 690 to 1,323 jobs by 2020, \$1,234,313,963 to \$2,008,178,709 in net economic output and \$646,003,722 to \$1,060,707,094 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

This program was established as a result of a competitive grant award, from U.S. Department of Energy. It is an incentive based voluntary program.

Recommendations for Future Actions and Reporting:

- Increase energy efficiency resources for residents, especially low- to middle-income households
 - Reduced energy usage mitigates GHGs
 - Reduced costs for homeowners and multifamily residents/projects
 - Less risk for mortgage lenders; fewer defaults
 - Independent analyses demonstrate high environmental and economic returns

Table 5-3. Success Metrics – U.S. DOE BeSMART (ARRA).

Action Item	CY 2009	CY 2010	CY 2011	CY 2012	CY 2013	CY 2014	CY 2015
Units	250	3,349	5,087	3,262	94	9	N/A
Dollars (1)	\$1,071,127	\$18,010,674	\$20,887,258	\$14,440,208	\$369,963	\$47,481	N/A

Savings (2)	7,625	102,144	155,153	99,491	2,867	274	N/A
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(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.

D.3. Energy Efficiency for Affordable Housing

Lead Agency: DHCD

Program Description

Since inception of the federally-funded Weatherization Assistance Program (WAP) in the seventies, more than seven million homes have been weatherized across the nation. Scientific Studies and the energy industry recognize that energy efficiency is among the most viable options for decreasing fossil fuel consumption and consequently reducing GHG emissions. Energy-efficiency is cost-effective and can be implemented quickly. A weatherized household can realize up to \$400 in first-year energy savings and an annual CO2 reduction of 2.65 metric tons on average.²⁶ WAP is designed to help eligible low-income households with the installation of energy conservation materials to reduce the consumption of energy and the cost of maintenance. The U.S. Department of Energy (DOE) has funded WAP since 1976, with major funding increases to the program under the American Recovery and Reinvestment Act of 2009. As noted previously, DHCD now delivers energy efficiency programs through a new unit named Housing & Building Energy Programs (HBEP).

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Energy Efficiency for Affordable Housing program in 2020 are estimated to be 0.02 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI’s 2015 Study estimated that the Energy Efficiency for Affordable Housing program, once fully operational, would support a total of 141 to 268 jobs by 2020, \$272,216,797 to \$437,927,248 in net economic output and \$172,016,143 to \$280,906,676 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

²⁶ U.S. Department of Energy, Oak Ridge National Laboratory, “Weatherization Assistance Program Technical Memorandum Background Data and Statistics,” <http://energy.gov>, March 2010

Implementation

This initiative is a voluntary incentive based program. It receives funding from State and federal sources, including MEA and U.S. Department of Energy.

Recommendations for Future Actions and Reporting:

- Revise DHCD action items to reflect operation categories
 - Multifamily, Single Family, Small Business
 - Coordinate and standardize energy metrics, factors, and assumptions across all energy efficiency programs
 - Improve reporting on local economic impacts and ROI to State

Table 5-4. Success Metrics – Energy Efficiency for Affordable Housing

Action Item	CY 2009	CY 2010	CY 2011	CY 2012	CY 2013	CY 2014	Jan-Mar 2015
Units	250	3,349	5,087	3,562	3,058	5,704	658
Dollars (1)	\$1,071,127	\$18,010,672	\$20,887,258	\$14,835,107	\$20,393,164	\$29,994,017	\$2,710,647
Savings (2)				1,485	15,833	14,687	1,646

(1) Funding sources for this program include U.S. DOE WAP, EmPOWER LIEEP and MEEHA, RGGI and MEAP.

(2) Savings reported are for EmPOWER, LIEEP and MEEHA only and are calculated using MWhs.

CDA – Home & Building Energy Programs
Weatherization Assistance and EmPOWER Low Income Energy Efficiency Programs
 homes by Jurisdiction: FY 2014

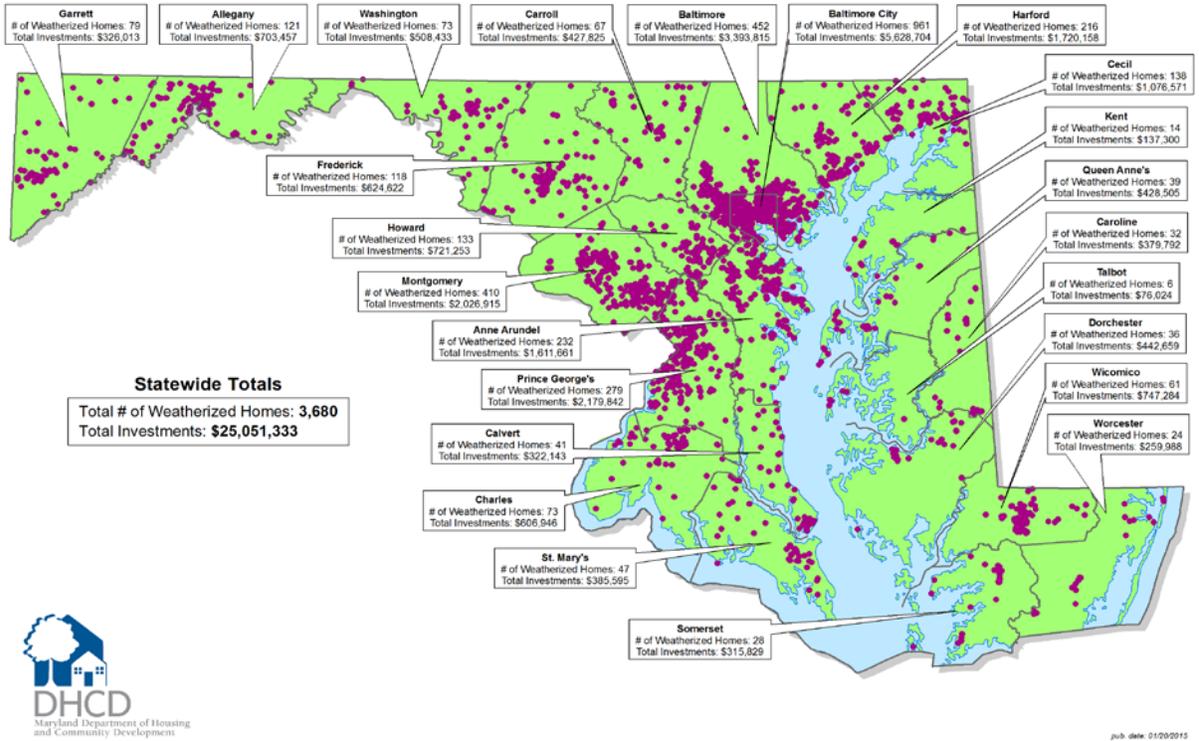


Figure 5-7. CDA – Home & Building Energy Programs – Weatherization Assistance and EmPOWER Low Income Energy Efficiency Programs. Homes by jurisdiction: FY 2014.

The Transportation Sector

Table 5-5. Transportation Sector GHG Reduction Programs.

TRANSPORTATION		
Program I.D.	Program	Potential GHG Emission Reductions (MMtCO₂e) Revised for 2015
E	Transportation Technologies	6.88
F	Public Transportation	1.85
G	Pricing Initiatives	1.99
H	Other Innovative Transportation Programs	Included in F.1
Total		10.72

E. Transportation Technologies

Transportation technologies reduce GHG emissions and other tailpipe pollutants through three primary strategies: (1) cleaner fuels; (2) vehicle emissions technology; and (3) system efficiencies. Maryland's transportation technologies programs employ all three strategies and encompass passenger travel and freight movement for both on road vehicles and off road transportation modes (air, ship and rail transport). Continued technology advancements and innovations will be needed to achieve deeper reductions in the State's transportation sector emissions by 2020 and in later years.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that programs under the Transportation Technologies group, once fully operational, would support an aggregated total of 1,031 to 1,134 jobs by 2020, \$1,112,700,515 to \$1,223,970,569 in net economic output and \$541,055,221 to \$595,160,748 in wages over the lifetime of the programs. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

E.1. Motor Vehicle Emission and Fuel Standards

Program Description

This suite of programs reduces GHG emissions in several ways. “Upstream” fuel standards, such as the federal Renewable Fuels Standard, require transportation fuel producers to blend renewable fuels into their petroleum products. Depending on fuel producers’ choices of renewable fuels, this program has the potential to reduce the per unit carbon intensity of their product inventory over time. The Maryland Clean Cars Program requires car manufacturers to meet a fleet-wide average GHG emissions standard for vehicles sold in the State. The national CAFE standards for light-duty vehicles and efficiency and emission standards for medium and heavy-duty vehicles require car and truck manufacturers to both reduce GHG emissions and increase the fuel efficiency (i.e., more miles per gallon) of their vehicle fleets over time. Maryland, California and other leadership states have played a key role in advancing more stringent national standards. In addition to achieving significant GHG reductions over time, these programs will produce public health, air quality, water quality and economic benefits for Marylanders.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Motor Vehicle Emission and Fuel Standards program group in 2020 are estimated to be 5.57 MMtCO₂e. Appendices C and J of this report provide a more detailed description of the process used to quantify GHG reductions.

E.1.A. Maryland Clean Cars Program

Lead Agency: MDE

Program Description

The Maryland Clean Cars Act of 2007 required MDE to adopt regulations implementing the California Clean Car Program. This program establishes a GHG emission standard based on fleet-wide averages; it does not set specific standards for individual vehicles. It is the responsibility of the manufacturers to demonstrate compliance with the required fleet averages for each model year. The fleet GHG standard under the Maryland Clean Cars Act of 2007 began with model year 2011 vehicles.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Maryland Clean Cars Program in 2020 have been aggregated with the estimated emission reductions from the Motor Vehicle Emission and Fuel Standards program group.

Job Creation and Economic Benefits

Revised 2015 Estimate

The job creation and economic benefits from the Maryland Clean Cars Program have been aggregated with the job creation and economic benefits from the Transportation Technologies program group. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

This program is mandated by the Maryland Clean Cars Act of 2007 and has been fully implemented through regulations codified in COMAR 26.11.34, the Low Emissions Vehicle Program, adopted and enforced by MDE.

E.1.B. Corporate Average Fuel Economy Standards (CAFE): Model Years 2008-2011

Lead Agency: MDOT

Program Description

Since introduction of the federal Corporate Average Fuel Economy (CAFE) standards in 1975, the standards have increased gradually from the initial standard of 18 miles per gallon. Each year the National Highway Traffic Safety Administration (NHTSA), charged with promulgating the standards, has analyzed the effect of its proposed annual standard on the environment as well as the U.S. economy.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Corporate Average Fuel Economy Standards (CAFE): Model Years 2008 – 2011 program in 2020 have been aggregated with the estimated emission reductions from the Motor Vehicle Emission and Fuel Standards program group.

Job Creation and Economic Benefits

Revised 2015 Estimate

The job creation and economic benefits from the Corporate Average Fuel Economy Standards (CAFE): Model Years 2008 – 2011 program have been aggregated with the job creation and economic benefits from the Transportation Technologies program group. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

This program was initially implemented through federal regulations adopted by NHTSA, which remains responsible for its enforcement. In 2010, the program was superseded by new, more rigorous national GHG and fuel economy standards for vehicles beginning in model year 2012, adopted through joint agency rulemaking by NHTSA and EPA. NHTSA's pre-existing standards for model years 2008-2011 will still be producing benefits in 2020 for those earlier year vehicles that remain in the fleet.

E.I.C. National Fuel Efficiency and Emission Standards for Medium and Heavy-Duty Trucks

Lead Agency: MDOT

Program Description

Medium and heavy-duty vehicles are the transportation sector's second largest contributor to fossil fuel consumption and GHG emissions. In 2011, the National Fuel Efficiency & Emission Standards for Medium and Heavy-Duty Trucks was adopted, the first national program designed to reduce GHG emissions and improve fuel efficiency for this class of on road vehicles. The program is implemented through a joint rule issued by EPA and NHTSA. The joint rule is comprised of complementary standards developed by the agencies under their respective authorities and covers model years 2014-2018. Under the rule, EPA's emission standards for CO₂ and NHTSA's fuel consumption standards cover the following regulatory categories: combination tractors, heavy-duty pickup trucks and vans, and vocational vehicles. EPA's standards also cover recreational on road vehicles. The heavy-duty fleet subject to the rule includes all on road vehicles rated at 8,500 lbs or more, except those covered by the current GHG emissions and federal Corporate Average Fuel Economy standards for model years 2012-2016.

On June 19, 2015, EPA and NHTSA, on behalf of the Department of Transportation, each proposed rules to establish a comprehensive Phase 2 Heavy-Duty National Program that will reduce GHG emissions and fuel consumption for new on-road medium and heavy-duty vehicles. This technology-advancing program would phase in over the long-term, beginning in the 2018 model year and culminating in standards for model year 2027.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the National Fuel Efficiency and Emission Standards for Medium and Heavy-Duty Trucks program in 2020 have been aggregated with the estimated emission reductions from the Motor Vehicle Emission and Fuel Standards program group.

Job Creation and Economic Benefits

Revised 2015 Estimate

The job creation and economic benefits from the National Fuel Efficiency and Emission Standards for Medium and Heavy-Duty Trucks program have been aggregated with the job creation and economic benefits from the Transportation Technologies program group. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

The federal regulations implementing this program were finalized in August 2011. The program will be federally enforced jointly by EPA and NHTSA.

E.1.D. Federal Renewable Fuels Standard

Lead Agency: MDOT

Program Description

Under the Clean Air Act, as amended by the Energy Independence and Security Act of 2007, EPA is required to set annual standards under the Renewable Fuel Standard program (RFS) based on gasoline and diesel projections from the U.S. Department of Energy's Energy Information Administration (EIA). EPA is also required to set the cellulosic biofuel standard each year based on the volume projected to be available during the following year, using EIA projections and assessments of production capability from industry.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Federal Renewable Fuels Standard program in 2020 have been aggregated with the estimated emission reductions from the Motor Vehicle Emission and Fuel Standards program group.

Job Creation and Economic Benefits

Revised 2015 Estimate

The job creation and economic benefits from the Federal Renewable Fuels Standard program have been aggregated with the job creation and economic benefits from the Transportation Technologies program group. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

This federal program has been implemented through regulations adopted by EPA, which has full responsibility for its enforcement.

E.2. On Road, Airport, Port and Freight/Freight Rail Technology Initiatives

Lead Agency: MDOT

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the On Road, Airport, Port and Freight/Freight Rail Technology Initiatives program group in 2020 are estimated to be 1.06 MMtCO₂e. Appendices C and J of this report provide a more detailed description of the process used to quantify GHG reductions.

Implementation

- Ongoing CHART operations and expansion of service
- Congestion relief strategies including low cost/short term operational improvements such as signal retiming and optimization and ITS, study of BRT corridors, and targeted capacity enhancements to relieve bottlenecks
- Telework/Employer Outreach Programs
- BWI, and MARC/MTA station and park-and-ride lot charging stations
- BWI Utility Master Plan
- Dray Truck Replacement (Port of Baltimore)
 - Over 100 trucks replaced to date, with 30 more funded in 2015
- APUs for existing locomotives
- Installation of 10 virtual truck weigh stations

E.2.A. On Road Technology

Lead Agency: MDOT

Program Description

Transportation technology initiatives are significant contributors to on road mobile emissions reductions and are an important element of the State's efforts to reduce GHGs. Projects under this program include intelligent transportation systems, traffic operational improvements, teleworking and engine replacements.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the On Road Technology program in 2020 have been aggregated with the estimated emission reductions from the On Road, Airport, Port and Freight/Freight Rail Technology Initiatives program group.

Job Creation and Economic Benefits

Revised 2015 Estimate

The job creation and economic benefits from the On Road Technology program have been aggregated with the job creation and economic benefits from the Transportation Technologies program group. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

Projects that contribute to a change in vehicle miles traveled growth and/or improve system efficiency are a subset of the State's complete Consolidated Transportation Program.

- Enhance CHART
 - The FY2015-2020 CTP includes \$113.8 million to continue to expand and enhance CHART.
- Provide Real Time Transit Information
 - MTA and WMATA have implemented real-time technologies. These are being expanded to some LOTS operators.
- Incentivize Truck Fleet Turnover
 - MDE, MDOT and MPA are working together to retire old dray trucks through grant programs.
- Promote Driver Education and Training (ECO-Driving)
 - Baltimore and Washington MPOs promote ECO-driving. The I-95 Corridor Coalition also promotes ECO-driving.
- Promote Black Carbon Reductions

- The diesel vehicle emissions control program specifically targets the vehicles most likely to emit black carbon. The program affects any diesel-powered vehicle with a gross vehicle weight rating of over 10,000 pounds traveling on Maryland's highways. Enforcement is carried out by the Maryland State Police and the Maryland Transportation Authority Police (MTAP), who can require any heavy-duty diesel vehicle to submit to a smoke emissions test at any time or place.

E.2.B. Airport Initiatives

Lead Agency: MDOT

Program Description

A 2011 energy audit conducted for the Maryland Aviation Administration (MAA) evaluated the potential emissions impact of reductions in consumption of electricity and conventional vehicle fuel at the Baltimore/Washington International Airport (BWI). These reductions would result in lower GHG emissions through the utilization of more energy efficient technologies and fuel conservation measures.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Airport Initiatives program in 2020 have been aggregated with the estimated emission reductions from the On Road, Airport, Port and Freight/Freight Rail Technology Initiatives program group.

Job Creation and Economic Benefits

Revised 2015 Estimate

The job creation and economic benefits from the Airport Initiatives program have been aggregated with the job creation and economic benefits from the Transportation Technologies program group. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

Some of the existing initiatives are voluntary; others are required to support the Environmental Impact Statement process mandated by the National Environmental Policy Act for major projects.

- BWI's periodic air quality assessments are required to support the Maryland State Implementation Plan under the Clean Air Act.

- Increase Alternative Fueled Ground Support Vehicles
 - 30% of MAA vehicles use alternative fuels.
- Promote Preferential Parking
 - Preferential Parking exists in both the daily and hourly garages at BWI.
- Promote Reforestation and Afforestation at BWI
 - MAA maintains a Reforestation Master Plan and Forestry Management Plan that comply with multi-agency regulations and specify areas set aside for forest conservation and retention.
- Promote Hybrid Car Rentals and Satellite Lot Shuttle Vehicles
 - Many car rental companies offer hybrid or “green” rental options, which are available at BWI.
- Promote More Transit Connections
 - RTA, ICC Bus, MTA Bus and WMATA Bus service are all available at BWI Thurgood Marshall. In addition, travelers can access MARC, AMTRAK and Light Rail trains.

E.2.C. Port Initiatives

Lead Agency: MDOT

Program Description

The Maryland Port Administration (MPA) has implemented an Environmental Management System, as well as other initiatives to reduce the environmental footprint associated with Maryland’s deepwater seaport in Baltimore. The MPA's emission reduction strategies for GHGs and other air pollutants includes use of cleaner diesel fuel port fleet vehicles, use of electric operated equipment, reduced truck emissions through turn time efficiency improvements, idle reductions/requirements, and dray truck replacements.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Port Initiatives program in 2020 have been aggregated with the estimated emission reductions from the On Road, Airport, Port and Freight/Freight Rail Technology Initiatives program group.

Job Creation and Economic Benefits

Revised 2015 Estimate

The job creation and economic benefits from the Port Initiatives program have been aggregated with the job creation and economic benefits from the Transportation Technologies program

group. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

This is a voluntary program.

- MPA has ongoing and planned administrative, management, maintenance, and operations strategies that will reduce energy consumption and GHG emissions from its transportation sector.

- Additional environmental information may be found at:

<http://www.mpa.maryland.gov/content/green-port.php>

- Electrification of Power for Docked Ships
 - MPA is conducting feasibility studies of this technology. The Port of Los Angeles and Port of Long Beach are good examples of recent successful implementation.
- Electrification of Ground Support Equipment
 - The Port continues to use grant and other funds to update equipment including engine repowers, anti-idling devices, vehicle replacements and electrification of gantries.
- Implementation of Marine Highways Corridors Program and Barge Subsidies
 - On behalf of its member and affiliate agencies, the I-95 Corridor Coalition submitted a successful application to USDOT and has attained designation of the M-95 Marine Highway Corridor. The corridor includes a series of waterways/crossings/connections within the Coalition's region, which includes the Port of Baltimore.

E.2.D. Freight & Freight Rail Programs

Lead Agency: MDOT

Program Description

The State is implementing initiatives to encourage and improve rail and freight transport. These initiatives focus on improving the efficiency of freight transportation to help reduce emissions of GHGs and other pollutants from the transportation sector. These efforts enhance connectivity and reliability of multimodal freight through infrastructure and technology investments, such as expansion and bottleneck relief on priority truck and rail corridors and enhanced intermodal freight connections at Maryland's intermodal terminals and ports. The following strategies are examples of State initiatives to encourage and improve rail and freight transport throughout Maryland.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Freight and Freight Rail Programs in 2020 have been aggregated with the estimated emission reductions from the On Road, Airport, Port and Freight/Freight Rail Technology Initiatives program group.

Job Creation and Economic Benefits

Revised 2015 Estimate

The job creation and economic benefits from the Freight and Freight Rail Programs have been aggregated with the job creation and economic benefits from the Transportation Technologies program group. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

The State will continue to expand its ongoing effort while seeking additional funding and, where necessary, State and Federal policy adjustments. Additional information may be found at:

- [http://www.mdot.maryland.gov/Office%20of%20Planning%20and%20Capital%20Programming/Freight Planning/Documents/Freight Plan_Final.pdf](http://www.mdot.maryland.gov/Office%20of%20Planning%20and%20Capital%20Programming/Freight%20Planning/Documents/Freight_Plan_Final.pdf)
- Evaluate Implementation of National Gateway Initiative and Multi-Modal Goods Movement Strategy
 - Maryland is continuing to work with CSX (National Gateway) and NS (Crescent Corridor).
- Accelerate Construction of High Speed Rail
 - MARC/Amtrak planning/engineering through Federal grants for Howard Street Tunnel, Susquehanna River Bridge, and BWI Station enhancement/new track are ongoing.
- Assist CSX in Constructing a New Intermodal Container Facility to Address Howard Street Tunnel Challenge
 - Parties decided not to go forward with the original location based on public input; discussions are ongoing.
- Explore Feasibility of Replacing Long Haul Truck Freight with Rail Hauling by 2020
 - Freight Plan and Rail Plan have considered some options
 - Continued partnerships with CSX and NS
 - Unlikely large-scale shifts in logistics patterns through 2020

E.3. Electric and Low Emitting Vehicle Initiatives

Lead Agencies: MDOT/MEA

Program Description

Initiatives to encourage the use of electric and other low and zero-emitting vehicles are part of the State's efforts to reduce emissions of GHGs and other air pollutants from mobile sources by providing alternatives to conventional internal combustion engine vehicles. Maryland has assumed a leadership role in facilitating the deployment of electric vehicles (EVs) and EV charging infrastructure in the State. EVs include plug-in all-electric vehicles, called battery electric vehicles (BEVs), and plug-in hybrid electric vehicles (PHEVs). BEVs produce zero tailpipe emissions of GHGs and other pollutants because they use battery power for propulsion rather than an internal combustion engine. PHEVs reduce tailpipe emissions by using batteries in addition to fossil fuels for propulsion. The carbon intensity of the energy used to charge the batteries from the electricity grid is decreasing over time as a result of Maryland's participation in RGGI, its Renewable Portfolio Standard program and fuel switching to cleaner natural gas. These programs are described under the Energy section of this chapter. The State is also partnering with private fleets to accelerate fleet turnover to heavy-duty hybrid vehicles. More information on the initiatives in this program can be found at:

- http://www.mdot.maryland.gov/Office%20of%20Planning%20and%20Capital%20Programming/Electric_Vehicle/EV_FAQ.html
- <http://www.mwcog.org/uploads/committee-documents/bV1cXldc20121011125334.pdf>.
- <http://www.energy.maryland.gov/Transportation/met>

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Electric and Low Emitting Vehicle Initiatives program in 2020 are estimated to be 0.25 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

The job creation and economic benefits from the Electric and Low Emitting Vehicle Initiatives program have been aggregated with the job creation and economic benefits from the Transportation Technologies program group. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

- Extend Tax Credits for EVs and EV Charging Equipment
 - Existing credit (up to \$3,000) is effective from July 1, 2014 through June 30, 2017.

- Extend HOV Lane Exemption
 - Existing HOV lane exemption is valid from October 1, 2010 through September 30, 2017.
- Provide EV Charging for State Employees
 - EV charging stations are available at several State facilities including MDOT HQ, MDE, UMD, DGS, and BWI.
- 5,000 EVs on the road
- 610 EV chargers in 259 locations
 - 32 chargers installed at MDOT locations since 2011
 - 45 installed at University System locations since 2011
- 26 Washington D.C. Fast Charge stations in 20 locations, supplementing 10 existing
- MTA adding 17 new chargers at 8 new locations

F. Public Transportation

Public transportation contributes to GHG emission reductions in the State’s transportation sector by providing alternatives to travel in personal vehicles, thus reducing vehicle miles traveled (VMT). The programs in this policy area include transit initiatives with a goal of substantially increasing transit ridership by 2020 and intercity transportation initiatives.

F.1. Public Transportation Initiatives

Lead Agency: MDOT

Program Description

For several decades, VMT has risen faster than the increase in population, in Maryland and nationwide. Land use development over the past 40 to 50 years has put more people living beyond the reach of easy access to transit facilities, increasing automobile driving and tailpipe emissions of GHGs and other air pollutants. This program is designed to advance the effort to meet a goal of substantially increasing transit ridership by 2020. In order to achieve this growth, actions are needed to increase the availability, attractiveness and convenience of public transportation, improve the operational efficiency of the system, and increase system capacity. Actions related to land use planning, pricing disincentives for driving cars or incentives for riding transit, and bike and pedestrian access improvements, addressed in other sections of this chapter, are also necessary to achieve the ridership goal.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Public Transportation Initiatives program in 2020 are estimated to be 1.85 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Public Transportation Initiatives program, once fully operational, would support a total of 927 to 1,854 jobs by 2020, \$1,172,430,639 to \$2,344,861,280 in net economic output and \$559,824,099 to \$1,119,648,197 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

- Expand Local Circulator Buses and Transit
 - MDOT provides funding for the LOTS program to support fleet replacement, maintenance/operations, and capacity enhancements.
- Implemented Real-Time Transit Information Technologies
 - MTA and WMATA have or are in the process of implementing real-time technologies.
- Expand Ridesharing through Apps and Social Marketing
 - Commuter Connections offers mobile apps to commuters where they can access ridesharing matches with other commuters living and working in the same area.
 - Commuter Connections also maintains Facebook and LinkedIn pages.
- Increase Commuter Choice Employer Incentives
 - Commuter Connections offers a broad range of services to employers, including consultation on many alternative modes of transportation and telework opportunities.
 - Maryland continues to offer tax credits for employers
 - <http://metroridehsare.com/employer-information/tax-credit/>
- MTA Bus Replacement
 - 85% of MTAs fleet uses cleaner alternatives to conventional diesel.
- Transit Oriented Development
 - Eight sites are undergoing development.

F.2. Intercity Transportation Initiatives

Lead Agency: MDOT

Program Description

Traffic congestion along the I-95 corridor between the Wilmington region, Baltimore and Washington, D.C. has been steadily increasing over the past few decades. The State is implementing strategies to reduce congestion and mobile emissions, including GHGs, by providing alternatives to single occupant vehicle use as well as improvements to Maryland's transportation systems. These strategies enhance connectivity and reliability of non-automobile intercity passenger options through infrastructure and technology investments. This includes expansion of intercity passenger rail and bus services as well as improved connections between air, rail, intercity bus, and regional or local transit systems. More information on this program can be found in Appendix J of this Plan.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Intercity Transportation Initiatives program in 2020 have been aggregated with the estimated emission reductions from the Public Transportation Initiatives program.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Intercity Transportation Initiatives program, once fully operational, would support a total of 102 to 127 jobs by 2020, \$175,447,514 to \$219,309,399 in net economic output and \$85,173,952 to \$106,467,444 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

- MARC Growth & Investment Plan implementation including track and signal improvements, recent enhancements at the Halethorpe and Edgewood stations, and planned/ongoing expansions at the BWI MARC/Amtrak station and the West Baltimore station
- New MARC Penn Line weekend service and additional weekday service on the MARC Camden Line
- Long-range Northeast Corridor improvements under study including environmental and engineering studies for the Susquehanna River Bridge and B&P Tunnel replacement projects
- MARC locomotive replacement and repowering

G. Pricing Initiatives

Lead Agency: MDOT

Program Description

This program includes transportation pricing disincentives and travel demand management incentive programs. Projects are tied to commute alternatives and programs including ride sharing (Commuter Connections), guaranteed ride home, transportation demand program management and marketing, outreach and education programs (Clean Air Partners), parking cash-out subsidies, transportation information kiosks, local car sharing programs, telework partnerships, parking fees, and vanpool programs. More information on this program can be found in Appendix J of this Plan.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Pricing Initiatives program in 2020 are estimated to be 1.99 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Pricing Initiatives program, once fully operational, would support a total of up to 405 jobs by 2020, up to \$1,305,838,372 in net economic output and up to \$614,542,355 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

- Increase Gasoline Sales Tax
 - 2013 General Assembly action
- Enhance Electronic Toll Collection
 - MDTA plans for Francis Scott Key and Hatem Bridge conversion to AET
 - Ongoing statewide feasibility study by MDTA
- Explore Other Revenue Instruments
 - In order to create an enhanced framework for future P3s that will attract private investment to help build new infrastructure, Maryland passed House Bill 560, which was signed into law on April 9, 2013.
 - The new legislation provides the private sector with a stronger, more predictable and streamlined process, protects public assets, ensures a strong workforce,

requires competitive bidding for all projects and allows the private sector to submit new unsolicited concepts to address Maryland’s infrastructure needs.

▪ <http://www.mdt.maryland.gov/partnerships/tp3overview.html>

- Strengthen Parking Programs
 - SHA/MTA expansion of park-and-rides, TERM funding for Commuter Connections, Commuter Choice Maryland
- Congestion Pricing
 - Opening of ICC and I-95 Express Toll Lanes
 - Future Plans for I-95 Phase 2 ETL uncertain
- Enhanced electronic toll collection through completion of the Intercounty Connector and the I-95 Express Toll Lanes
- Added high-speed electronic toll lanes at the Fort McHenry Tunnel and Key Bridge toll plazas
- Commuter Choice Maryland and Commuter Connections ridesharing and guaranteed ride home programs
- Park and Ride lots
 - Over 1,000 new spaces under construction or planned in 2015/2016
- Other local and regional transportation demand management strategies

H. Other Innovative Transportation Strategies/Programs

H.1. Evaluating the GHG Emissions Impact of Major New Transportation Projects

Lead Agency: MDE

Program Description

This initiative is aimed at ensuring that potential increases in GHG emissions associated with the growth and increased vehicle miles traveled (VMT) resulting from major new transportation projects and other major new projects are analyzed, considered and addressed during the transportation planning process. The primary goal of this initiative is to ensure that potential “growth related” GHG emission increases (both direct and induced) are addressed when decisions to approve and fund major projects are made.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Evaluating the GHG Emissions Impact of Major New Transportation Projects program in 2020 were not calculated.

Job Creation and Economic Benefits

Revised 2015 Estimate

A detailed economic analysis of this initiative was not conducted as it is a new effort that is still evolving.

Implementation

MDE is working with the Baltimore Regional Transportation Board (BRTB), the Metropolitan Washington Council of Governments (COG), MDOT and other state agencies/stakeholders to implement separate but related voluntary efforts to:

- Study the existing and future levels of greenhouse gases in multiple sectors, including the transportation sector.
- Identify viable, implementable and, in some cases, stretch strategies for reducing GHG emissions across key sectors, including the transportation sector, and to quantify the associated emissions benefits.
- Analyze the co-benefits, in terms of other air pollutant reductions, from the identified strategies.

These efforts will assist the MPOs and State agencies with presenting informed positions to policy makers in terms of when and how any future state or regional GHG emission reduction goals should be set or reevaluated.

- BRTB “How Far Can We Get?” Study
 - The “How Far Can We Get?” Study was initiated by the BRTB as part of the FY 2014 UPWP. The purpose of this study was to understand the level of emission reductions that are achievable through a reasonable level of reduction measure implementation, and to inform the region’s next long range transportation plan. This study identifies several transportation emission reduction measures (TERMs) that members believe feasible and have potential interest in promoting. EPA’s MOVES 2010 motor vehicle emissions model was used as one of the tools in the How Far Can We Get Analysis. It was used to get an overall picture of the sources of greenhouse gases and nitrogen oxide emissions, within the on-road transportation sector. The Energy and Emissions Reduction Policy Analysis Tool (EERPAT) model was used to perform two rounds of scenario testing of different TERMS. The EERPAT model enables rapid scenario evaluation of alternative emission reduction policy scenarios. It produces results of emission reduction and VMT change at the county, regional, metropolitan and state level.
 - A draft report was distributed for review on August 11, 2015 and is currently being revised in response to comments that were received by committee members.
- COG “What Would It Take?” scenario
 - The “What Would it Take?” scenario, completed in 2010, was the first step toward answering major questions about transportation and climate change

mitigation in the Washington metropolitan region. This study was undertaken by the TPB and led by the TPB Scenario Study Task Force in 2007 in direct response to growing concern about climate change and a desire to position the region for early action. The outcome of this analysis was the identification of effective and cost-effective transportation strategies for climate change mitigation that could be adopted by state and local jurisdictions in the region. The emissions targets used in this study were taken from the COG Climate Change Report. These targets are to reduce annual regional CO₂ emissions to 2005 levels by 2012, 20% below 2005 levels by 2020, and 80% below 2005 levels by 2050. The study used these same reduction targets, but importantly only extended analysis out to 2030 due to travel demand modeling limitations. Therefore, the final target for this study was a 40% reduction below 2005 levels by 2030.

- A final report was released on May 18, 2010. Short-term regional actions were likely to be implementable between 2010 and 2020. This group includes twenty-seven different strategies across five categories of:
 - Increased transit use
 - Increased bike/pedestrian use
 - Pricing
 - Improve operation efficiency
 - Reducing travel
- There are no further updates at this time
- COG Multi-Sector Working Group
 - On November 12, 2008 COG adopted voluntary goals to reduce GHG emissions 20% below 2005 levels by 2020 and 80% below 2005 levels by 2050. On January 30, 2015, COG established the Multi-Sector Working Group (MSWG). The propose of the MSWG is to conduct a study to examine all sectors of the economy to identify potentially viable local, regional, and state actions to significantly reduce GHG emissions in accordance with the voluntarily adopted goals. The study identifies potentially viable, implementable, and stretch local, regional, and state strategies for reducing GHG across key sectors, analyze the potential GHG benefits of these strategies, and identify co-benefits, costs, and implementation timeframes. The MSWG, consists of technical and policy staff from COG's member jurisdictions, as well as state and regional agencies, who have expertise in one or more of the main sectors from which the region's GHG emissions come — energy/built environment, land use, and transportation. The MSWG released a Draft Technical Interim Report on July 27, 2015 that examines potential emissions reductions from all considered strategies on their own and in combination.
 - Current Status: A Draft Technical Interim Report was released on July 27, 2015. The Draft Final Report will be presented to the COG board in January 2016. Development of a Proposed Action Plan will begin in January 2016.

- Chapter 725, "Transportation -- Consolidated Transportation Program -- Evaluation and Selection of Proposed Capital Projects", (HB1155, 2010 Laws of Maryland) alters the selection criteria for capital projects to be included in the State's annual Consolidated Transportation Plan (CTP). Under the law, MDOT must evaluate capital project requests based on the climate goals of the GGRA and GGRA Plan (among other State goals), with input from the counties, municipalities and other entities proposing the projects. For each capital project selected for funding in the CTP, MDOT must provide a Purpose and Need Statement that includes a description of why the project satisfies GGRA climate goals. The law also requires MDOT to evaluate the impact of transportation investments on GGRA climate goals in the performance goals and benchmarks it adopts for attainment of State transportation goals. These benchmarks are reviewed annually by the Smart Growth Subcabinet.

H.2. Bike and Pedestrian Initiatives

Lead Agency: MDOT

Program Description

This program is part of the State's effort to reduce GHG and other motor vehicle emissions from cars by providing alternatives to single occupant vehicle use. Building appropriate infrastructure for additional bicycle and pedestrian travel in urban areas increases access to and use of public transit and supports the State's goal of increasing transit ridership.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Bike and Pedestrian Initiatives program in 2020 have been aggregated with the estimated emission reductions from the Public Transportation Initiatives program.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Bike and Pedestrian Initiatives program, once fully operational, would support a total of 1,040 to 2,748 jobs by 2020, \$1,057,426,231 to \$3,282,996,491 in net economic output and \$347,661,479 to \$691,442,757 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

- Bike Shelters & Bike Sharing
 - Bike sharing program underway
- Consider Bike Accommodations for all Roadway Projects
 - 77 roadway capacity or bridge upgrade projects in MDOT's Consolidated Transportation Program include accommodations for bicycles and pedestrians
 - Bikeways Program (23 bike network projects funded in 2014) and Bikeshare Program (ongoing awards supporting successful implementation in Baltimore City, College Park/UMD, and Montgomery County)
 - SHA manages the Sidewalk Construction for Pedestrian Access Program, Retrofit Bicycle Program, and the Community Safety and Enhancement Program
 - Cycle Maryland
 - East Coast Greenway

The Agriculture and Forestry Sector

Table 5-6. Agriculture and Forestry Sector GHG Reduction Programs.

AGRICULTURE AND FORESTRY		
Program I.D.	Program	Potential GHG Emission Reductions (MMtCO₂e) Revised for 2015
I	Forestry and Sequestration	4.55
J	Ecosystem Markets	0.68
Total		5.23

I. Forestry and Sequestration

I.1. Managing Forests to Capture Carbon

Lead Agency: DNR

Program Description

Managing forests to capture carbon will promote sustainable forestry management practices in existing Maryland forests on both public and private lands. The enhanced productivity resulting from enrolling unmanaged forests into management regimes will increase rates of carbon sequestration in forest biomass, increase amounts of carbon stored in harvested, durable wood products which will result in economic benefits, and increased availability of renewable biomass for energy production. Enhanced forestry management in Maryland should contribute to a 1.8 MMtCO₂e reduction in the State's GHG emissions by 2020.

The goals of this program are to improve sustainable forest management on 30,000 acres of private land annually and on 100 percent of State-owned resource lands, and ensure 50 percent of State-owned forest lands will be third-party certified as sustainably managed.

This program is performing as designed.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Managing Forests to Capture Carbon program in 2020 are estimated to be 1.80 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Managing Forests to Capture Carbon program, once fully operational, would support a total of 268 jobs by 2020, \$28,564,453 in net economic output and \$28,137,209 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

Public Lands:

- Since 2006, 211,000 acres of State Forests have been certified with Dual Third Party Certification for Forest Sustainability to the Sustainable Forestry Initiative (SFI) and Forest Sustainability Certification (FSC) standards.
- DNR is working to develop similar sustainable forest management practices on State parkland and wildlife management areas.
- Dual Third Party Certification for Forest Sustainability on State Forests
 - WMAs and Parks (e.g., early successional habitat) (Currently working with WHS on several projects. Will begin developing Forest Stewardship plan on several Parks in 2015)
 - Accelerated Pace of Silvicultural Activity (Audit Received: Savage River State Forest will increase the number of sales from 14 to 20. DNR is working to decrease the backlog of timber sales).
 - State Forest Annual Workplans

Private Lands:

- Since 2006, 160,495 acres of Stewardship Plans, 99,933 acres of Sediment Control, and 81,860 acres of forest stand improvements (“Tree Planting”, “Timber Stand Improvements”, and “Wildlife Habitat”) for a total of 342,288 acres have been implemented on private lands.
- DNR is currently on track to meet their goal by 2020.
- Technical Assistance – Forest Stewardship Plan Preparation
- Forest Stewardship Plan Implementation
 - Expanded Special Rivers Project
- Financial Assistance
 - State and Federal Cost Sharing
 - Woodland Incentive Program

- Healthy Forests/Healthy Waters (Currently working on developing the next round of projects)
- Backyard Buffer Program
- Environmental Quality Incentive Program
- Conservation Reserve Enhancement Program
- TAXMOD – expanded eligibility (as of 10/27/14, 3 applicants from the expanded eligibility)
- Forest Conservation and Management Program
- Woodland Assessment Program

Table 5-7. Managing Forests to Capture Carbon on Private Lands.

Year	Stewardship Plans	Sediment Control	Tree Planting	Timber Stand Imp.	Wildlife Habitat	Acres
2006	12,106	11,580	3,082	4,796	2,196	33,760
2007	13,630	9,799	2,661	3,300	2,456	61,846
2008	20,657	13,060	2,286	8,519	3,760	48,282
2009	22,228	9,037	2,234	4,188	4,327	42,014
2010	16,895	11,249	1,497	3,542	1,835	35,018
2011	14,866	10,479	2,428	2,778	3,149	33,700
2012	24,640	11,167	1,151	4,607	2,489	44,054
2013	17,822	13,252	1,166	5,171	2,627	44,038
2014	17,651	10,310	1,237	3,850	528	33,576
2015	18,000	11,000	1,500	4,500	2,800	37,800
2016	18,000	11,000	1,500	4,500	2,800	37,800
2017	18,000	11,000	1,500	4,500	2,800	37,800
2018	18,000	11,000	1,500	4,500	2,800	37,800
2019	18,000	11,000	1,500	4,500	2,800	37,800
2020	18,000	11,000	1,500	4,500	2,800	37,800
Total	268,844	166,623	27,005	68,401	42,439	573,312
Average Annual						38,220

Current/Recent Efforts:

- Development and application of the UMCP remote sensing capability for forest carbon assessment
 - Completed
- Launch of NASA, USDA and DOE climate science project for remote sensing, modeling, and field-based measurements to quantify the carbon consequences of alternate development and management plans across rapidly changing forests in Maryland.
 - Pending funding approval

- DNR with other partners, including USFS, UMCES and UMD Extension to release topic related fact sheets and technical guidance on woodland and climate change stewardship principles.
 - Completed

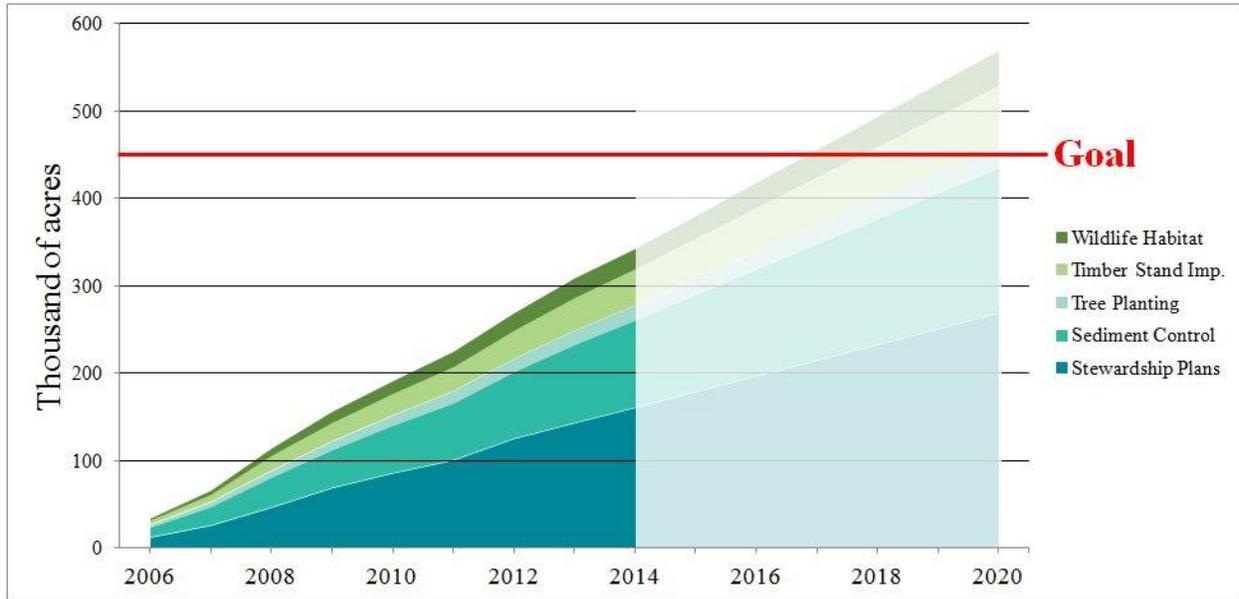


Figure 5-8. Managing Forests to Capture Carbon. DNR is promoting sustainable forestry management practices in Existing Maryland forests on Public and private land through a suite of efforts, policies and programs.

1.2. Planting Forests in Maryland

Lead Agency: DNR

Program Description

Planting trees expands forest cover and associated carbon stocks by regenerating or establishing healthy, functional forests through practices such as soil preparation, erosion control, and supplemental planting, to ensure optimum conditions to support forest growth. By 2020, the implementation goal of this program is to achieve the afforestation and/or reforestation of 43,030 acres in Maryland. Achieving the 43,030 acre target should reduce GHG emissions in the State by 1.79 MMtCO_{2e} by 2020.

This program is performing as designed.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Planting Forests in Maryland program in 2020 are estimated to be 1.79 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Planting Forests in Maryland program, once fully operational, would support a total of 92 jobs by 2020, \$11,077,882 in net economic output and \$14,862,060 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

DNR is implementing this program through a suite of efforts, policies, and programs, including:

- Public Lands:
 - State Forest System Annual Workplan Implementation

- Private Lands:
 - Technical Assistance
 - Forest Stewardship Plan Implementation
 - FCA Implementation
 - Financial Assistance
 - Rural Lands: State and Federal Cost Sharing
 - Woodland Incentive Program (WIP –MD Forest Service)
 - TAXMOD (MD Forest Service; as of 10/27/14, 3 applicants from the expanded eligibility)
 - Environmental Quality Incentive Program (EQIP – Federal/NRCS)
 - Conservation Reserve Enhancement (CREP – Federal/NRCS)
 - Urban Lands: Public/Private Partnerships
 - Tree-Mendous/Arbor Day
 - Marylanders Plant Trees/Private Nurseries (Additional \$150,000 has been received from OAG)
 - Lawn to Woodland (e.g. National Arbor Day Foundation, etc.) (Kicked off in spring 2014 with 14.3 acres planted. Planning for 105 acres in spring 2015 and at least 70 in 2016.)
 - Small Community UTC Grants (Possibly Spring 2015)
 - MD Urban & Community Forestry Council Grants
 - Expanded eligibility for Reforestation Law funding on to private land (Initial Lawn To Woodland plantings used this fund source.)

- Current/Recent Efforts:
 - “Lawn to Woodland” pilot
 - Program initiated in April 2014
 - A total of 14.3 acres planted
 - Planning for 105 acres in spring of 2015

Table 5-8. Forest Planting and Regeneration on Private Lands.

Year	Afforestation	Reforestation	Riparian Buffers	Private Natural	Total (acres)
2006	558	2,104	420	1,400	4,482
2007	334	1,991	336	1,400	4,061
2008	415	1,596	275	1,400	3,686
2009	531	1,497	206	1,400	3,634
2010	566	403	528	1,400	2,897
2011	1,231	639	558	1,400	3,828
2012	330	607	214	1,400	2,551
2013	286	602	278	1,400	2,556
2014	342	544	334	1,400	2,595
2015	400	700	239	1,400	2,900
2016	400	700	400	1,400	2,900
2017	400	700	400	1,400	2,900
2018	400	700	400	1,400	2,900
2019	400	700	400	1,400	2,900
2020	400	700	400	1,400	2,900
Total	7,051	14,339	5,388	21,000	48,005

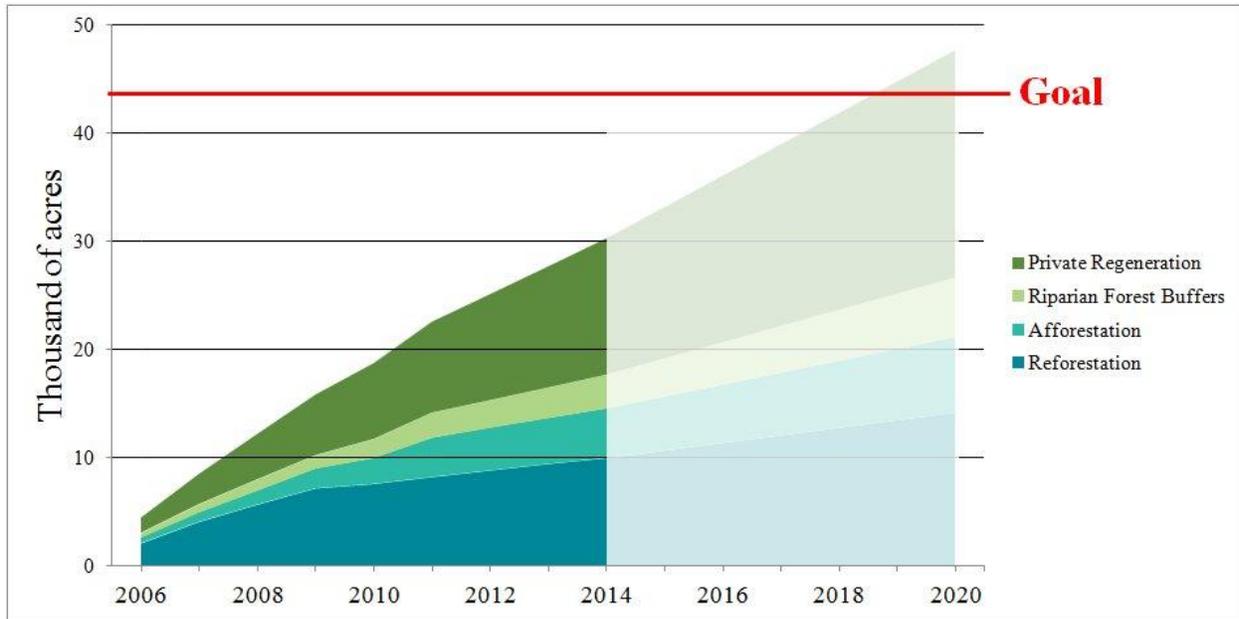


Figure 5-9. Planting Forests in Maryland.

I.3. Creating and Protecting Wetlands and Waterway Borders to Capture Carbon

Lead Agency: DNR

Program Description

In addition to forests, wetlands and marshlands are known to be very efficient at sequestering carbon. Therefore, DNR is planting forested stream buffers and pursuing the creation, protection and restoration of wetlands to promote carbon sequestration through several means, including undertaking on-the-ground wetland restoration projects through its Coastal Wetlands Initiative, the development of a terrestrial carbon sequestration protocol, a DNR Power Plant Research Project wetland study in Dorchester County, and the Sea Level Affecting Marshes Model.

The goals of this program are the restoration of 1,142 acres of wetlands on state and public land and planting 645 acres of streamside forest buffers on state and public lands.

This program is exceeding the established goals.

GHG Emission Reductions in 2020

Revised 2015 Estimate

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 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Creating and Protecting Wetlands and Waterway Borders to Capture Carbon program, once fully operational, would support a total of 62 jobs by 2020, \$28,717,043 in net economic output and \$15,045,166 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

To date, 1,476 acres of wetlands have been restored and 3,388 acres of streamside buffers planted.

Table 5-9. Riparian Forest Buffers.

Year	Acres
2006	420
2007	336
2008	275
2009	206
2010	528
2011	558
2012	214
2013	278
2014	334
2015	239
Total	3,388

1.4. Biomass for Energy Production

Lead Agency: DNR

Program Description

Maryland is working to promote the use of locally produced woody biomass for generation of thermal energy and electricity. Energy from forest by-products can be used to offset fossil fuel-

based energy production and associated GHG emissions. There are many end users that could potentially benefit from such a program, including Maryland's public schools which could enjoy wood heating and cooling; hospitals which could utilize wood as primary heating/cooling source; municipalities which could utilize local fuel markets as key component of their urban tree management programs; and all rural landowners which would have access to a wood fuel market.

The goal of this program is to develop policies that recognize wood as a preferred renewable energy source, recognize wood as the largest source of energy consumption in Maryland, and offer incentives to utilize locally produced wood to meet thermal energy needs.

This program is performing as designed.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Biomass for Energy Production program in 2020 are estimated to be 0.33 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Biomass for Energy Production program, once fully operational, would support a total of 51 jobs by 2020, \$24,871,827 in net economic output and \$12,756,348 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

- Working with partners MES, MEA, COMMERCE and US Forest Service to facilitate installation of wood energy systems
- Various projects in earliest stages of investigation in Baltimore County and Baltimore City
- Both Ft. Meade and Andrews Air Force Base are evaluating the opportunities for incorporating wood systems in their overall green energy transformations

Awareness of wood energy technology is the primary barrier to this program. Actions needed include:

1. Educate State agency leadership
2. Develop policy supporting THERMAL energy

3. Recognize wood as a preferred renewable energy source, on par with solar, geothermal, and wind
4. Establish financial incentive programs

I.5. Conservation of Agricultural Land for GHG Benefits

Lead Agency: MDA

Program Description

MDA is working to safeguard Maryland's network of natural areas, agricultural lands, and coastal lands through its established conservation programs and practices. MDA will contain the conversion and development of agricultural lands through the protection of productive farmland and will continue to pursue policies and programs that complement those of DNR and MDP by preserving or promoting forested, grassed, and wetland areas on agricultural land.

The Maryland Agricultural Land Preservation Foundation (MALPF), which was established in 1977, is one of the first and most successful programs of its kind in the country. Besides maintaining prime farmland and woodland as a viable local base of food and fiber production in the state, the preservation of agricultural land curbs the expansion of random urban development, safeguards wildlife habitat, and enhances the ecology of the Chesapeake Bay and its tributaries. The state's forward reaching goal is to protect 962,000 acres from commercial, residential, or industrial development by 2020.

Since 1997, Maryland has partnered with the USDA in the Conservation Reserve Enhancement Program (CREP) to offer rental payments for leased easements along with other incentives to encourage agricultural producers to protect environmentally sensitive lands, improve wildlife habitat, and reduce sediment and nutrient loss. If fully implemented at its authorized 100,000 acres, CREP has the potential to plant up to 16,000 acres of marginal land into grass, shrubs, and trees, establish 77,000 acres of grassland and forest buffers and 5,000 acres of water and wetland habitat, and restore 2,000 acres of habitat for declining, threatened, or endangered species.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Conservation of Agricultural Land for GHG Benefits program in 2020 are estimated to be 0.18 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Conservation of Agricultural Land for GHG Benefits program, once fully operational, would support a total of 292 jobs by 2020, \$982,330,321 in net economic output and \$173,229,219 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

MALPF:

- 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.

CREP:

- 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.
- Maryland Agricultural Water Quality Cost Share Program (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.
 - Commodity prices influence participation rates, but given their recent history and the long-term nature of program contracts, the downward trend in enrollments 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

Program Description

Trees in urban areas directly impact Maryland’s carbon budget by absorbing GHG emissions from power production and vehicles, reducing heating and cooling costs and energy demand by moderating temperatures around buildings, and slowing the formation of ground level ozone as well as the evaporation of fuel from motor vehicles. Implementation is supported by several other Maryland laws and programs that include outreach and technical assistance for municipalities to assess and value their urban tree canopy goals, and plant trees to meet those goals.

The goals of this program are to plant 12.5 million trees in urban areas through the Forest Conservation Act, Marylanders Plant Trees, Tree-Mendous Maryland, and 5-103 State Highway Reforestation Act planting programs.

This program is performing as designed.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Increasing Urban Trees to Capture Carbon program in 2020 are estimated to be 0.02 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI’s 2015 Study estimated that the Increasing Urban Trees to Capture Carbon program, once fully operational, would support a total of 375 jobs by 2020, \$288,146,970 in net economic output and \$93,017,577 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

To date, 5,214,302 trees have been planted from 2006 to 2014.

Table 5-10. Urban Tree Planting (number of trees).

Year	FCA	5-103	Tree-	Totals
-------------	------------	--------------	--------------	---------------

			Mendous/MPT	
2006	623,700	33,750	8,178	665,628
2007	473,400	27,000	6,057	506,457
2008	499,500	9,900	2,160	511,560
2009	450,900	13,950	39,020	503,870
2010	337,950	308,250	23,000	669,200
2011	481,050	15,750	17,200	514,000
2012	42,300*	68,850	21,700	132,850
2013	119,250*	23,850	23,800	166,900
2014	140,580*	24,615	21,500	186,695
Totals	3,168,630	525,915	162,615	3,857,160

Note: Urban Tree data updated on September 30 of each year. 2015 data will be available on or after September 30, 2015.

* Not yet fully reported by counties.

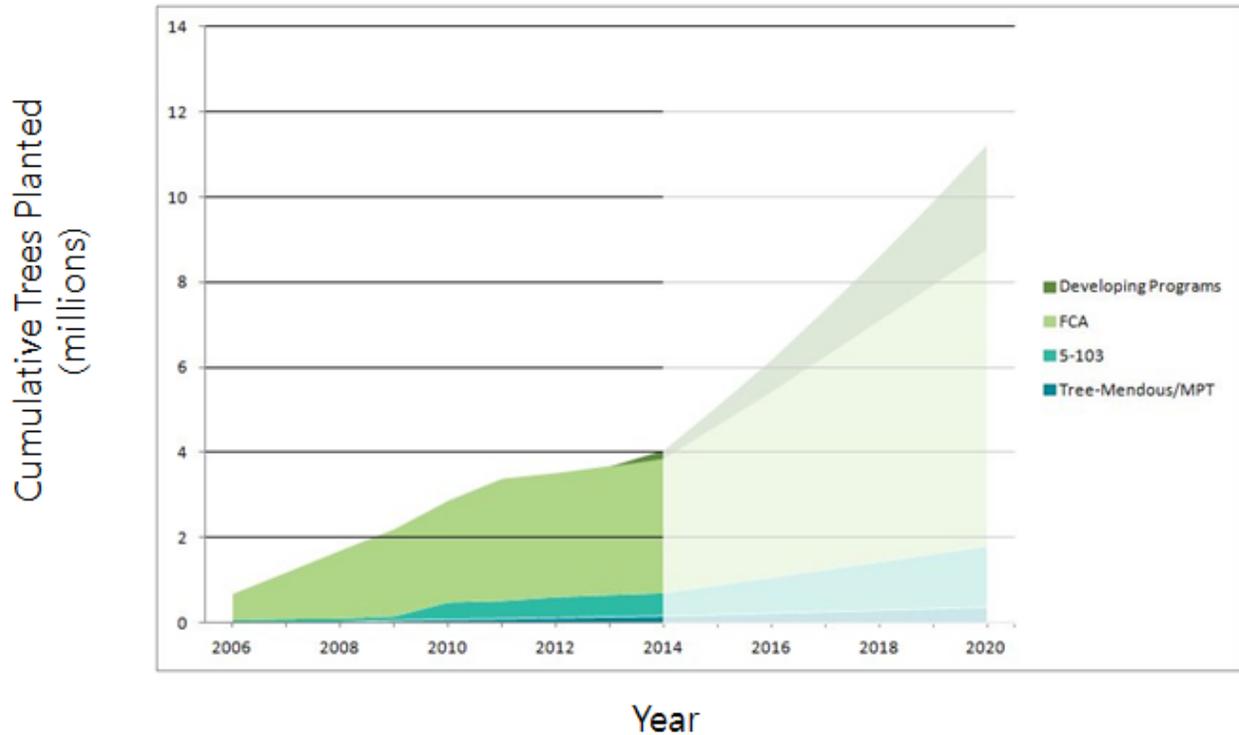


Figure 5-10. Increasing Urban Trees to Capture Carbon.

I.7. Geological Opportunities to Store Carbon

Lead Agency: DNR

Program Description

Geological carbon sequestration differs from other discussed sequestration methods as it captures carbon at the source, transports it to the sequestration site, and then sequesters it. Maryland is one of eight partner states in the Midwest Region Carbon Sequestration Partnership whose role is to identify, locate, and characterize potential geologic storage levels. More than 10 gigatonnes of storage capacity has been identified to be available within Maryland (103 years of storage capacity at current CO₂ estimated production rate of 97 million metric tons per year).

The goal of this program is to identify and assess geologic storage opportunities. However, no quantification target has been assigned.

This program is performing as designed.

GHG Emission Reductions in 2020

Revised 2015 Estimate

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.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Geological Opportunities to Store Carbon program, once fully operational, would support a total of 217 jobs by 2020, \$312,011,719 in net economic output and \$62,194,826 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

- DNR's Resource Assessment Service is currently evaluating total organic carbon content in western Maryland black shales (e.g., Marcellus), in prelude of determining the viability of these as storage units
- Characterization of potential permanent carbon storage units within different areas of the State
- Deep well study of western Maryland and deep saline aquifers in Maryland's offshore areas
- Delineation and characterization of Maryland depleted deep gas storage fields as sites of permanent carbon storage
- Examination of potential development of stray gas migration into potable aquifers
- Current research is assessing the CO₂ adsorption capacity of power plant combustion by-products and the organic shales and clays in the closest geologic formations

- Site testing is underway in Michigan and Ohio and completed in Kentucky. It has been proposed to attempt a site test on the Eastern Shore of Maryland; however, this is still in discussion.
- Resource Assessment along with 4 other Mid-Atlantic States, Battelle, and DOE are assessing the potential for permanent storage of carbon within deep saline aquifers and basalt structures in offshore areas
 - Potential is over 400 gigatonnes
- Currently the Maryland Geological Survey is identifying and characterizing geologic intervals in western Maryland that have sequestration potential.
- Depleted gas fields present the most immediate option for permanent storage of carbon dioxide in western Maryland.
 - Maryland Geological Survey is currently assessing the potential of utilizing black shales (e.g., Marcellus) as permanent sequestration locations as a logical reutilization of natural gas infrastructure, should it be permitted.
- Deep saline aquifers within the onshore and offshore areas of Maryland's eastern shore have potential for significant quantities of permanent carbon storage (current estimate ~4.4 gigatonnes).
- RAS-MGS is currently studying the possibility of stray gas migration its potential for water well contamination within the Accident gas storage facility.

J. Ecosystems Markets

J.1. Creating Ecosystems Markets to Encourage GHG Emission Reductions

Lead Agency: DNR

Program Description

Increased attention to the benefits and cost efficiencies that ecosystem markets could provide has spurred evaluation of the potential its programs and policies may have for fostering carbon market development. Maryland's Forest Conservation Act and Critical Area Act require mitigation for natural resource impacts generated through land development, and mitigation banking is an option to address these mitigation requirements

The goal of this program is the establishment of ecosystem markets, creation of a tracking mechanism and the development of protocols to assess/quantify GHG benefits of individual markets. However, no quantification target has been assigned.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Creating Ecosystems Markets to Encourage GHG Emission Reductions program in 2020 are estimated to be 0.11 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI’s 2015 Study estimated that the Geological Opportunities to Store Carbon program, once fully operational, would support a total of -1,758 jobs by 2020, \$423,431,394 in net economic output and \$358,169,556 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

- DNR has initiated a study to economically value a suite of ecosystem services for select habitats along an urban to rural gradient.
- The net effect will be conservation of natural lands and reduction of GHG emissions.
- The first phase of the study will be released in Q4 FY2015.
- 15 services that forests provide to humans have been economically quantified.
 - Similar assessments have been completed for wetlands.
 - Additional assessments are being conducted for stream buffers, urban forests, oyster reefs and SAV beds.

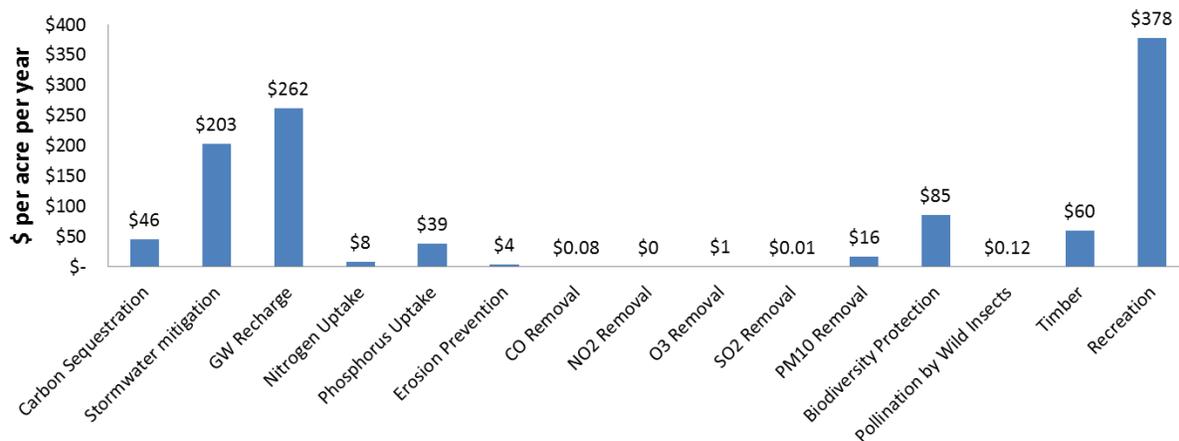


Figure 5-11. Creating Ecosystem Markets to Encourage GHG Emission Reductions Preliminary Results (per acre of forest).

J.2. Nutrient Trading for GHG Benefits

Lead Agency: MDA/ MDE

Program Description

Since many of the agronomic, land use, and structural practices promoted by the Maryland Nutrient Trading Program administered by MDA also store carbon and lower other GHG emissions, the existing nutrient marketplace could provide a platform for the addition of a voluntary carbon component. Just like the nutrient and sediment markets, carbon trading offers entities under regulatory requirements a potentially more cost-effective means to meet their obligations while giving farmers and landowners the opportunity to receive compensation for implementing and maintaining conservation practices. MDA plans to add carbon credits and enhanced nutrient credits to the Maryland Nutrient Trading Program. Carbon and enhanced nutrient credits would be “stacked” onto existing nutrient and sediment credits as tradable commodities, thereby increasing the potential value of the total credit package and taking another incremental step toward building a comprehensive environmental marketplace. Encouraging trades between nonpoint sources, such as agricultural operations, and point sources, such as wastewater treatment plants, and industrial facilities, or other nonpoint sources, such as highway contract and development projects, would not only create new possibilities for GHG reductions, but also improve water quality, reduce fertilizer use and soil erosion, restore wetlands and wildlife habitat, provide supplemental income for farmers and foresters, create new employment opportunities, and promote Smart Growth goals by preserving agricultural and forested lands.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Nutrient Trading for GHG Benefits program in 2020 are estimated to be 0.57 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI’s 2015 Study estimated that the Nutrient Trading for GHG Benefits program supported approximately 5 jobs, \$915,527 in net economic output and \$423,432 in wages during development of web-based calculation, marketplace, and trading registry tools through 2013, but has not estimated the potential impacts that would occur with an active environmental market. Such a market would support employment of engineers, technical advisors, contractors, and other professions, in addition to providing revenue for farmers and landowners who implement conservation practices. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

Unlike many trading programs across the county which supply compliance credits for existing wastewater treatment plants, Maryland's program was designed to provide offsets for new growth and development.

- The lack of progress in finalizing stormwater policies and regulations has left the program without the necessary driver for trading although several proposals to meet reduction requirements under the Bay Total Maximum Daily Load (TMDL) will 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.
- 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 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 5-11. Building Sector GHG Reduction Program.

BUILDING		
Program I.D.	Program	Potential GHG Emission Reductions (MMtCO₂e) Revised for 2015
K	Building and Trade Codes in Maryland	3.15

K. Building and Trade Codes in Maryland

Lead Agency: DHCD

Program Description

Given the long lifetime of buildings, updating state and local building codes on a periodic basis will provide long-term greenhouse gas emissions reductions. The statewide building code in Maryland is adopted by the Maryland Codes Administration, which is within the Department of Housing and Community Development (DHCD). The statewide building code is called the Maryland Building Performance Standards (MBPS) and is updated every three years following the International Codes Council (ICC) cycle. The MBPS is based primarily on the international codes books (I-Codes) published by the ICC; the core code books adopted by Maryland are the International Building Code (IBC), the International Residential Code (IRC), and the International Energy Conservation Code (IECC). In January of each third year, the Maryland Codes Administration adopts the latest codes into the MBPS, as required by law; subsequently, the local building code authorities must adopt and implement the MBPS by July of that same year. Local code authorities may amend the MBPS to meet the specific conditions and needs of their jurisdiction – with a few exceptions. For example, the energy code (IECC) and the accessibility code (Maryland Accessibility Code or MAC) cannot be weakened. Other codes, such as the recently authorized International Green Construction Code (IgCC), are a voluntary option for local jurisdictions.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Building and Trade Codes in Maryland program in 2020 are estimated to be 3.15 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Building and Trade Codes in Maryland program, once fully operational, would support a total of 727 jobs by 2020, \$357,208,251 in net economic output and \$64,971,923 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

Recommendations for Future Actions and Reporting:

- Consider rethinking building code action items due to changes in building technology
 - Consider code changes to facilitate “Net Zero” energy buildings
 - Consider code changes to make home retrofits/renovations easier and more affordable
 - Improve and expand training statewide

The Recycling Sector

Table 5-12. Recycling Sector GHG Reduction Program.

RECYCLING		
Program I.D.	Program	Potential GHG Emission Reductions (MMtCO₂e) Revised for 2015
L	Zero Waste	1.48

L. Zero Waste

Lead Agency: MDE

Program Description

In Maryland, waste diversion is defined as the volume of waste that is diverted from entering the waste stream through recycling or source reduction activities. Source reduction activities are those that reduce or prevent the creation of waste. Maryland estimates the source reduction rate using a checklist for counties to document their source reduction activities, including backyard composting, reuse programs, and technical assistance. The counties' responses are tallied and correspond with a source reduction credit, up to a maximum of 5%, which is added to the recycling rate to produce the waste diversion rate.

Reducing the generation and disposal of waste has many benefits. It saves energy and natural resources, preserves the capacity of existing solid waste disposal facilities and reduces greenhouse gases and other pollutants generated by landfills and manufacturing processes.

MDE has developed a "Zero Waste" Action Plan – a comprehensive strategy comprised of short and longer term measures designed to nearly eliminate the need for waste disposal facilities by 2030 by reducing the generation of waste and increasing reuse and recycling. The Action Plan establishes the following future Statewide recycling and waste diversion rate goals (Table 5-13):

Table 5-13. Future State-wide Recycling and Waste Diversion Rate Goals.

Year	2015	2020	2030
Waste Diversion Goal	54%	65%	85%

Recycling Goal	50%	60%	80%
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GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Zero Waste program in 2020 are estimated to be 1.48 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Recycling & Source Reduction program, once fully operational, would support a total of 326 to 558 jobs by 2020, \$303,588,866 to \$419,730,048 in net economic output and \$123,645,781 to \$175,740,920 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

- Jurisdictions with populations greater than 150,000 are required to recycle 35 percent or more of their waste and jurisdictions with populations less than 150,000 are required to recycle 20 percent or more of their waste beginning December 2015. In no case is the recycling rate to be less than 15 percent for the larger counties and 10% for smaller counties.
- State Government must reduce by recycling the amount of the solid waste stream generated for disposal by at least 30 percent or an amount that is determined practical and economically feasible, but in no case may the amount to be recycled be less than 15 percent. This requirement begins in July 2014.
- A State Agency Recycling Plan was developed and implemented as a result of 2009 legislation that requires recycling of glass, paper, metal, and plastic at State-owned or State-operated buildings.²⁷ Agencies are now revising their plans to meet the higher goal (30%) established in 2012 legislation.²⁸ MDE has encouraged all agencies to strive to attain a recycling rate of 40% by 2015.
- Scrap tires are banned from disposal in a landfill.
- Counties must address the feasibility of composting mixed solid waste when developing their 10-year solid waste management plans.
- Separately collected yard waste is banned from disposal at solid waste acceptance facilities.

²⁷ 2009 Md. Laws ch. 408.

²⁸ 2012 Md. Laws ch. 692.

- Mercuric oxide battery manufacturers are responsible for the collection, transportation, and recycling or disposal of these batteries sold or offered for promotional purposes in the State.
- State law requires a program or system for the collection, recycling, or disposal of each cell, rechargeable battery or rechargeable product sold in the State.
- Electronics manufacturers who sell or offer for sale their product in Maryland must register and pay a fee to MDE. Fees may be used to provide grants to counties and municipalities for computer and video display device recycling activities.
- Electronics manufacturers are encouraged to implement takeback programs for reuse and recycling of electronic products.
- Motor vehicle manufacturers are required to develop and submit to MDE a mercury minimization plan that includes information on mercury switch removal from motor vehicles.
- A county is required to submit a revised recycling plan to MDE. A county's recycling plan is required to address the collection, processing, marketing, and disposition of recyclable materials from county public schools. By October 1, 2013, counties must address multi-family residential recycling in their county recycling plans. By October 1, 2014, apartments and condominiums with 10 or more units must provide recycling opportunities for residents.
- Pursuant to 2011 legislation, MDE was required to study composting in the State and make recommendations to the General Assembly by January 2013 on ways to promote composting. These recommendations were to include any necessary legislative, regulatory, or programmatic changes. MDE convened a stakeholder workgroup to develop these recommendations, which include proposed statutory changes to provide MDE with authority to regulate composting of source-separated organics (food scraps, yard trim, etc.) separately from the solid waste requirements.²⁹

Long Term 2015-2016 Initiatives:

- Quantifying the extent of existing commercial recycling
- Encouraging local governments to adopt "Pay-As-You-Throw" (PAYT) Fee Systems

Long Term 2017-2018 Initiatives:

- Achieving recycling and diversion rates of 60% and 65% by 2020
- Expanding product stewardship and extended producer responsibility (EPR) in Maryland
- Considering additional product disposal bans
- Considering bans on additional products

Long Term 2018-2020 Initiatives:

- Adopting a universal recycling requirement (all residences and commercial and institutional establishments)
- Adopt universal collection of organic materials for composting

²⁹ 2011 Md. Laws ch. 363.

Maryland's Innovative Initiatives

Table 5-14. Maryland's Innovative Initiatives GHG Reduction Programs.

MARYLAND'S INNOVATIVE INITIATIVES		
Program I.D.	Programs	Potential GHG Emission Reductions (MMtCO₂e) Revised for 2015
M	Leadership-By-Example	1.78
N	Maryland's Innovative Initiatives	0.21
O	Future or Developing Programs	0.02
Total		2.01

M. Leadership-By-Example

M.1. Leadership-By-Example: State of Maryland Initiatives

Lead Agency: DGS

Program Description

Through lead-by-example programs, state government in Maryland aims to improve energy efficiency, reduce waste, and integrate renewable energy practices in all of its agencies' operations and facilities, as well as their purchasing practices. DGS currently manages the following lead-by-example programs:

- Maryland Green Building Council
- Maryland Green Purchasing Committee
- State Energy Database
- Renewable Energy Portfolio

GHG Emissions Reductions in 2020

Revised 2015 Estimate

The potential emissions reductions from the Leadership-By-Example: State of Maryland Initiatives program in 2020 are estimated to be 0.56 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Leadership-By-Example: State of Maryland Initiatives program, once fully operational, would support a total of 20 to 27 jobs by 2020, \$63,812,257 to \$76,796,100 in net economic output and \$35,251,618 to \$43,345,713 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

The State's lead-by-example programs in high performance buildings and procurement are statutorily driven.

- DGS shares responsibility with the Board of Public Works, MDE, the Department of Budget and Management, Maryland Green Building Council, and Maryland Green Purchasing Committee for administering them.
- Programmatic progress is tracked in annual reports which both the Maryland Green Building Council and the Maryland Green Purchasing Committee are required to submit to the General Assembly.

DGS is working with the Governor's Office on reduction goals:

- A schedule for the State government's purchase of electricity from renewable sources that meets the State's RPS interim and final (2022 targets)

M.2. Leadership-By-Example: Maryland Colleges and Universities

Lead Agency: MDE

Program Description

In Maryland, the presidents' of 23 colleges and universities—including all USM schools, Morgan, SMCM, 4 community colleges and 4 independent institutions— have signed the American College and University Presidents Climate Commitment, which requires each school to complete a GHG inventory, develop a climate action plan and implement strategies to reduce GHG emissions to achieve a set target. Schools are encouraged to commit to become climate neutral by a certain date, meaning GHG emissions sourced from the school be reduced or mitigated from a base year, with remaining emissions offset by purchasing carbon credits or other means.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Leadership-By-Example: Maryland Colleges and Universities program in 2020 are estimated to be 0.56 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Leadership-By-Example: Maryland University Lead by Example Initiatives program, once fully operational, would support a total of 182 jobs by 2020, \$89,416,504 in net economic output and \$56,152,345 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

M.3. Leadership-By-Example: Federal Government

Lead Agency: MDE

Program Description

Federal agencies with facilities located in Maryland are implementing suites of lead-by-example programs to improve efficiency, reduce waste, and integrate renewable energy and sustainable practices into their operations, facilities and fleets. These programs include tools to benchmark and track energy use and GHG emissions in order to report progress. Examples of programs include energy reduction in public buildings, facilities and lands, improved efficiencies in fleet vehicles and fuels, water conservation, waste reduction and recycling, purchasing of products and services with lower life-cycle impacts, and greater use of renewable energy.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Leadership-By-Example: Federal Government program in 2020 are estimated to be 0.41 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Leadership-By-Example: Federal Government program, once fully operational, would support a total of 1,347 jobs by 2020, \$179,016,115 in net

economic output and \$121,429,442 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

In 2009 the “Federal Leadership in Environmental, Energy, and Economic Performance” was signed, which calls on the federal government to reduce its GHG emissions from direct sources to 28 percent below 2008 levels by 2020 and implement aggressive energy and water efficiency programs (Executive Order 13514, issued October 8, 2009). Federal agencies are specifically directed to set agency-wide reduction targets for Scopes 1, 2 and 3 GHG emissions and to develop and implement Strategic Sustainability Performance Plans designed to meet the targets. In July 2010 the federal government-wide target was expanded to require a 13 percent reduction by 2020 for GHG emissions from indirect sources, such as employee travel and commuting.

Data available for FY09 shows that the federal government nationally decreased energy consumption per square foot of building space by approximately 13.1 percent compared with FY03, surpassing the FY09 goal of 12 percent. The federal government also purchased or produced 2,331 gigawatt-hours of electricity from renewable sources – approximately 4.2 percent of its electricity use – surpassing the goal of 3 percent for FY09. EPA continues to provide assistance in determining the amount of federal reductions which have occurred in Maryland.

M.4. Leadership-By-Example: Local Government

Lead Agency: MDE

Program Description

Maryland county and municipal governments, together with State agencies, are adopting policies and practices to obtain high performance and energy-efficient buildings, facilities and vehicle fleets, and reduce the carbon footprint in purchasing, procurement and other government operations. Some jurisdictions have conducted GHG inventories, adopted climate action plans and targets, and implemented tracking protocol, such as those provided by the International Council for Local Environmental Initiatives.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Leadership-By-Example: Local Government program in 2020 are estimated to be 0.25 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Leadership-By-Example: Local Government program, once fully operational, would support a total of 1,982 jobs by 2020, \$248,107,910 in net economic output and \$187,011,716 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

This program combines both voluntary and mandatory initiatives. There are a wide range of implementation tools being used at the local level including ordinances, resolutions, and voluntary sustainability plans.

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 5-15. Summary of County Data with a 25 Percent GHG Reduction.

County	Base Year	Base Year Emissions		25% Reduction from Base	Low Estimate	50% Reduction from Base	High Estimate
		Metric tons of CO ₂ -equivalent	MMtCO ₂				
Baltimore City	2007	608,988	0.61	0.46	0.15	0.30	0.30
Frederick	2007	134,667	0.13	0.10	0.03	0.07	0.07
Montgomery	FY2005		0.45	0.34	0.11	0.23	0.23
Howard	2007	340,042	0.34	0.26	0.09	0.17	0.17
Prince Georges	FY2007	95,877	0.10	0.07	0.02	0.05	0.05
Baltimore County	2006	142,701	0.14	0.11	0.04	0.07	0.07
Annapolis	FY2006	11,991	0.01	0.01	0.00	0.01	0.01
Chevy Chase	2007	162	0.00	0.00	0.00	0.00	0.00
Takoma Park	1990	1,901	0.00	0.00	0.00	0.00	0.00

					0.45		0.89
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N. Maryland’s Innovative Initiatives

N.1. Voluntary Stationary Source Reductions

Lead Agency: MDE

Program Description

GGRA provides two paths for sources in the State’s manufacturing sector to follow to potentially get credit for any voluntary programs that they are implementing. Either companies may simply take totally voluntary action and provide a good faith estimate of potential reductions, which if appropriate, included in the plan as a reduction, or a company can implement an early voluntary GHG emissions reduction plan, which must be approved by MDE before January 1, 2012 and secure a formal “credit.”

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Voluntary Stationary Source Reductions program in 2020 are estimated to be 0.17 MMtCO_{2e}. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI’s 2015 Study estimated that the Voluntary Stationary Source Reductions program, once fully operational, would support a total of 4 jobs by 2020, \$5,126,953 in net economic output and \$1,785,280 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

This is a voluntary program.

N.2. Buy Local for GHG Benefits

Lead Agency: MDA

Program Description

Although farm stands and farmers markets are not new, the phenomenal surge in the locally grown movement has been fueled by not only by increasing awareness of the benefits of fresh, healthful foods and mounting consumer interest in supporting nearby producers, but also concerns raised by well publicized episodes of product contamination and foodborne illness. MDA's "Maryland's Best" campaign continues to be highly successful in promoting local farms as preferred sources of food for Marylanders by helping agricultural producers market their products directly to supermarket, food service, institutional, and other wholesale buyers, as well as consumers.

MDA will promote the sustainable production and consumption of local agricultural goods and thereby help to displace the production and consumption of products transported from other states and countries. In addition to the energy savings and GHG reductions resulting from decreased transportation emissions, greater demand for local products preserves the agricultural landscape, supports agro-biodiversity, and encourages beneficial environmental practices. MDA will work with farmers, local governments, restaurants, food distributors and retailers, value-added producers, public and private institutions, and trade associations to maintain and expand its popular "Maryland's Best – Local, Fresh" program. By 2020, MDA aims to raise the number of farmers markets by 20%, establish a state farmers market association, and increase direct sales (buyer/grower) by 20%.

MDA created the website "Maryland's Best" (www.marylandsbest.net) as an online resource to help buyers and consumers find locally grown products. A directory of markets also can be found online at:

http://mda.maryland.gov/maryland_products/pages/farmers_market_dir.aspx.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Buy Local for GHG Benefits program in 2020 are estimated to be 0.02 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Buy Local for GHG Benefits program, once fully operational, would support a total of 27 jobs by 2020, \$17,395,022 in net economic output and \$8,266,448 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report

provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

MDA appears to have already fulfilled its goals under this initiative

- The Maryland Farmers Market Association (www.marylandfma.org) was established in 2012 through a federal matching grant awarded to MDA in cooperation with the University of Maryland and Maryland's market managers.
- As of spring 2015, there were 145 farmers markets across the State, with at least one in every Maryland county and Baltimore City.
 - This number represents 94% of the 2020 goal, but it is likely that the target of 155 markets has been achieved because there are always markets that are not included in the official count for a variety of reasons.
 - MDA participates in the USDA Farmers Market Nutrition Program (FMNP), which provides checks to low-income residents to purchase fresh produce.
 - 400 Maryland farmers enrolled in this effort last year and received over \$500,000 through the program.
 - In 2014, the Maryland Department of Human Resources joined with the Farmers Market Association to install point-of-sale machines in farmers markets across the state so that purchases can be made by low-income residents on electronic benefit transfer cards.
 - In 2015, 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.
- MDA does not track direct sales figures, but if annualized participant numbers at the buyer-grower expo held each winter since 2002 are used as a proxy, the event has grown 93% in the last nine years.
 - The Jane Lawton Farm-to-Food Program established by the General Assembly-in 2008 promotes and facilitates the sale of farm products to Maryland schools and educates students about the sources of their food, how it is produced, and the benefits of a healthy diet.
- 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.

N.3. Pay-As-You-Drive® Insurance in Maryland

Lead Agency: MIA

Program Description

Pay-As-You-Drive® automobile insurance is also known as use-based insurance. Generally, use-based insurance plans are designed to align the amount of premium paid with actual vehicle usage. The distance an automobile is driven, the speed at which it is driven, and the time of day it is driven all are factors that can be used to determine premiums under a use-based plan.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Pay-As-You-Drive® Insurance program in 2020 are estimated to be 0.02 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Pay-As-You-Drive® Insurance program, once fully operational, would support a total of 1 job by 2020, -\$122,071 in net economic output and \$30,518 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

This is a voluntary program. However, more companies are offering use-based insurance to customers than in 2012.

N.4. Job Creation and Economic Development Initiatives Related to Climate Change

Lead Agency: COMMERCE

Program Description

This program promotes economic development opportunities associated with reducing GHG emissions in Maryland. There are six areas of focus:

- Strengthen coordination and communication across State agencies, partners and stakeholders to provide strategic vision for advancing a green economy
- Promote energy and resource efficiency efforts
- Develop and foster clean, local energy production and industrial capacity

- Capitalize upon economic opportunities to restore and protect Maryland’s natural resources
- Promote sustainable development practices that create jobs, generate prosperity and make Maryland more self-reliant
- Increase access to capital for green businesses and projects

GHG Emission Reductions in 2020

Revised 2015 Estimate

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.

Job Creation and Economic Benefits

Revised 2015 Estimate

Although the Job Creation and Economic Development Initiatives Related to Climate Change program will provide both economic output and job creation, the benefits of this program are accounted for in the other programs detailed in this chapter of the GGRA plan. Listing the benefits of this program in both this section and in the other programs would result in double counting of the benefits. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

This is a voluntary initiative.

O. Future or Developing Programs

O.1. The Transportation and Climate Initiative

Lead Agency: MDE/MDOT

Program Description

The Transportation and Climate Initiative (TCI) is a regional effort of Maryland and 10 other Northeast and Mid-Atlantic states and Washington, D.C.¹ to reduce GHG emissions in the region’s transportation sector, minimize the transportation system’s reliance on high-carbon fuels, promote sustainable growth to address the challenges of vehicle-miles traveled, and help build the clean energy economy across the region.

More information on this program can be found at:

- www.transportationandclimate.org
- www.georgetownclimate.org/

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the TCI program in 2020 are estimated to be 0.02 MMtCO₂e. Appendices C and J of this report provide a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the TCI program, once fully operational, would support a total of 1 job by 2020, \$784,738 in net economic output and \$697,548 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

The Transportation and Climate Initiative is a multi-state collaborative and voluntary initiative

O.2. Clean Fuels Standard

Lead Agency: MDE

Program Description

The Clean Fuels Standard program is a cooperative effort being undertaken by eleven Northeast and Mid-Atlantic States to design and implement a regional low carbon fuel standard to reduce the carbon intensity of transportation fuels. The Clean Fuels Standard program is a collaboration of commissioners from the environmental and energy agencies in those 11 states. This effort is still in the analysis stage and there are no specific plans on implementation at this time.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Clean Fuels Standard program in 2020 are estimated to be 0.00 MMT_{CO₂e}. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Job Creation and Economic Benefits

Revised 2015 Estimate

A detailed economic analysis of this initiative was not conducted as it is a new effort that is still evolving.

Implementation

This program is still under development. At this time, the eleven states involved in the partnership have not made any decisions about program design or implementation. If finalized, this program would be implemented through regulations adopted by MDE.

Land Use

Table 5-16. Land Use Sector GHG Reduction Program.

LAND USE		
Program I.D.	Program	Potential GHG Emission Reductions (MMtCO₂e) Revised for 2015
P	Land Use Programs	0.64

P. Land Use Programs

The two programs designed to minimize GHG emissions from future land development are P1. Reducing Emissions through Smarter Growth and Land Use/Location Efficiency and P2. Priority Funding Area (Growth Boundary) Related Benefits. MDP is the lead agency for these efforts, which involve the private sector and various agencies and commissions at all levels of government within the State.

By better managing growth, local communities can minimize harmful sprawl development and contribute to a reduction in Maryland's GHG emissions. Smart growth is characterized by compact, transit-oriented, bicycle-friendly land use, with neighborhood schools, walkable streets, mixed-use development and a wide range of housing choices. Smart growth concentrates new development and redevelopment in areas with existing or planned infrastructure to avoid sprawl, which is generally characterized as the increased development of land in suburban and rural areas *outside* of their respective urban centers. This increased development on the outskirts of towns, villages and metropolitan areas is often accompanied by a *lack* of development, redevelopment or reuse of land *within* the urban centers themselves and results in a marked increase in GHG emissions.

It should be noted that many local governments in Maryland are already implementing smarter, more sustainable land use policies and programs that are: promoting green building and compact, transit-oriented development; reducing aggregate VMT; preserving vegetated/forested lands (which sequester carbon); and protecting agriculture.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Land Use Programs in 2020 are estimated to be 0.64 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions.

Implementation

Transportation Model Issue:

- The *2012 GGRA Plan* noted that “conventional transportation models have focused on speed, distance, and the number of vehicles accommodated. To measure GHG reductions from land use/location efficiency, transportation models must also emphasize access, proximity and VMT.”
- To begin to address this issue, SHA is refining the Maryland Statewide Transportation Model (MSTM) which, together with similar regional four step travel demand models, have been used to forecast growth in vehicle volumes, test scenarios, make performance measurements, etc.
- MDP in cooperation with SHA has been using the MSTM and regional models to evaluate progress toward compact development and GHG prevention.

Other Indicators of Land Use:

- The *2012 GGRA Plan* noted that “until an updated transportation model is in place that can adequately take into account the GHG reduction benefits of land use/location efficiency factors, MDP recommends additional metrics to determine progress.”
 - MDP is supporting the Maryland Sustainable Growth Commission in its effort to develop and evaluate smart growth indicators. A draft web tool entitled “Current Status Check: Progress toward Sustainable Development and Conservation Objectives” is in development that includes sustainable transportation and land use indicators.

As part of MDP’s technical assistance to local and state government to promote smart growth and land use/location efficiency, MDP provides data analysis and forecasting, making use of a variety of data sets and analytical tools, such as the MDP parcel database, U.S. Census information, MDP land use/land cover data, and MDP Growth Simulation Model. MDP is also assisting local governments on infill and redevelopment projects in existing communities, utilizing various best planning practices to help revitalize and attract new development to this areas.

MDP continues to implement the following existing programs in support of achieving 0.64 MMtCO₂e in GHG reduction by 2020:

Smart Growth Subcabinet:

- If necessary, recommends to the Governor changes in State law, regulations, and procedures needed to support Smart Growth Policy and works to create, enhance, support, and revitalize Sustainable Communities across Maryland.

Maryland Sustainable Growth Commission:

- Charged with assessing the progress that State, regional, and local planning agencies are making towards achieving the goals of the State Economic Growth, Resource Protection, and Planning Policy (12 visions)
- Consistent with the 12 visions, the Commission is to make recommendations on the adequacy, coordination, and implementation of funding mechanisms and State assistance for planning, infrastructure, and land preservation.
- To facilitate voluntary joint planning among State and local jurisdictions, the Commission will make recommendations that promote coordination and cooperation.
- The Commission will advise on the content, preparation, and implementation of the State Development Plan, the State Transportation Plan, and the State Housing Plan, and also consider how they relate to local land use plans.

Sustainable Communities Act of 2010:

- Established the “Sustainable Communities” designation in order to strengthen reinvestment and revitalization
- Enhanced an existing rehabilitation tax credit into the Sustainable Communities Tax Credit Program
- Simplified the framework for designated revitalization target areas in the Community Legacy and Neighborhood BusinessWorks programs
- Requires the Maryland Department of Transportation to consider Sustainable Communities as it annually considers the Consolidated Transportation Program

2009 legislative suite (HB294/SB273, HB297/SB280 and HB295/SB276):

- Incorporation of the 12 new planning visions in local comprehensive plans
- Development of local land use goals
- Consistency of local land use ordinances with comprehensive plans
- Submittal of local annual reports

Priority Funding Areas:

- Maryland law directs the use of State funding for roads, water and sewer plants, economic development and other growth-related needs toward Priority Funding Areas, recognizing that these investments are the most important tool the State has to influence smarter, more sustainable growth and development.

The 2009 California Climate Scoping Plan notes that GHG prevention should double every 20 years through a combination of land use and enhanced transit policies (Figure 5-12.).

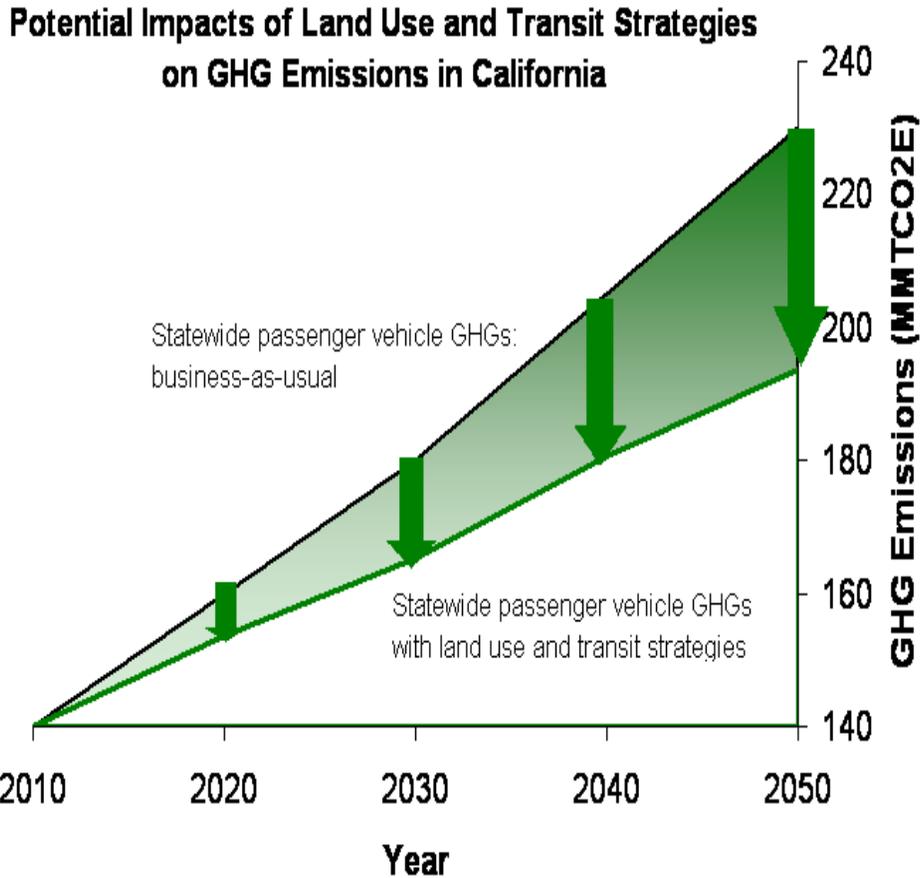


Figure 5-12. Potential Impacts of Land Use and Transit Strategies on GHG Emissions in California. The possible impacts of land use and transportation policies have been well documented. Most recently, a 2008 U.C. Berkeley study reviewed over 20 modeling studies from California (including the State’s four largest MPOs), other states and Europe. The study found a range of 0.4 to 7.7 percent reduction in VMT resulting from a combination of land use and enhanced transit policies compared to a business-as-usual case over a 10-year horizon, with benefits doubling by 2030.³⁰

P1. Reducing Emissions through Smart Growth and Land Use/Location Efficiency

Lead Agency: MDP

Program Description

³⁰ Rodier, Caroline. U.C. Berkeley, Transportation Sustainability Research Center, “A Review of the International Modeling Literature: Transit, Land Use, and Auto Pricing Strategies to Reduce Vehicle Miles Traveled and Greenhouse Gas Emissions,” August 2008. http://www.arb.ca.gov/planning/tsaq/docs/rodier_8-1-08_trb_paper.pdf

This program reduces Marylanders' dependence on motor vehicle travel, especially single occupant vehicles, by developing incentives and requirements for development projects and regional land use patterns that achieve land use/location efficiency with regard to transportation. The purpose is to reduce VMT and the combustion of fossil fuels. Land use/location efficiency means that residences, jobs, shopping, schools, and recreational opportunities are in close proximity to each other and that alternative transportation modes (walking, biking and mass transit) are convenient and easily accessed. The Smart Growth development pattern, together with land use/location efficiency, results in shorter trip lengths, less need for automobile and truck travel, and greater use of alternative transportation modes.

Existing state laws and initiatives that support the P.1 strategy include the Maryland Sustainable Growth Commission, Smart Growth Subcabinet, Sustainable Communities Act of 2010, 2009 planning legislation, MDP data analysis and forecasting, and MDP indicator development.

GHG Emission Reductions in 2020

Revised 2015 Estimate

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.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Reducing Emissions through Smart Growth and Land Use/Location Efficiency program, once fully operational, would support a total of 1,855 to 4,921 jobs by 2020, \$6,678,779,555 to \$7,045,812,977 in net economic output and \$1,115,978,571 to \$5,182,441,243 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

P2. Priority Funding Area (Growth Boundary) Related Benefits

Lead Agency: MDP

Program Description

Maryland has established Priority Funding Areas to preserve existing communities, to target State resources to build on past investments, and to reduce development pressure on critical farmland and natural resource areas. By encouraging projects in already developed areas, PFAs reduce the GHG emissions associated with sprawl. Priority Funding Areas are geographic

growth areas defined under Maryland law and designated by local jurisdictions to provide a map for targeting State investment in infrastructure. A map of the Priority Funding Areas in Maryland is available on MDP's website at: <http://planning.maryland.gov/OurProducts/pfamap.shtml>. Maryland law directs the use of State funding for roads, water and sewer plants, economic development and other growth-related needs toward Priority Funding Areas, recognizing that these investments are the most important tool the State has to influence smarter, more sustainable growth and development.

GHG Emission Reductions in 2020

Revised 2015 Estimate

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.

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Priority Funding Area (Growth Boundary) Related Benefits program, once fully operational, would support a total of 3,776 to 4,769 jobs by 2020, \$8,579,756,640 to \$13,809,582,408 in net economic output and \$3,447,810,437 to \$6,745,858,578 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

The Public Sector

Table 5-17. Public Sector GHG Reduction Program.

PUBLIC		
Program I.D.	Program	Potential GHG Emission Reductions (MMtCO₂e) Revised for 2015
Q	Outreach and Public Education	0.03

Q Outreach and Public Education

Lead Agency: A multi-agency effort coordinated by MDE

Program Description

State-sponsored public education and outreach combined with community actions form the foundation for behavioral and life style changes necessary to reduce GHG emissions. This program is designed to promote new actions and encourage continuation of existing efforts such as the educational efforts and action campaigns of State agencies, such as MDE, DNR, Maryland State Department of Education, and University of Maryland; electric utilities; non-profit organizations; faith communities; and others. This combination of efforts insures that scientifically based factual information is made available through public education and outreach efforts and reaches all segments of the public.

GHG Emission Reductions in 2020

Revised 2015 Estimate

The potential emission reductions from the Outreach and Public Education program in 2020 are estimated to be 0.03 MMtCO₂e. Appendix C of this report provides a more detailed description of the process used to quantify GHG reductions

Job Creation and Economic Benefits

Revised 2015 Estimate

RESI's 2015 Study estimated that the Outreach and Public Education program, once fully operational, would support a total of zero jobs by 2020, \$152,588 in net economic output and

\$61,036 in wages over the lifetime of the program. Chapter 6 and Appendix K of this report provide more detail on the RESI studies and the job creation and economic benefits associated with this program.

Implementation

This is a voluntary program.

Outreach and public education are supporting efforts to other programs. It does not exist as a separate, quantifiable entity.

Program Enhancements

The following programs have been identified as areas to focus continued research and analyses on to explore opportunities that could further reduce GHG emissions while strengthening Maryland's economy, creating jobs and protecting Maryland consumers. Any emissions reductions obtained by enhancement options that are currently implemented have been accounted for relative to obtaining the 2020 GGRA goal.

MDE and the other State Agencies implementing the measures in the *2015 GGRA Plan Update* will work with the Maryland Climate Change Commission's Mitigation Working Group to analyze at least the measures listed below:

- Continued effort on electric vehicles, electric vehicle infrastructure, zero emission vehicles and other possible enhancements to the Maryland Clean Cars program
- Additional analyses of options designed to promote renewable energy, conservation and energy efficiency that support State economic development goals and protect Maryland consumers
- Expanded efforts on forestry and agricultural strategies that line up with State goals in those areas while also supporting a strong economy
- New initiatives on fast acting climate changers, regional and local partnerships and creative financing to support investment into transportation, energy and other technologies, that generate significant cost savings over time, but not widely used at this time because of the initial capital investment that is needed
- Additional emerging issues for potential analysis include:
 - Life cycle analyses of various energy strategies
 - Health risk and benefits analysis
 - Hydraulic fracturing and other natural gas issues

The following programs have been enhanced based upon the *2012 GGRA Plan*.

A. EmPOWER Maryland

In July 2015, the PSC issued an order directing the continuation of utility programs supporting EmPOWER Maryland energy reduction policy and set new savings targets that will extend beyond the original 2015 goals in the EmPOWER Maryland statute. In its order, the PSC directed utilities to ramp up electricity savings to 2% of gross sales³¹ for as long as cost-effective savings continue to be available. The PSC also directed workgroups to recommend by February 1, 2016, separate goals for natural gas savings and low- and moderate-income sector savings. Savings can come from a variety of sources, including traditional equipment-based measures,

³¹ This is not equivalent to requiring that total electricity sales decrease by 2% a year. Instead, it requires verified savings to be equivalent to 2% of the most recent baseline year's weather-normalized gross sales. For example, if a utility's most recently baseline year's weather-normalized gross sales were 1,000,000 MWh, their electricity savings target would be 20,000 MWh (2% of 1,000,000).

“smart meter” enabled analytics, and more efficient distribution grid hardware. Utilities will be reviewing their current plans and proposing modifications as needed to meet the new goals.

While the PSC order does not specifically contemplate a separate savings goal for non-utility entities, MEA and other state agencies will continue to work closely with the PSC and Maryland utilities to ensure that programs are effectively designed and implemented. Additionally, MEA and DGS continue to work on efforts to reduce energy use in State buildings.

E.1.A. Maryland Clean Cars Program

The State is pursuing the following options to increase GHG emission reductions from motor vehicles by 2020 and beyond:

- Incentivize Passenger Fleet Turnover
- Incentivize Taxi Fleet Turnover

E.1.C. National Fuel Efficiency and Emission Standards for Medium and Heavy- Duty Trucks

MDOT efforts requiring trucks to maintain an average fleet age to ensure fleet turnover is discussed as an enhancement option in E.2.A. On Road Technology, below.

E.2.A. On Road Technology

The following enhancement options have been implemented to achieve additional reductions in GHG emissions by 2020 and beyond:

- Enhance CHART
 - The FY2015-2020 CTP includes \$113.8 million to continue to expand and enhance CHART.
- Provide Real Time Transit Information
 - MTA and WMATA have implemented real-time technologies. These are being expanded to some LOTS operators.
- Incentivize Truck Fleet Turnover
 - MDE, MDOT and MPA are working together to retire old dray trucks through grant programs.
- Promote Driver Education and Training (ECO-Driving)
 - Baltimore and Washington MPOs promote ECO-driving. The I-95 Corridor Coalition also promotes ECO-driving.
- Promote Black Carbon Reductions
 - The diesel vehicle emissions control program specifically targets the vehicles most likely to emit black carbon. The program affects any diesel-powered vehicle with a gross vehicle weight rating of over 10,000 pounds traveling on Maryland’s highways. Enforcement is carried out by the Maryland State Police and the

Maryland Transportation Authority Police (MTAP), who can require any heavy-duty diesel vehicle to submit to a smoke emissions test at any time or place.

E.2.B. Airport Initiatives

The following enhancement options have been implemented to achieve additional reductions in GHG emissions by 2020 and beyond:

- Increase Alternative Fueled Ground Support Vehicles
 - 30% of MAA vehicles use alternative fuels.
- Promote Preferential Parking
 - Preferential Parking exists in both the daily and hourly garages at BWI.
- Promote Reforestation and Afforestation at BWI
 - MAA maintains a Reforestation Master Plan and Forestry Management Plan that comply with multi-agency regulations and specify areas set aside for forest conservation and retention.
- Promote Hybrid Car Rentals and Satellite Lot Shuttle Vehicles
 - Many car rental companies offer hybrid or “green” rental options, which are available at BWI.
- Promote More Transit Connections
 - RTA, ICC Bus, MTA Bus and WMATA Bus service are all available at BWI Thurgood Marshall. In addition, travelers can access MARC, AMTRAK and Light Rail trains.

E.2.C. Port Initiatives

The following enhancement options have been implemented to achieve additional reductions in GHG emissions by 2020 and beyond:

- Electrification of Power for Docked Ships
 - MPA is conducting feasibility studies of this technology. The Port of Los Angeles and Port of Long Beach are good examples of recent successful implementation.
- Electrification of Ground Support Equipment
 - The Port continues to use grant and other funds to update equipment including engine repowers, anti-idling devices, vehicle replacements and electrification of gantries.
- Implementation of Marine Highways Corridors Program and Barge Subsidies
 - On behalf of its member and affiliate agencies, the I-95 Corridor Coalition submitted a successful application to USDOT and has attained designation of the M-95 Marine Highway Corridor. The corridor includes a series of waterways/crossings/connections within the Coalition’s region, which includes the Port of Baltimore.

E.2.D. Freight & Freight Rail Programs

The following enhancement options have been implemented to achieve additional reductions in GHG emissions by 2020 and beyond:

- Evaluate Implementation of National Gateway Initiative and Multi-Modal Goods Movement Strategy
 - Maryland is continuing to work with CSX (National Gateway) and NS (Crescent Corridor).
- Accelerate Construction of High Speed Rail
 - MARC/Amtrak planning/engineering through Federal grants for Howard Street Tunnel, Susquehanna River Bridge, and BWI Station enhancement/new track are ongoing.
- Assist CSX in Constructing a New Intermodal Container Facility to Address Howard Street Tunnel Challenge
 - Parties decided not to go forward with the original location based on public input; discussions are ongoing.

E.3. Electric and Low Emitting Vehicle Initiatives

The following enhancement options have been implemented to achieve additional reductions in GHG emissions by 2020 and beyond:

- Extend Tax Credits for EVs and EV Charging Equipment
 - Both incentives have been extended by General Assembly to June 30, 2017 (2014 Session). EV charging equipment tax credit was changed to a point of purchase rebate.
- Extend HOV Lane Exemption
 - The General Assembly extended this to 2017 (2103 Session).
- Adopt EV Fleet Purchasing Goal
 - An Executive Order was signed establishing fleet purchasing goals in January 2015. It is currently under review and a new fleet purchasing goal is under consideration.
- Provide EV Charging Stations for State Employees
 - The State has installed several new charging stations at State facilities and is in the process of reviewing State facilities to determine which facilities would be appropriate for charging stations. In addition, the State has implemented a program to install 21 DC Fast Chargers throughout the state by the first quarter of 2016. When completed, this program will more than double the existing Fast Charger network and allow EV travel throughout the state.
- Extend Idle Reduction Technology Grants
 - This program was discontinued in the fall of 2014 due to a loss in federal funding. The State is exploring other funding options.

F.1. Public Transportation Initiatives

The following enhancement options have been implemented to achieve additional reductions in GHG emissions by 2020 and beyond:

- Expand Local Circulator Buses and Transit
 - MDOT provides funding for the LOTS program to support fleet replacement, maintenance/operations, and capacity enhancements.
- Implemented Real-Time Transit Information Technologies
 - MTA and WMATA have or are in the process of implementing real-time technologies.
- Expand Ridesharing through Apps and Social Marketing
 - Commuter Connections offers mobile apps to commuters where they can access ridesharing matches with other commuters living and working in the same area.
 - Commuter Connections also maintains Facebook and LinkedIn pages.
- Increase Commuter Choice Employer Incentives
 - Commuter Connections offers a broad range of services to employers, including consultation on many alternative modes of transportation and telework opportunities.
 - Maryland continues to offer tax credits for employers
 - <http://metroridehsare.com/employer-information/tax-credit/>
- MTA Bus Replacement
 - 85% of MTAs fleet uses cleaner alternatives to conventional diesel.
- Transit Oriented Development
 - Eight sites are undergoing development.

G. Pricing Initiatives

The following enhancement options have been implemented to achieve additional reductions in GHG emissions by 2020 and beyond:

- Increase Gasoline Sales Tax
 - 2013 General Assembly action
- Enhance Electronic Toll Collection
 - MDTA plans for Francis Scott Key and Hatem Bridge conversion to AET
 - Ongoing statewide feasibility study by MDTA
- Explore Other Revenue Instruments
 - In order to create an enhanced framework for future P3s that will attract private investment to help build new infrastructure, Maryland passed House Bill 560, which was signed into law on April 9, 2013.
 - The new legislation provides the private sector with a stronger, more predictable and streamlined process, protects public assets, ensures a strong workforce, requires competitive bidding for all projects and allows the private sector to submit new unsolicited concepts to address Maryland's infrastructure needs.
 - <http://www.mdta.maryland.gov/partnerships/tp3overview.html>
- Strengthen Parking Programs
 - SHA/MTA expansion of park-and-rides, TERM funding for Commuter Connections, Commuter Choice Maryland

- Congestion Pricing
 - Opening of ICC and I-95 Express Toll Lanes
 - Future Plans for I-95 Phase 2 ETL uncertain
- Enhanced electronic toll collection through completion of the Intercountry Connector and the I-95 Express Toll Lanes
- Added high-speed electronic toll lanes at the Fort McHenry Tunnel and Key Bridge toll plazas
- Commuter Choice Maryland and Commuter Connections ridesharing and guaranteed ride home programs
- Park and Ride lots
 - Over 1,000 new spaces under construction or planned in 2015/2016
- Other local and regional transportation demand management strategies

H.2. Bike and Pedestrian Initiatives

The following enhancement options have been implemented to achieve additional reductions in GHG emissions by 2020 and beyond:

- Bike Shelters & Bike Sharing
 - Bike sharing program underway
- Consider Bike Accommodations for all Roadway Projects
 - 77 roadway capacity or bridge upgrade projects in MDOT's Consolidated Transportation Program include accommodations for bicycles and pedestrians
 - Bikeways Program (23 bike network projects funded in 2014) and Bikeshare Program (ongoing awards supporting successful implementation in Baltimore City, College Park/UMD, and Montgomery County)
 - SHA manages the Sidewalk Construction for Pedestrian Access Program, Retrofit Bicycle Program, and the Community Safety and Enhancement Program
 - Cycle Maryland
 - East Coast Greenway

M.1. Leadership-By-Example: State of Maryland Initiatives

DGS will work with the Governor and General Assembly to improve energy efficiency, reduce waste, and integrate renewable energy practices in State buildings:

- DGS is working with State Agencies to develop Energy Plans that set priorities for improvement at each Agency.
- DGS is working with State agencies to train the Agency Energy Coordinator staff at each Agency to analyze energy consumption and account for improvements and implementation of energy efficiency programs.
- DGS is working with the Maryland Green Building Council to ensure new State facilities are independently metered for energy and water consumption.

- DGS is providing resources and expertise to local governments, businesses, and institutions to promote widespread adoption of the State's lead-by-example practices in environmentally preferable purchasing.

Chapter 6: Maryland Jobs and the Economy

Frequently Used Abbreviations and Acronyms

GGRA: Greenhouse Gas Emissions Reduction Act

GHG: Greenhouse Gas

MDE: Maryland Department of the Environment

RESI: Regional Economic Studies Institute of Towson University

REMI: Regional Economic Models, Inc.

Introduction

Climate change and mitigation strategies are important factors for many elements of the economy and society in general: the rising costs of energy and transportation, threats to the environment, and the health of the greater population (and, by extension, the labor pool). Energy, transportation, agriculture and forestry, recycling, buildings, land use, and many other areas are affected by climate change. As such, mitigating climate change is a vital concern.

Maryland State government agencies are doing their part to mitigate the negative effects of climate change by creating and implementing climate change mitigation strategies designed to reduce GHG emissions in the State. The GGRA strategies under various state government agencies have been organized into eight subject areas: energy, transportation, agriculture and forestry, recycling, multi-sector, buildings, land use, and innovative initiatives.

This report is a refinement of RESI's 2014 results, taking into account the short-term job creation, economic activity, and wage effects from these GGRA strategies and potential enhancements of some programs. The 2014 report was a preliminary analysis of the potential economic impacts of mitigation strategies for the *2012 GGRA Plan*. During this refinement, RESI used a dynamic model known as the REMI model PI+ to assist in determining cumulative benefits and annual impacts to the region. This model allowed RESI to review the interactions among agencies within the region from the strategies and changes that would result from the interaction of those agencies. The results of this report are considered to be a more accurate representation of the possible outcomes from these reduction strategies and provide a potential estimation of economic activity through 2020.

This report includes refined data from agencies that outlined spending on programs, and allocation of funds to different industries. Additionally, areas such as transportation were refined with agency coordination to determine the impact from these programs directly associated with GHG reduction, and the categories of spending such as architecture, planning, land acquisition,

and construction. This report highlights how the GGRA will benefit Maryland in job creation across all economic groups, as well as retain Maryland's currently highly educated workforce through programs associated with the green economy.

Summary of Findings

RESI analyzed data collected in collaboration with state agencies and MDE in order to estimate the economic impacts of climate action strategies and their subprograms. Using data contained in strategy write-ups provided by MDE as well as external research from a variety of sources, including the implementing agencies, RESI estimated the impacts of each strategy and subprogram.

RESI coordinated with state agencies to develop a methodology. The agencies assisted in the development and finalization of all assumptions used in the economic modeling for RESI's analysis. Through this coordinated effort, RESI built upon their original design in 2011 creating an investment and operation phase. A detailed explanation of the investment and operation phases and what they entail can be found in Appendix B.1 of Appendix E-1 of the *2012 GGRA Plan*.

To quantify the economic and fiscal impacts of climate action strategies and their subprograms, RESI utilized the REMI PI+ input/output model. For more information regarding REMI PI+, please refer to Appendix B.2 of Appendix E-1 of the *2012 GGRA Plan*, which presents *The Economic Impact Analysis Revision for the Greenhouse Gas Emissions Reduction Act 2012 Plan*.

A summary of RESI's findings, including the total economic impacts (employment, output, and total net benefits) of all strategies within a subject area can be found in Table 6-1. The total wage impacts can be found in Tables 6-2 and 6-3. Total net benefits can be found in Tables 6-4 and 6-5.

RESI reviewed findings for both status quo program spending and enhancement spending. Although the enhancements are not guaranteed funding, the potential to reduce more greenhouse gases and increase jobs within the state was analyzed. Enhanced programs ranged from energy, transportation, land use, and innovative initiatives. The agencies provided the potential costs to achieve these new GHG targets under the enhanced scenarios of specific strategies, and RESI used this data to create a secondary analysis.

This update provides updated costs and benefits associated with GGRA policies as analyzed in the 2014 report. In addition to updated annual data, RESI received detailed data regarding funding of programs, spending, and how programs would be implemented if enhanced GGRA reductions were approved.

For more detailed impacts and further explanation, please refer to Section 3.0 of Appendix A in the *2012 GGRA Plan* Appendix E-1. Information regarding the modeling assumptions and

procedures used to derive impacts for each strategy within the subject areas can be found in Appendix C of Appendix E-2 of the 2012 GGRA Plan. Appendix D of Appendix E-2 of the 2012 GGRA Plan provides a discussion of the general occupations most likely to be associated with each subject area.

Table 6-1. Total Annual Economic Impacts by Strategy Subject Area—Investment and Operation Phases, 2010–2020^{32,33}.

Subject Area	Jobs³⁴	Output	Total Cost	Total Net Benefit
Energy				
Status Quo	12,156.0	\$14,039,556,803	\$14,983,805,248	-\$944,248,445
Enhancement	14,058.1	\$15,448,356,592	\$16,729,297,904	-\$1,280,941,312
Transportation				
Status Quo	3,099.7	\$3,491,312,335	\$2,206,654,201	\$1,284,658,134
Enhancement	6,267.7	\$8,383,504,300	\$4,244,515,129	\$4,138,989,171
Agriculture				
Status Quo	-298.2	\$2,099,151,612	\$632,038,070	\$1,467,113,542
Enhancement	-297.7	\$2,104,949,646	\$760,708,403	\$1,344,241,243
Recycling				
Status Quo	325.5	\$303,588,867	\$9,257,145	\$294,331,722
Enhancement	558.0	\$419,730,048	\$15,869,391	\$403,860,657
Buildings				
Status Quo	726.8	\$357,208,252	\$7,873,194	\$349,335,058
Enhancement	N/A	N/A	N/A	N/A
Land Use				
Status Quo	6,748.1	\$15,258,536,194	\$15,564,480,642	-\$305,944,448
Enhancement	8,522.9	\$21,967,353,014	\$23,832,525,089	-\$1,865,172,075
Innovative Initiatives				
Status Quo	3,564.2	\$602,800,640	\$213,878,700	\$388,921,940
Enhancement	3,572.4	\$616,880,934	\$228,332,229	\$388,548,705
Outreach				
Status Quo	0.1	\$152,588	\$22,500	\$130,088
Enhancement	N/A	N/A	N/A	N/A

³² The *Transportation* and *Innovative Initiatives* subject areas exhibit impacts from 2020 to 2025. However, those impacts were excluded in Figure 1 and Figure 2. For the specific distribution of impacts over time, refer to Section 3.0 of the full report. In addition, summed impacts throughout the report may not add up exactly to totals due to rounding.

³³ All dollar values are reported in 2015 dollars.

³⁴ Jobs figures reflect net job impacts in the year 2020.

Total				
Status Quo	26,322.2	\$36,152,307,291	\$33,618,009,700	\$2,534,297,591
Enhancement	33,442.8	\$49,298,135,374	\$45,819,143,839	\$3,478,991,535

Source: RESI

As shown in the table above, during the investment and operation phases of these strategies, the total economic benefits would include approximately 26,322 jobs maintained in 2020 and \$36.2 billion in output between 2010 and 2020 for the status quo. The total cost of all strategies in all subject areas is approximately \$33.6 billion, for the status quo. The expected net benefits under the enhanced scenarios would be \$3.5 billion in net benefit with 33.4 thousand jobs maintained in 2020. The net benefit includes public and private costs. It is important to note that employment impacts are not cumulative, and therefore annual impacts are jobs created above the baseline forecast. For more information on interpreting the results, please review the REMI PI+ model overview in Appendix B.2 of Appendix E-1 of the *2012 GGRA Plan*. All employment impacts in this report represent the number of jobs created or maintained in a given year as compared to the baseline.

A summary of the wage impacts is represented in Table 6-2 and 6-3. The investment phase generates more jobs than the operation phase because the public and private sectors must hire workers to implement the strategies. However, once policies are in place, growth stabilizes, and maintenance and monitoring are the primary employment needs of a program.

Table 6-2. Wage Impact by Strategy Subject Area—Investment Phase, 2010–2020³⁵.

Subject Area	Jobs³⁶	Wages
Energy		
Status Quo	9,019.5	\$4,651,750,397
Enhancement	10,041.5	\$7,761,206,051
Transportation		
Status Quo	2,490.0	\$1,439,102,172
Enhancement	5,018.7	\$2,980,082,579
Agriculture		
Status Quo	498.4	\$59,032,440
Enhancement	498.9	\$61,617,397
Recycling		
Status Quo	773.1	\$292,888,641
Enhancement	1,325.3	\$414,719,170
Buildings		
Status Quo	18.6	\$10,284,424
Enhancement	N/A	N/A
Land Use		
Status Quo	4,920.9	\$4,744,735,057
Enhancement	5,652.4	\$8,053,793,823
Innovative Initiatives		
Status Quo	361.1	\$228,725,433
Enhancement	368.3	\$236,843,110
Outreach		
Status Quo	0.0	\$0
Enhancement	N/A	N/A
Total		
Status Quo	18,081.6	\$11,426,518,564
Enhancement	22,923.6	\$19,518,546,554

Source: RESI

³⁵ All dollar values are reported in 2015 dollars.

³⁶ Job figures reflect net job impacts in the year 2020.

Table 6-3. Wage Impact by Strategy Subject Area—Operation Phase, 2010–2020³⁷.

Subject Area	Jobs³⁸	Wages
Energy		
Status Quo	3,136.4	\$1,273,496,043
Enhancement	4,051.2	\$1,932,556,944
Transportation		
Status Quo	609.8	\$131,679,378
Enhancement	1,249.0	\$247,501,555
Agriculture		
Status Quo	-796.6	\$698,379,517
Enhancement	-796.6	\$698,379,517
Recycling		
Status Quo	-447.6	-\$169,242,859
Enhancement	-767.3	-\$238,978,248
Buildings		
Status Quo	708.2	\$54,687,500
Enhancement	N/A	N/A
Land Use		
Status Quo	1,827.2	\$1,601,903,602
Enhancement	2,870.5	\$2,488,973,900
Innovative Initiatives		
Status Quo	3,203.1	\$181,956,159
Enhancement	3,204.0	\$182,612,688
Outreach		
Status Quo	0.1	\$61,035
Enhancement	N/A	N/A
Total		
Status Quo	8,240.7	\$3,772,920,375
Enhancement	10,519.2	\$5,365,794,892

Source: RESI

As shown in the tables above, these strategies result in a wage impact that ranges from of \$11.4 to \$19.5 billion in the investment phase for status quo and enhancement, respectively. In the operation phase, wage impacts range from \$3.8 to \$5.4 billion for status quo and enhancements, respectively. The strategies generate approximately 18.1 to 22.9 thousand jobs in the investment phase and 8.2 to 10.5 thousand jobs in the operation phase for status quo and enhancements, respectively.

³⁷ All dollar values are reported in 2015 dollars.

³⁸ Jobs figures reflect net job impacts in the year 2020.

RESI also calculated the total net benefits from these strategies. A summary of these findings can be found in Tables 6-4 and 6-5. Although some of these policies may generate negative net impacts, the programs are still generating other benefits that are not accounted for in the market. These benefits include environmental improvements to ecosystems and improvements to human health from reduced pollution and greenhouse gases. Additionally, the program as a whole has net economic benefits.

Table 6-4. Total Net Benefit by Strategy Subject Area—Investment Phase, 2010–2020³⁹.

Subject Area	Output	Total Cost	Total Net Benefit
Energy			
Status Quo	\$11,154,722,778	\$13,097,859,286	-\$2,197,436,981
Enhancement	\$12,316,690,319	\$13,881,581,739	-\$1,783,499,402
Transportation			
Status Quo	\$3,270,160,599	\$2,206,654,201	\$1,056,522,384
Enhancement	\$7,990,266,382	\$4,244,515,129	\$313,182,368
Agriculture			
Status Quo	\$65,643,311	\$214,057,002	-\$148,867,164
Enhancement	\$71,441,345	\$222,727,335	-\$151,285,990
Recycling			
Status Quo	\$719,085,693	\$9,257,145	\$709,828,548
Enhancement	\$990,256,168	\$15,869,391	\$974,386,777
Buildings			
Status Quo	\$17,364,502	\$7,688,994	\$9,675,508
Enhancement	N/A	N/A	N/A
Land Use			
Status Quo	\$9,780,953,979	\$15,230,800,642	-\$1,133,515,000
Enhancement	\$15,158,674,064	\$22,837,241,668	-\$974,355,000
Innovative Initiatives			
Status Quo	\$301,666,260	\$213,878,700	\$176,430,870
Enhancement	\$393,191,252	\$228,332,229	\$175,316,299
Outreach			
Status Quo	\$0	\$0	\$0
Enhancement	N/A	N/A	N/A
Total			
Status Quo	\$25,309,597,123	\$30,980,195,969	-\$5,670,598,846
Enhancement	\$36,937,884,032	\$41,437,956,486	-\$4,500,072,454

Source: RESI

³⁹ All dollar values are reported in 2015 dollars.

Table 6-5. Total Net Benefit by Strategy Subject Area—Operation Phase, 2010–2020⁴⁰.

Subject Area	Output	Total Cost	Total Net Benefit
Energy			
Status Quo	\$2,884,834,025	\$1,885,945,962	\$963,202,841
Enhancement	\$3,131,666,273	\$2,847,716,165	\$226,564,081
Transportation			
Status Quo	\$221,151,736	\$0	\$106,127,930
Enhancement	\$393,237,918	\$0	\$202,999,028
Agriculture			
Status Quo	\$2,033,508,301	\$417,981,068	\$1,514,239,386
Enhancement	\$2,033,508,301	\$537,981,068	\$854,071,331
Recycling			
Status Quo	-\$415,496,826	\$0	-\$415,496,826
Enhancement	-\$570,526,120	\$0	-\$570,526,120
Buildings			
Status Quo	\$339,843,750	\$184,200	\$339,659,550
Enhancement	N/A	N/A	N/A
Land Use			
Status Quo	\$5,477,582,215	\$333,680,000	\$1,165,863,599
Enhancement	\$6,808,678,950	\$995,283,421	\$820,949,641
Innovative Initiatives			
Status Quo	\$301,134,380	\$0	\$223,458,425
Enhancement	\$223,689,682	\$0	\$223,277,695
Outreach			
Status Quo	\$152,588	\$22,500	\$130,088
Enhancement	N/A	N/A	N/A
Total			
Status Quo	\$10,842,710,169	\$2,637,813,730	\$8,204,896,439
Enhancement	\$12,360,251,342	\$4,381,187,354	\$7,979,063,988

Source: RESI

As shown in Tables 6-4 and 6-5, total net benefit during the investment phase totals a negative \$5.7 billion and a positive \$7.9 billion during the operation phase for the status quo. For enhancements, as shown in Tables 6-4 and 6-5 the total net benefit during the investment phase totals a negative \$4.5 billion and a positive \$8.0 billion during the operation phase. Total net benefit is the difference between output impact and total cost. Total net benefit is analogous to “profit” in the business sense. Positive total net benefit values recognize desirable policy

⁴⁰ All dollar values are reported in 2015 dollars.

outcomes for Marylanders. The total net benefit from both the investment and operation phases totals \$2.3 billion for status quo, a desirable outcome. An additional net benefit of \$3.5 billion can be claimed in enhancement programs are considered into Maryland's GGRA initiatives.

Chapter 7: Emerging Technologies

Frequently Used Abbreviations and Acronyms

BECCS: Bio-energy with Carbon Capture and Storage

CO₂-equivalent: Carbon Dioxide Equivalent

GGRA: Greenhouse Gas Emissions Reduction Act of 2009

GHG: Greenhouse Gas

Introduction

Various technologies are in development to mitigate the impacts of GHG emissions. This chapter summarizes the more prominent emerging technologies in this field. Further analysis of these and other emerging technologies can be found in Appendix E.

Emerging Technologies

Energy Storage

Constant improvements to the technology of energy storage have created a lot of important implications for GHG reduction. As the use of renewable energy sources, specifically solar and wind, have massively increase, so has the need for a reliable way to store the energy produced. Recent improvements to energy storage would allow for renewable energy to be utilized when it is needed instead of immediately when it is generated. This will allow for solar energy to be stored on sunny days and used as the same rate when the sun is down or covered. The same applies for wind energy when the air is still. Energy storage is also important to remove the reliance on “peakers”, which are power plants that operate only during peak energy demand. These power plants are often more polluting and expensive than regular plants, so allowing energy to be stored during off-peak hours will make peakers obsolete. In addition to energy storage connected to the grid, home energy storage is also emerging with the release of the Tesla Powerwall, which will allow consumers the option to store their own renewable or off-peak energy to power their homes.

Smart Grid Technology

A smart grid is an electrical grid that has the ability to gather information and then act on it. It integrates both the generator’s and consumer’s information, such as usage or behaviors, and uses it to create the most efficient, economical, and sustainable system possible. Through increasing efficiency and conservation, renewable energy integration, and plug-in electric vehicle

integration, smart grids can greatly reduce GHG emissions. Smart grids also have numerous benefits in addition to lower GHG emissions. A few other benefits are: reduced operating costs for utilities, increased ability to use all available infrastructure, better coordination of plug-in electric vehicles, and easier installation of new technologies into the grid. Smart grids reduce the power outages, inefficiencies, and lack of information problems for which the complex U.S. electrical grid is infamous; thus creating a system that is much more reliable and responsive.

Electric Vehicles

Due to a large portion of GHG emissions coming from the transportation sector, replacing gasoline-fueled vehicles with electric vehicles would have a significant impact on the climate. Electric vehicles are vehicles that are powered by electricity that is usually stored in the vehicle in a battery, but vehicles can also be connected directly to generator plants, which is how electric trains and trolleys work. As electric vehicle technology improves, the range of the vehicles on a single charge goes up and the prices go down, raising consumer interest in them. This is therefore closely tied in with small scale energy storage technology so that the onboard batteries can hold a large charge and provide a larger range for the vehicle. While electric vehicles don't emit greenhouse gasses themselves, they move the source of pollution to the power plant generating the extra energy required to power the vehicles. Electric vehicles still have a net positive impact, but this could be expanded even more by generating the electricity they require with renewable sources. Electric vehicles using charging off of electricity generated by solar or wind power would be the most effective way of decreasing transportation emissions. Some electric vehicles have even been designed with solar panels on the roof to produce electricity for some basic processes in the vehicles, and as solar panels become more efficient these vehicles could use its own generated solar power for most of the vehicle's functions. Electric vehicles used in tandem with a smart grid that provides significant charging infrastructure for the vehicles would also greatly encourage their use.

The Water-Energy Nexus

The water-energy nexus refers to the connection between how much water is evaporated in energy production and how much energy is used in the human use of water, such as the collecting, cleaning, and moving of water. It is estimated that around 2 gallons of water is evaporated in order to create 1 kilowatt hour of energy. This amounts to around 3,000 to 6,300 gallons of water being evaporated to power one 60W light bulb for one year. This results in water shortages as the energy industry must also compete with other major water consumers, especially the ever-growing agriculture industry. It is also true that a lot of energy is required to use water in all processes. Therefore a way to decrease GHG emissions is to maximize the efficiency of the water-energy nexus. Using less water and less energy continues the cycle in the most efficient way possible. Less water use also means less wastewater to deal with, which produces methane. Some GHG reduction plans have already framed their plans around water mitigation, such as Massachusetts aiming for drinking water and wastewater facilities to reach a 20% GHG reduction goal.

CO₂ Reduction Technology

Integrated Environmental Services, Inc. has developed CO₂ Reduction Technology that breaks down CO₂ into graphite and oxygen. The graphite that it produced can then go on to be used in other industries, such as battery, hybrid electric vehicle, and solar panel production. This process of breaking down CO₂ used to be inefficient due to it emitting more CO₂ when producing the energy needed to undergo the process than was removed, but IES has developed a method where they pre-process the CO₂ which allows the molecular bond to require less energy to be broken. This results in the process eliminating more CO₂ than is produced. This technology can be used in power plants to reduce their CO₂ emissions and allow them to produce graphite that can be used in other industrial processes.

Bio-energy with Carbon Capture and Storage (BECCS)

Another emerging technology that is commonly debated is BECCS, or bioenergy with carbon capture and sequestration. This is the process of generating electricity from biomass and then capturing and storing the resulting CO₂ emissions. This process allows the generation of energy to become carbon negative by removing CO₂ from the atmosphere and releasing none. However, there is still a lot of issues with the technology that must be dealt with before it is considered viable. The methods of capturing carbon and storing it underground are incredibly expensive and there are a lot of technological gaps to be filled in about it. The compression and transport of CO₂ leaves a lot of room for potential leaks and spills that would release large amounts of CO₂ right back into the atmosphere, and the same can happen when it is stored underground. One method that MIT has determined is geologically viable is injecting and storing the captured CO₂ in deep saline aquifers. Another option that is being considered is injecting the CO₂ into depleted oil and gas fields. The Department of Energy currently has a BECCS project at a corn ethanol facility in Illinois that captures about 1,000 metric tons of CO₂ and stores it in a sandstone formation 7,000 feet underground.

Biochar

A technology similar to BECCS is biochar, a carbon-negative plant byproduct that resembles charcoal. Biochar is made via pyrolysis (which is heating vegetation slow without oxygen) of lumber waste, dried corn stalks and other plant residues. The resulting biochar is very carbon rich and can be placed in the soil as fertilizer. This allows carbon to be locked underground instead of being emitted into the atmosphere. However there are some risks to keep in mind to ensure that it remains carbon negative and doesn't harm the soil it is meant to be fertilizing. Biochar must be used in soils of similar pH or else it can have a negative effect on soil fertility. Also, biochar made from waste biomass, sustainably harvested crop residues, or crops grown on non-forested abandoned land will be carbon negative. If the biochar is made from forest ecosystems, the result could be a net increase in greenhouse gases.

Green Cement

Green cement and concrete is also an emerging carbon negative technology that can be used in place of regular concrete. First of all, it uses fly ash in the mix which prevents large amounts of it reaching landfills. The mix also requires only half the amount of water that is normally required to mix normal concrete, which helps cut down on water demand. Finally, it undergoes a unique process which requires the concrete to consume CO₂ as it cures. This results in the process being carbon negative since it reduces the amount of CO₂ in the atmosphere.

Algae Systems

Algae Systems has developed an advanced process that uses algae to produce carbon negative fuels. The whole system is overall extremely sustainable. It starts by taking untreated wastewater and giving it to algae, which uses CO₂ and sunlight to convert the nutrients and carbon from the wastewater into biomass. This process also turns wastewater treatment from a huge energy sink into an energy source. The wet biomass is then converted into liquid fuels at high temperature and pressure. This results in “biocrude” which can either be used directly or refined into a replacement for fossil crude. This results in a carbon-negative fuel because the algae consumes more CO₂ than the end product biofuels emit.

Fuel Cell Vehicles

As an alternative to fossil fuel hybrids or electric vehicles, fuel cell vehicles are an emerging technology that shows a lot of promise. Fuel cells are used to directly produce electricity inside the vehicle using hydrogen or natural gas, as opposed to batteries which must be charged for a long time from an external source. Hydrogen fuel cells are remarkable due to their only emission being pure liquid or gaseous water. Fuel cell vehicles can also travel much further than battery powered electric vehicles, with a current range of up to 650 kilometers on a tank of compressed hydrogen gas. Hydrogen fuel cells have gotten some controversy due to the fact that it requires a lot of energy to electrolyze water, which is how the hydrogen fuel is produced. Therefore it releases a lot of CO₂ into the air when the hydrogen gas is created, which can make the whole usage of hydrogen cells carbon positive despite the lack of emissions from the vehicle itself. In order to avoid this, wind or solar power could be used to power electrolysis, but these power sources are still relatively inefficient compared to fossil fuels. If fossil fuels are utilized, one of the technologies above can be used to capture and store/sequester the CO₂ that is produced to prevent it from entering the atmosphere.

Geoengineering

Geoengineering is a broad term for deliberate, large-scale manipulations of Earth’s environment that have been proposed as methods to potentially offset some of the consequences of climate change. In general, proposed geoengineering techniques fall into two categories: solar radiation management approaches that aim to change the incoming solar radiation balance, and carbon dioxide removal approaches that would reduce the amount of carbon dioxide in the atmosphere.

The National Academies of Sciences completed their *Geoengineering Climate: Technical Evaluation of Selected Approaches* study and released two reports in February 2015; *Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration*, and *Climate Intervention: Reflecting Sunlight to Cool Earth*. These reports can be found in the *2015 GGRA Plan Update* as Appendices F and G, respectively. More information on geoengineering and the two associated reports can be found at the National Academies of Sciences website at the following links:

- <https://nas-sites.org/americasclimatechoices/studies-in-progress/geoengineering-technical-evaluation-of-selected-approaches/>
- <http://nas-sites.org/americasclimatechoices/public-release-event-climate-intervention-reports/>

Chapter 8: Impact Analysis of GGRA on the Manufacturing Industry in Maryland

This chapter is based upon material provided by the Regional Economic Studies Institute (RESI) of Towson University

Frequently Used Abbreviations and Acronyms

GGRA: Greenhouse Gas Emissions Reduction Act of 2009

MDE: Maryland Department of the Environment

RESI: Regional Economic Studies Institute

Overview

The Maryland Department of the Environment (MDE) tasked the Regional Economic Studies Institute (RESI) to complete an impact analysis of the policies from the *Greenhouse Gas Emissions Reduction Act (GGRA) 2012 Plan* on Maryland's manufacturing industry. RESI employed the REMI PI+ model using agency level data collected for the *2012 GGRA Plan* to determine the impact on Maryland's Manufacturing industry. In RESI's report (Appendix I), RESI assumed that all GGRA initiatives were implemented and results are reported for the Manufacturing industry by the four-digit North American Industry Classification System (NAICS) codes.

In addition to an economic impact analysis, RESI solicited feedback from regional manufacturers to include in the report. Manufacturer interviews included in this report are case studies of greenhouse gas reduction measures taken by these firms to remain compliant with government environmental mandates. RESI and representatives from MDE visited these manufacturers to witness their methods and interview them one on one in regard to the challenges faced with reducing greenhouse gas emissions, if any.

Historical Trend Analysis

To provide background for the economic impact analysis, RESI analyzed the current historical trends of Manufacturing in Maryland. RESI found the following:

- The average weekly wages in the Manufacturing industry increased from \$933 in 2002 to \$1,324 in 2012.

- Preliminary estimates indicate that average weekly wages increased by \$16 between 2012 and 2013—an increase from \$1,324 in 2012 to \$1,340 in 2013.⁴¹
- The industry accounted for 5.9 percent of Maryland’s total output in 2012.

The industry remains a vital component of Maryland’s economic base, despite declines since the recent recession. Industry data indicates that the workforce is shifting to demand employees with middle skills and more training. Partnerships with state-based groups such as the Regional Manufacturing Institute (RMI) and state agencies such as Maryland Public Service Commission (PSC) and Maryland Energy Administration have assisted manufacturers through funding opportunities to meet energy efficiency goals.

National partnerships are also key in building the needed workforce, such as those with Manufacturing Extension Partnership (MEP) and the National Institute of Standards and Technology. This partnership seeks to build and establish training to meet the higher skill needs of employers by the local workforce. As the industry shifts towards a higher skill-based workforce, partnerships such as those between industry leaders, state agencies, and federal agencies will be vital to producing the workforce needed to implement the policies outlined in the GGRA.

Economic Impact Findings

RESI analyzed the GGRA initiatives outlined in the GGRA to determine the economic impacts on the manufacturing industry. Using agency-provided data along with external research, RESI found the following:

- The manufacturing industry will create 113 total jobs by 2020 related to implementation of the policies between 2010 and 2020.
- Directly, policy implementation between 2010 and 2020 will result in 104 direct jobs created to support the greenhouse gas reduction policies under the GGRA.
- The Computer and electronic product manufacturing sector will experience the greatest gains in employment between 2010 and 2020.
- The industry’s wages will increase to \$10.7 million by 2020.
- The industry’s output will increase to \$26.5 million by 2020.

RESI’s economic impact analysis confirms historical and current trend analyses. To implement the strategies outlined in the GGRA, Maryland will create an additional 113 jobs in the Manufacturing industry by 2020. Of these 113 jobs, nearly 54 percent will be created within higher skilled sectors, such as Computer and electronic product manufacturing and Electrical equipment and appliance manufacturing. Some sectors, such as Food Manufacturing and Textile mills; Textile product mills will see minimal job declines between 2010 and 2020 as the industry shifts to a higher-skilled workforce demand to meet policy implementation associated with the

⁴¹ “Quarterly Census of Employment and Wages,” Bureau of Labor Statistics, accessed April 9, 2014, <http://data.bls.gov/pdq/SurveyOutputServlet>.

GGRA. Despite all the change in Maryland's Manufacturing industry, there is no conclusive evidence that any closures or relocations outside Maryland are directly attributable to the GGRA or climate change planning. Based on the analysis provided within this report, RESI finds no discernible impacts on the manufacturing sector as a result of the GGRA programs. Furthermore, RESI recommends based on this analysis that Maryland not adopt any manufacturing specific GHG regulations in the future.

Chapter 9: Federal Actions

Frequently Used Abbreviations and Acronyms

111(d): Clean Air Act Section 111(d)

CO₂: Carbon Dioxide

EPA: U.S. Environmental Protection Service

GGRA: Greenhouse Gas Emissions Reduction Act

GHG: Greenhouse Gas

MDE: Maryland Department of the Environment

PSD: Prevention of Significant Deterioration

RGGI: Regional Greenhouse Gas Initiative

Introduction

The GGRA requires that MDE report on the state of any federal program designed to reduce GHG emissions. The following initiatives are specific to EPA but there are additional Federal programs being implemented by other Federal Agencies such as Housing and Urban Development, Department of Energy, Department of Agriculture, etc., that are not specifically discussed in this chapter.

Clean Power Plan

Clean Air Act 111

The federal Clean Power Plan addresses both new and existing power plants under separate regulations through Clean Air Act Section 111. Clean Air Act Section 111 provides direction for setting standards for stationary sources from a specific source sector such as power plants. Section 111(b) allows EPA to set standards for new sources while Section 111(d) applies to existing sources. Under Section 111(d) EPA may establish guidelines for states to set standards for existing sources. EPA formulates the guidance by considering systems of emission reductions that have been adequately demonstrated and the degree of emission limitation achievable considering cost, environmental impact, compliance time periods and other factors. In this case EPA has interpreted the best system of emission reductions broadly. States then formulate emission limits following the guidance.

Maryland will continue to monitor the progress of this program.

EPA Regulatory Initiatives

Stationary Sources

Final Greenhouse Gas Tailoring Rule

On May 13, 2010, EPA set GHG emissions thresholds to define when permits under the New Source Review Prevention of Significant Deterioration (PSD) and Title V Operating Permit programs are required for new and existing industrial facilities. This final rule "tailors" the requirements of these Clean Air Act permitting programs to limit covered facilities to the nation's largest GHG emitters: power plants, refineries, and cement production facilities

Transportation/Mobile Sources

EPA and the National Highway Traffic Safety Administration (NHTSA) Standards to Cut Greenhouse Gas Emissions and Fuel Use for New Motor Vehicles

EPA and NHTSA are taking coordinated steps to enable the production of a new generation of clean vehicles-- from the smallest cars to the largest trucks--through reduced GHG emissions and improved fuel use. Together, the enacted and proposed standards are expected to save more than six billion barrels of oil through 2025 and reduce more than 3,100 million metric tons of carbon dioxide emissions.

Renewable Fuel Standard (RFS) Program

EPA is also responsible for developing and implementing regulations to ensure that transportation fuel sold in the United States contains a minimum volume of renewable fuel. By 2022, the RFS program will reduce GHG emissions by 138 million metric tons, about the annual emissions of 27 million passenger vehicles, replacing about seven percent of expected annual diesel consumption and decreasing oil imports by \$41.5 billion.

Heavy-Duty Trucks

The proposed regulation is actually Phase 2, following Phase 1 standards finalized in August 2011 that created standards for new Medium and Heavy Duty Vehicles (MDVs and HDVs). The Phase 1 plan is expected to result in saving 530 million barrels of oil and avoid the emissions of 270 million metric tons of GHG, while also producing \$50 billion in fuel savings and \$49 billion in societal benefits. Phase 2 builds on this by presenting technology-advancing standards that would roll out through model year 2027.

Other Related Actions

- Landfill Air Pollution Standards

- Oil and Natural Gas Air Pollution Standards
- Geologic Sequestration of Carbon Dioxide

Emissions Reporting

Greenhouse Gas Reporting Program

The Greenhouse Gas Reporting Program collects GHG data from large emission sources across a range of industry sectors, as well as suppliers of products that would emit GHGs if released or combusted. GHG data are available through the Greenhouse Gas Reporting Program Data Publication Tool:

- <http://www.epa.gov/ghgreporting/ghgdata/reportingdatasets.html>

Chapter 10: Multi-Pollutant Planning Exercise for Maryland

The Northeast States for Coordinated Air Use Management (NESCAUM) contributed to this chapter.

Frequently Used Abbreviations and Acronyms

CMAQ: Community Multi-scale Air Quality

EPA: U.S. Environmental Protection Agency

GGRA: Greenhouse Gas Emissions Reduction Act

GHG: Greenhouse Gas

MDE: Maryland Department of the Environment

NAAQS: National Ambient Air Quality Standards

NE-MARKAL: Northeast version of the Market Allocation model

NESCAUM: Northeast States for Coordinated Air Use Management

NO_x: Nitrogen Oxides

REMI: Regional Economic Models, Inc.

SIP: State Implementation Plan

SO₂: Sulfur Dioxide

Maryland Context for Multi-pollutant Planning

The NESCAUM report (Appendix H) presents the findings of a multi-pollutant planning exercise the Maryland Department of the Environment (MDE) initiated in April 2013. The goals are to continue to build capacity in Maryland to conduct multi-pollutant planning and analyses as well as inform Maryland's 2012 Greenhouse Gas Emissions Reduction Act (GGRA) Plan Progress Report. The *2012 GGRA Plan's* Progress Report is due in 2015.

The *2012 GGRA Plan* seeks to achieve a 25 percent statewide reduction in greenhouse gas (GHG) emissions by 2020, while also spurring job creation and helping improve the economy. In the multi-pollutant planning context, it is part of a "multi-pollutant" planning approach for selecting and analyzing control programs to address multiple public health and environmental goals. The *2012 GGRA Plan* will not only help reduce emissions of GHGs, but will also help Maryland meet its mandates to: (1) further clean up the Chesapeake Bay; (2) meet and maintain

National Ambient Air Quality Standards for ground-level ozone, fine particles, sulfur dioxide, and nitrogen dioxide; and (3) meet federal and state requirements to further reduce regional haze as well as air emissions of mercury and other air toxics.

Maryland also intends to use a multi-pollutant framework to look at all pollutants whenever a single pollutant State Implementation Plan (SIP) is being developed. Therefore, this exercise is also a part of Maryland's preliminary effort to establish credit for energy efficiency and renewable energy (EE/RE) programs as part of its ozone SIP. To that end, it feeds into a larger effort in Maryland to better address some of the uncertainties associated with the SIP process through an expanded weight-of-evidence (WOE) approach.

Multi-Pollutant Policy Analysis Framework

The planning exercise presented in the NESCAUM report employed the Multi-pollutant Policy Analysis Framework (MPAF), which consists of the following model components to provide a broad view of climate and air quality program impacts:

1. NE-MARKAL, a Northeast version of the MARKET ALlocation (MARKAL) model, an energy model that is widely used in Europe. EPA has a nine-region national version of this model, called US9r
2. Regional Economic Models, Inc. (REMI), a 12-state model that evaluates the effects of policies and programs on the economies of local regions
3. EPA's Community Multi-scale Air Quality (CMAQ) model, which assesses future air quality impacts arising from changes in air emissions due to a set of policies and programs
4. EPA's Environmental Benefits Mapping and Analysis Program (BenMAP), which estimates health impacts and associated monetized values resulting from changes in ambient air pollution

Two meta-scenarios, an initial and an enhanced, were developed in collaboration with MDE and other Maryland state agencies, which were then analyzed through the MPAF. Each meta-scenario combined a suite of selected policies into a single NE-MARKAL run that captured their interactive effects. The initial meta-scenario was comprised of selected policies as they were defined in the *2012 GGRA Plan*. The enhanced meta-scenario was comprised of a combination of individual policies, some of which had enhanced goals defined either in the GGRA Plan or by MDE. Note that enhanced policies not based on the GGRA Plan are for analytical exercise purposes only, and may not reflect current Maryland policy.

Multi-Pollutant Impact of GGRA Policies

The multi-pollutant planning exercise demonstrated that the selected GGRA policies collectively made positive contributions to near-term air quality outcomes, including the 2020 GGRA climate target. The analysis also indicated that further reductions in CO₂ emissions are needed to meet a

hypothetical 80 percent reduction goal by 2050. In order to meet longer-term emission reduction goals, more measures involving the transportation sector would need to be considered. Climate sensitivity analyses undertaken as an extension of the meta-scenarios analyses found that in 2050, the combination of the most aggressive modeled GGRA policies alone lowered Maryland's reference case 2050 GHG emissions from almost 90 million tons of CO₂ to about 46 million tons (other GHGs were not considered in these analyses). This is still about 30 million tons short of a 2050 80 percent GHG reduction target of 17 million tons (relative to 2006 emissions). Of the 46 million tons, about 35 million tons comes from the transportation sector. This is not surprising, as the sensitivity analyses focused on more aggressive options for renewable energy and energy efficiency, while more aggressive transportation policies were not considered.

The GGRA measures in the two meta-scenarios also led to projected emission reductions in nitrogen oxides (NO_x) and sulfur dioxide (SO₂), key precursor pollutants for the criteria pollutants ozone (NO_x) and PM_{2.5} (NO_x and SO₂) over the modeling timeframe through 2023. Cumulatively over this time period, the initial meta-scenario projected reductions of 63,000 tons of NO_x and 399,000 tons of SO₂ in Maryland. Larger reductions were seen for the enhanced meta-scenario, with 70,000 tons of NO_x and 492,000 tons of SO₂ reduced.

GGRA Contributions to Maryland's Ozone State Implementation Plan Reductions

A selected set of GGRA measures that were included in an ozone sensitivity analysis demonstrated promise for achieving additional NO_x reductions relevant to Maryland's ozone SIP timelines (2017 to 2023). These NO_x reductions go beyond current ozone SIP baseline projections and enforceable control strategies, thus they provide the technical basis for an expanded weight-of-evidence demonstration of reasonably foreseeable NO_x reductions in excess of those attributable to traditional ozone SIP measures.

The estimated additional NO_x reductions from the GGRA measures are in the range of 1,200 to 1,600 tons in the year 2017, which is Maryland's ozone attainment deadline for the 0.075 ppb ozone NAAQS (current NAAQS at the time of this analysis). Additional NO_x reductions in the range of 2,200 to 2,600 annual tons are projected for the year 2023, which is relevant to maintaining the current ozone NAAQS, as well as achieving a possible future revised ozone NAAQS. By way of comparison, the annual NO_x reductions projected under the ozone SIP sensitivity scenarios are somewhat less than, but comparable to, projected annual NO_x reductions from gasoline passenger vehicles in Maryland expected from implementation of EPA's Tier 3 motor vehicle program. The Tier 3 program represents one of the largest, if not the largest, measure in Maryland for reducing NO_x emissions in 2017 and beyond, and the results of the ozone sensitivity runs indicate the potential for additional NO_x reductions of a similar magnitude from the modeled GGRA policies.

Maryland's GGRA Measures Have Positive Air Quality, Health, and Economic Benefits

The projected GGRA emission changes estimated by NE-MARKAL were input into the Community Multi-scale Air Quality (CMAQ) model to evaluate their impacts on ambient air quality. The projected changes in emissions estimated by NE-MARKAL give rise to CMAQ-modeled air quality improvements for ozone and fine particulate matter (PM_{2.5}) in Maryland and in regions outside of the State, which in turn result in positive net health benefits in terms of avoided adverse health outcomes, including premature mortality. These avoided health incidences were quantified, along with their monetized benefits, using EPA's BenMAP tool coupled with the modeled air quality changes in ozone and PM_{2.5} from CMAQ for each of the meta-scenarios.

As a result of the air quality changes attributable to the GGRA meta-scenarios, the BenMAP analysis found many reduced incidences of respiratory ailment, asthma attack, heart attack, hospital room visits, and lost work and school days. The monetary benefits of these public health improvements were driven largely by the reduced mortality, which includes (within Maryland) 43 to 100 avoided deaths per year due to reduced ozone and PM_{2.5} under the initial meta-scenario, and 84 to 192 avoided deaths per year under the enhanced meta-scenario.

The monetized value of avoided mortality within Maryland ranges between \$420 million to \$850 million per year under the initial meta-scenario, and between \$810 million to \$1.6 billion per year under the enhanced meta-scenario, assuming a 3 percent discount rate for future health effects. With a 7 percent discount rate, the value is \$320 million to \$740 million per year under the initial meta-scenario, and \$620 million to \$1.4 billion under the enhanced meta-scenario.

The regional economic assessment using REMI found that overall, the GGRA measures as analyzed under the initial meta-scenario will benefit Maryland's economy with respect to jobs, wages, and real disposable income growth. However, the output and value added to Maryland's economy may decline given the large declines in demand for energy and maintenance associated with the electric power sector in the short term. Private, state, and households' continual structured investments in the economy toward GGRA goals under the enhanced meta-scenario mitigated some loss reported in the initial meta-scenario. Specifically, programs associated with increasing public transit helped to offset the later declines. The initial work creates construction jobs within the region, but the longer-term benefits associated with reduced motor fuel purchases and maintenance of private vehicles provide additional disposable income to households in the form of savings. Given this newly acquired disposable income, consumers are more likely to spend it locally, thereby creating additional induced impacts. Review of both scenarios indicates there will be a short-term negative impact incurred for implementation, but Maryland's economy benefits from nearly 20 additional years of increased jobs, wages, and output in the long-term.

Chapter 11: MDE Recommendations

Frequently Used Abbreviations and Acronyms

GGRA: Greenhouse Gas Emissions Reduction Act

GHG: Greenhouse Gas

MCCC: Maryland Climate Change Commission

MDE: Maryland Department of the Environment

Background

The GGRA requires MDE to include recommendations in the *2015 GGRA Plan Update* on how the State should move forward to continue making progress on Climate Change.

The GGRA requires MDE to provide:

“Recommendations on the need for science based adjustments to the requirement to reduce greenhouse gas emissions by 25% by 2020”

The GGRA further requires that:

“On review of the study required in Section 2-1207 of this subtitle (the *2015 GGRA Plan Update*), the General Assembly may act to maintain, revise or eliminate the 25% greenhouse gas emissions reductions required under this subtitle.”

Section 6.7 of the Act states:

“And be it further enacted, That Section 2 (*see below*) of this Act shall take effect October 1, 2009. It shall remain in effect for a period of 7 years and 3 months, and at the end of December 31, 2016, with no further action required by the General Assembly, Section 2 of this Act shall be abrogated and of no further force and effect.”

Section 2 of the Act, in total, states:

“The State shall reduce statewide greenhouse gas emissions by 25% from 2006 levels by 2020.”

This chapter provides the MDE recommendations required by the GGRA.

This chapter also provides more technical recommendations from MDE on several emerging issues that will need to be considered in the future.

Meeting the 2020 Requirements: Reducing GHG Emissions by 25% by 2020

The GGRA requires MDE to submit the *2015 GGRA Plan Update* to summarize the State's progress toward achieving the 25% GHG emission reduction goal by 2020 established by the GGRA. This report shows that Maryland is on track to meet this goal.

As described earlier in this report, the 25 percent reduction in Statewide GHG emissions from 2006 levels by 2020 goal of the GGRA has been calculated to be 34.66 MMtCO₂e. The combined emissions reductions of all programs in the *2015 GGRA Plan Update* will yield a total of 38.37 MMtCO₂e in emissions reductions. This will exceed the GGRA 2020 goal by 3.71 MMtCO₂e.

Meeting the 2020 Requirements: Maryland Jobs and the Economy

Continued implementation of the programs included in the *2015 GGRA Plan Update* will support new industry and will accelerate investments in green technologies in Maryland by encouraging investments in the energy, transportation, and land use sectors of our economy. Implementing the *2015 GGRA Plan Update* will lead to increased investments in energy efficiency, green buildings, renewable energy and low emission vehicles. Investing in Maryland's green economy now will encourage smarter investments and support more sustainable economic growth for generations to come.

Current analyses project that the *2012 GGRA Plan* will result in estimated economic benefits of between \$2.5 billion and \$3.5 billion in increased economic output by 2020 and help create and maintain between 26,000 and 33,000 new jobs.

An Update on the Science of Climate Change

The *2015 GGRA Plan Update* includes an update from the MCCC's Scientific and Technical Working Group on how climate change is already impacting Maryland and what additional future GHG reductions need to be considered to continue the States progress in reducing GHG emissions.

MDE Recommendations on Continuing Progress

The GGRA requires MDE to provide recommendations in the *2015 GGRA Plan Update* on how the State should move forward on climate change. The law requires the General Assembly to take an action in 2016 or the key requirements of the GGRA sunset. The *2015 GGRA Plan*

Update is intended to provide the Governor and the General Assembly with the information they need to determine how the State should move forward. MDE's recommendation includes the following:

- Continue to implement and enhance the programs in the *2012 GGRA Plan* with a increased focus on finding ways to continue emission reductions that also support economic development and job creation.
 - MDE recommends that the 2020 goal be maintained and that additional enhancements to the GGRA Plan be considered, as long as those enhancements have a clear positive impact on Maryland's economy and job creation in Maryland while also protecting Maryland consumers.
 - MDE would work through the MCCC and the MCCC working groups to develop these enhancements where appropriate.
- Move beyond 2020 by adopting a "next step" of incremental progress towards the deeper science-based reductions needed by 2050. This next step should also increase the emphasis on improving Maryland's economy by establishing quantitative goals for economic growth, job creation and wages linked to the States GHG reduction efforts.
- Continued efforts should expand the "true-up" process in the current law to not only include an every three year check-in on achieving the GHG emission reductions goals, but to expand this check-in process to include economic and job goals. The purpose of the true-up process is to make sure that the programs are achieving the projected emission reduction, economic and job creation goals in the real world and to adjust programs appropriately when needed.
- Continue efforts to analyze emerging issues linked to continuing the progress the State has made in reducing GHGs that have been identified by MDE over the past six years, the MCCC working groups and stakeholders. These emerging issues include, but are not limited to:
 - Enhanced efforts on renewable energy, energy efficiency and transportation that seek to further reduce emissions in a way that fosters economic development, creates new jobs and protects consumers
 - Continuing analyses of new scientific and technical opportunities like life-cycle analysis, hydraulic fracturing and other natural gas related topics, fast acting climate changers, and other emerging issues related to the scientific, mitigation and adaptation efforts needed to continue the State's progress in addressing climate change.
- Increased efforts on climate resiliency to insure that the State is focusing not just on GHG emission reductions but on community preparedness and adaptation for extreme weather and other changing climate conditions.

MDE Recommendation on the Manufacturing Sector

The GGRA exempts the manufacturing sector from control under the law unless those controls are required by federal law or regulation or part of existing State law adopted prior to 2009.

The GGRA states:

“Unless required by federal law or regulations or existing State law, regulations adopted by State agencies to implement the final plan may not:

1. Require greenhouse gas emissions reductions from the State’s manufacturing sector; or
2. Cause a significant increase in the costs to the State’s manufacturing sector.”

The GGRA requires MDE to complete an analysis of the manufacturing sector as part of the *2015 GGRA Plan Update*. The law reads:

“An institution of higher education in the State shall conduct an independent study of the economic impacts of requiring greenhouse gas emission reductions from the State’s manufacturing sector.”

This analysis of the manufacturing sector, performed by Towson University, is summarized in Chapter 8 of this report. The full analysis can be found in Appendix I.

Based upon this work and the MDE inventory analyses that show that GHG emissions from the manufacturing sector are significantly less in 2015 than they were in 2009, MDE recommends that the manufacturing sector exemption contained in the GGRA be maintained as part of any future efforts to continue progress reducing GHG emissions.