Maryland
Department of
the Environment

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The Greenhouse Gas Emissions Reduction Act

2019 GGRA Draft Plan

Prepared for:

Governor Lawrence J. Hogan
State of Maryland

and the Maryland General Assembly

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Frequently Used Abbreviations and Acronyms

CARES	Maryland Clean and Renewable Energy Standard
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DGS	Maryland Department of General Services
DHCD	Maryland Department of Housing and Community Development
DNR	Maryland Department of Natural Resources
EPA	United States Environmental Protection Agency
EV(s)	electric vehicle(s)
GGRA	Greenhouse Gas Emissions Reduction Act
2019 GGRA Draft Plan	Greenhouse Gas Emissions Reduction Act – Reauthorization Draft Plan
GGRA of 2009	Greenhouse Gas Emissions Reduction Act of 2009
GGRA of 2016	Greenhouse Gas Emissions Reduction Act – Reauthorization
GHG(s)	greenhouse gas(es)
HFC(s)	hydrofluorocarbon(s)
IPCC	Intergovernmental Panel on Climate Change
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
MEA	Maryland Energy Administration
$MMtCO_2e$	million metric tons of carbon dioxide equivalent
NO_x	nitrogen oxide
PJM	Pennsylvania Jersey Maryland Interconnection, LLC
PSC	Maryland Public Service Commission
REC	renewable energy credit
RESI	Regional Economic Studies Institute at Towson University
RGGI	Regional Greenhouse Gas Initiative
RPS	Maryland Renewable Portfolio Standard
SF_6	sulfur hexafluoride
TCI	Transportation and Climate Initiative
USDA	United States Department of Agriculture
VMT	vehicle miles traveled
ZEV(s)	zero emission vehicle(s)

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Executive Summary

ES.1 Prologue

The Maryland Department of the Environment (MDE), in coordination with other agencies and stakeholders, has proposed a draft Greenhouse Gas Emissions Reduction Act (GGRA) plan to achieve Maryland's goal of reducing greenhouse gas (GHG) emissions by 40% by 2030 while benefiting the State's economy and creating jobs, entitled the *2019 GGRA Draft Plan*. The *2019 GGRA Draft Plan* sets forth a comprehensive set of measures to reduce and sequester GHGs, including investments in energy efficiency and clean and renewable energy solutions, widespread adoption of electric vehicles (EVs), and improved management of forests and farms to sequester more carbon in trees and soils. The *2019 GGRA Draft Plan* will set Maryland on a path to achieve an ambitious goal, and set an example for how the nation can respond to the threat of climate change while growing the economy and creating jobs.

Before finalizing the GGRA Plan, Maryland will be undertaking a significant stakeholder process to ensure that opportunities exist to publicly comment on the *2019 GGRA Draft Plan*. The release of the *2019 GGRA Draft Plan* is the first step in this process. Maryland invites comment on this draft plan, the measures that are being counted on to reduce emissions, the programs to adapt, the analyses completed to show the emission and economic benefits, and other aspects included within. Maryland will consider these comments in the development of the final GGRA Plan.

ES.2 The Greenhouse Gas Emissions Reduction Act – Reauthorization of 2016

On April 4, 2016 the Greenhouse Gas Emissions Reduction Act – Reauthorization (GGRA of 2016) was signed into law by Maryland Governor Larry Hogan. Expanding on the requirements of the original GGRA law (GGRA of 2009), the GGRA of 2016 requires the state to achieve a minimum of a 40% reduction in statewide GHG emissions from 2006 levels by 2030, which is substantially more ambitious than the United States' international commitment under the Paris accord to reduce emissions by 26-28% by 2025. To achieve this goal, the GGRA of 2016 requires MDE to develop a statewide GHG reduction plan. The GGRA of 2016 also requires MDE to solicit public comment on the proposed draft plan from interested stakeholders and the public, and to adopt a final plan by Dec. 31, 2019. The state is also required to demonstrate that the new reduction goal can be achieved in a way that has a net positive impact on Maryland's economy, protects existing manufacturing jobs and creates significant new "green" jobs in Maryland.

The requirements and content of the GGRA of 2016 are summarized below:

Table ES-1. GGRA of 2016 Requirements.

Maryland shall reduce statewide GHG emissions by 40% from 2006 levels by 2030.
MDE must: • Submit a proposed draft plan that reduces statewide GHG emissions by 40% from 2006 levels by 2030; • Make the proposed draft plan for public comment; and • Convene a series of public workshops to provide interested parties with an opportunity to comment on the proposed draft plan.
Maryland must adopt a final plan that reduces statewide GHG emissions by 40% from 2006 levels by 2030 by 2019. The plan must: • Include adopted regulations that implement all plan measures for which State agencies have existing statutory authority; • Include a summary of any new legislative authority needed to fully implement the plans, and a timeline for seeking legislative authority; • Ensure no net loss of existing manufacturing jobs; and • Ensure a net increase in jobs and 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.
In 2022, an independent study of the economic impact of requiring GHG emissions reductions from the state's manufacturing sector is due to the governor and General Assembly, which will be overseen by the Maryland Commission on Climate Change (MCCC).
In 2022, a report is due to the governor and General Assembly assessing the progress toward the 40% emissions reduction and the GHG emissions reductions needed by 2050 in order to avoid anthropogenic changes to the Earth's climate system. This report also summarizes impacts on the economy.
By 2023, the General Assembly 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 40% reduction by 2030.

The *2019 GGRA Draft Plan* is a comprehensive, multi-sector, multi-agency plan developed with assistance and input from more than a dozen state agencies and nongovernmental organizations. Building from the programs developed in the previous GGRA plans, the programs outlined in the *2019 GGRA Draft Plan* provide a blueprint, which if fully implemented, **will achieve reductions greater than the 40% GHG reduction required by the GGRA of 2016, with significant positive job growth and economic benefits.** As this is a draft 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 *2019 GGRA Draft Plan* can still be modified and improved, and adjustments to the entire plan can still be made, if needed.

Table ES-2. *2019 GGRA Draft Plan* Economic, Employment, Public Health, and Climate Benefits.

	Through 2030	Through 2050
Average Job Impact[1]	+ 11,649 Job-years	+ 6,703 Job-years
GSP Impact[2]	+ $11.54 Billion	+ $18.63 Billion
Personal Income Impact[2]	+ $10.04 Billion	+ $15.67 Billion
Avoided Mortality[2]	+ $0.60 Billion	+ $3.68 Billion
Avoided Climate Damages[2]	+ $4.30 Billion	+ $27.11 Billion

[1]Average number of job-years created or sustained each year.
[2]2018 Dollars, Cumulative, Net Present Value using 3% discount rate. Climate damage evaluated using Federal Social Cost of Carbon (2015)

ES.3 Sectors and Programs

The *2019 GGRA Draft Plan* utilizes various strategies, programs, and initiatives that the state is developing and implementing to meet the emissions reductions and economic benefit goals. Some of these strategies are already being fully implemented, while others are in an earlier phase of the implementation process. The suite of programs encompasses multiple sectors, including the electricity sector, the transportation sector, the agriculture and forestry sector, the buildings sector, the waste management sector, and additional non-specific sectors. The plan also includes numerous partnerships with key stakeholders like the private sector, underserved communities, state universities, and the Port of Baltimore.

The core programs of the *2019 GGRA Draft Plan* extend from the suite of programs developed for previous GGRA plans, specifically the state's 25% by 2020 Plan. Based on the recently completed 2017 inventory, the state's GHG emissions are already below the 2020 Plan goal. These results are encouraging; however, continued progress is necessary to ensure we maintain reductions to 2020.

The core programs included in the 25% by 2020, along with recommended new programs, voluntary and non-traditional programs, outreach efforts to build public awareness and promote voluntary action, additional programs being analyzed, and emerging technologies, will all contribute to the state's goal of reducing GHG emissions by 40% by 2030.

Programs of note include:

Clean and Renewable Energy Standard (CARES)

A major component of the *2019 GGRA Draft Plan* to reduce GHG emissions from electricity generation is the proposed Clean and Renewable Energy Standard (CARES), which requires that an increasingly large share of Maryland's electricity be generated by zero- and low-carbon resources.

- *100% Clean Electricity*
  - CARES would build off the existing Renewable Portfolio Standard (RPS), and require that 100% of Maryland's electricity come from clean sources by 2040, which is among the most ambitious goals in the nation.

- *Market Based and Technology-Neutral*
  - CARES would adopt a technology-neutral approach to achieving 100% clean electricity at the lowest cost. By incorporating all available and emerging zero- and low-carbon sources in Maryland, CARES would foster greater competition among available renewable and clean energy resources, which would reduce costs for ratepayers. The broad set of eligible technologies would include:
    - Additional Maryland solar beyond the requirements of the RPS solar carve out
    - New efficient Combined Heat and Power (CHP), cogeneration systems in Maryland
    - Hydropower in Maryland
    - Nuclear Power in Maryland
    - Natural gas power with carbon capture and storage (CCS) technology in Maryland

- *Homegrown Energy and Jobs*
  - CARES would rely on electricity generators in Maryland to make progress beyond the existing goals, ensuring that Marylanders benefit from the direct job creation resulting from investments in clean energy resources.

Continually Stronger Regional Greenhouse Gas Initiative (RGGI) with Geographic Expansion

In 2017 RGGI completed a program review, and strengthened RGGI to continue steady, deeper reductions of GHG emissions by 2030.

With the success of the initiative, and as a national leader in the effort to combat climate change, Maryland and the other participating RGGI states are actively working to engage new participants in the program. The first-in-the-nation carbon cap-and-invest program for power plants has been strengthened by implementing the participating states' plan to secure an additional 30% reduction in power plant emissions by 2030, and expanding the program to new participating states in the region to reduce pollution from power plants supplying electricity into Maryland.

As the chair of the RGGI, Inc. board of directors since 2018, MDE led deliberations among the RGGI states to broaden participation to include New Jersey and Virginia. In July 2019, New Jersey finalized regulations allowing it to renew its participation in January 2020. Virginia also finalized regulations, and although they are unable to participate in 2020 due to budget restrictions, MDE is hopeful that they will be able to in the near future. Other states including Pennsylvania have taken important steps that could lead to future participation.

Public Transit Expansion

Maryland continues to devote record levels of funding for public transportation, which emits roughly 40% to 50% less GHG emissions per passenger mile than an average single occupancy vehicle. The programs in this policy category include transit initiatives that support a goal of increasing public transit ridership, and intercity transportation initiatives that support Maryland Area Regional Commuter and regional and national passenger rail services such as Amtrak. By providing alternatives to vehicle transit, these initiatives have the potential to reduce vehicle miles traveled (VMT) and GHG emissions. Public transportation strategies analyzed for the Maryland Department of Transportation (MDOT) GGRA plan update are broadly classified into two strategy groups:

- Transition to cleaner and efficient public transportation fleets, and
- Expansion of public transportation or intercity passenger service (new or increased capacity, improved operations)

MDOT works with metropolitan planning organizations (MPOs), transit operators, and other local agencies in Maryland to implement projects aimed at advancing a more efficient and accessible multimodal transport system. These include transportation demand management programs (such as MDOT's Commuter Choice Maryland and Metropolitan Washington Council of Governments' (MWCOG) Commuter Connections, which are detailed further in the pricing policy option), transit-supportive enhancements, including bicycle and pedestrian access projects, bicycle parking and bike racks on buses, and coordination with expanding bike-sharing programs. There is an emphasis on improving service quality and reliability, better aligning of transit service to demand, and improved transit information dissemination to customers. MDOT Maryland Transit Administration (MDOT MTA) is also focused on sustainability and is moving toward a more efficient fleet.

Clean Cars and Zero Emission Vehicle (ZEV) Mandate

The Maryland Clean Cars Act of 2007 required MDE to adopt regulations implementing California's stricter vehicle emission standards. The Clean Cars Program represented the first motor vehicle program to directly regulate carbon dioxide emissions. In addition to regulating GHG from passenger vehicles, the Clean Cars Program includes a Zero Emissions Vehicle (ZEV) mandate that car manufacturers must meet. These vehicles produce zero or near-zero tailpipe emissions, and include EVs and plug-in hybrid EVs. These vehicles will also reduce pollutants from the transportation sector as well as reduce dependence on foreign oil. Since initially

adopting the Clean Cars Program, California has developed stricter tailpipe and GHG standards referred to as Cal LEV III, which were adopted by Maryland in 2012. The LEVIII program when fully implemented in 2025 will reduce GHG emissions from vehicles by 34%. The LEVIII program also strengthens the ZEV mandate, increasing the requirements beginning in 2018.

The ZEV mandate is a technology forcing component and the LEVIII program's requirements beginning in 2018 are aggressive. Maryland continues to be a national leader in supporting the LEVIII program, deploying ZEVs, supporting legislation and initiatives to remove barriers, developing EV charging infrastructure, and providing incentives in support of these vehicles. The Clean Cars Acts of 2017 and 2019 are examples of Maryland's commitment. California is in the early stages of developing a regulatory update to the Clean Cars Program that will strengthen the GHG standards beyond 2025. Maryland will continue to work with California and other states that have adopted its program to ensure a robust program that delivers the GHG reductions necessary to meet our climate goals.

Transportation and Climate Initiative (TCI)

TCI is a regional effort of Maryland and 11 other Northeast and mid-Atlantic states and Washington, D.C. 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 VMT, and help build the clean energy economy across the region.

Cooperation continues between Maryland and the other states to develop a regional cap-and-invest program for road transportation fuels that will drive investment in clean transportation infrastructure, and encourage widespread use of EVs powered by increasingly clean electricity. TCI is using many of the successful concepts from RGGI, an energy sector cap-and-invest program, to design the transportation initiative.

Enhanced Forest Management

Maryland forests on both public and private lands are managed to capture carbon through sustainable forest management practices. Enrolling unmanaged forests into management regimes will increase rates of carbon sequestration in forest biomass, and increase amounts of carbon stored in harvested, durable wood products, which will result in economic benefits and increased availability of renewable biomass for energy production. The goals of this program are to improve sustainable forest management on approximately 30,000 acres of private land annually, ensure third-party certified sustainable forest management on approximately 200,000 acres of state forests, support forest markets that keep land in forest use, and provide sustainable management for multiple benefits on other Maryland Department of Natural Resources (DNR) lands where possible.

Enhanced Healthy Soils Incentives

In addition to reducing nutrient and sediment flows into the Chesapeake Bay and its tributaries, many of the agronomic and conservation practices used by Maryland's farmers have the potential to make a significant contribution to the state's climate change goals by sequestering carbon and other GHG emissions.

The 2017 Healthy Soils Act charged the Maryland Department of Agriculture (MDA) with the development of a healthy soils program to improve the health, yield, and profitability of Maryland's soils, and promote the further adoption of conservation practices that foster soil health while increasing sequestration capacity. In support of this initiative, MDA collaborated with stakeholders from the Healthy Soils Consortium to complete a comprehensive scientific literature review to identify those practices that are most effective in improving soil health and building soil carbon stocks, as well as create a menu of Maryland-specific practices. MDA intends to use this information to determine the metrics and tools used to quantify soil carbon, and provide incentives to encourage the

additional implementation of climate-friendly soil practices. Exiting programs are also being examined to find ways to capitalize on co-benefits for both water quality and carbon sequestration.

EmPOWER Maryland Expansion

Enacted by the General Assembly in 2008, EmPOWER Maryland initially established a goal to reduce per capita electricity consumption and peak demand by Maryland consumers by 15% by 2015 from the 2007 baseline. The EmPOWER Maryland suite of energy efficiency programs offered by the participating utilities are funded by ratepayers. Each utility is responsible for procuring or providing programs in its service territory designed to meet the EmPOWER program goals. The Maryland Public Service Commission (PSC) monitors and analyzes the impact of the programs and, in consultation with the Maryland Energy Administration (MEA), reports to the General Assembly on the status of the programs, a recommended funding level for the programs, and the per capita electricity consumption and peak demand for the previous calendar year.

EmPOWER programs must be approved in advance by the PSC. In addition to these utility-provided EmPOWER programs, other state efforts, including energy programs offered by MEA, help reduce statewide per capita electricity usage.[1]

In July 2015, the PSC order No. 87082, directing the continuation of utility programs supporting EmPOWER Maryland energy reduction policy, and setting new savings targets that 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 each company's gross retail sales baseline[2] based on three-year cycles. In 2017, the General Assembly codified the energy savings goals and cost-effectiveness measurements in PSC Order No. 87081. Savings can come from a variety of sources, including traditional equipment-based measures, "smart meter" enabled analytics, and more efficient distribution grid hardware.

While the EmPOWER program does not specifically contemplate a separate savings goal for non-utility entities, MEA and other agencies will continue to work closely with the PSC and Maryland utilities to ensure that programs are effectively designed and implemented. Additionally, MEA and the Maryland Department of General Services (DGS) continue to work on efforts to reduce energy use in state buildings, including Executive Order 01.01.2019.08.

The current EmPOWER statute requires the utilities to continue programs focusing on the efficient use and conservation of energy, subject to the review and approval of the PSC, after 2023. Without prejudice toward the PSC's process, the *2019 GGRA Draft Plan* proposes that the state continue to invest in energy efficiency through EmPOWER beyond 2023, at levels of effort roughly consistent with those required to achieve the current program cycle goals. The *2019 GGRA Draft Plan* also proposes to begin incentivizing increased deployment of efficient electric heat pumps to heat homes in Maryland, including in homes that currently use a different fuel for heat, in order to improve the efficiency of residential heating systems, and to transition the energy source for home heating toward increasingly clean electricity.

Department of General Services (DGS) State Building Efficiency Executive Order (EO 01.01.2019.08)

[1] The Strategic Energy Investment Fund (SEIF) was created by legislative act of the General Assembly. "Regional Greenhouse Gas Initiative - Maryland Strategic Energy Investment Program," (Subtitle 20B of the State Government Article). A portion of the fund is allocated to the MEA to administer energy efficiency programs. The utility-provided EmPOWER programs are mandated by the "EmPOWER Maryland Energy Efficiency Act" (§ 7-211 of the Public Utilities Article). The law requires participating utilities to reduce per capita electricity consumption in Maryland by 10% by 2015 and per capita peak demand by 15% by 2015 within their respective service territory by implementing energy efficiency programs targeted to consumers.

[2] 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 recent 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).

On June 25, 2019, Governor Hogan issued an executive order establishing a new energy savings goal for state government. DGS, in cooperation with MEA is to manage a "Maryland Leads by Example" energy savings initiative that will oversee reducing, by the year 2029, the energy use of state-owned buildings by 10% compared to a 2018 baseline.

The executive order outlines five specific tasks, one supporting role, and a partnership role to be performed by DGS:

- Task 1 - On an annual basis, the DGS Office of Energy Performance and Conservation, utilizing the Comprehensive Utility Records Management Database (Utility Database), shall analyze the entire inventory of state-owned buildings in order to identify and prioritize the least energy efficient buildings in the state.

- Task 2 - Every year, a minimum of 2 million square feet of the least efficient buildings will undergo a DGS energy audit to identify low cost measures with a five-year or less payback period. A copy of the energy audit shall be provided to each participating agency's secretary or director.

- Task 3 - DGS will measure post-installation energy use for one year following the installation of these measures, which will be normalized and compared to the buildings' pre-installation total energy use to determine energy savings.

- Task 4 - Progress toward the 10% savings goal, monitored through the Utility Database, will be reported to the governor annually each fiscal year by DGS, with the support of MEA.

- Task 5 - DGS, MEA, the Department of Budget and Management, and Department of Information Technology shall collaborate on designing and implementing additional cost-effective and -efficient energy saving programs that may include any combination of technology adoption, management protocols, information technology solutions, and staff education and engagement.

Hydrofluorocarbon (HFC) Regulation

Under a federal Clean Air Act program designed to identify and evaluate alternatives to stratospheric ozone-depleting substances, HFCs have been one of the most common alternatives. However, HFCs are extremely potent GHG emissions. One pound of certain HFCs is potentially as potent as 1,400 pounds of carbon dioxide. After efforts have stalled at the federal level, states have begun their own phase-out initiatives. MDE will develop regulations similar to those in development in California, Delaware, New York, Massachusetts, Connecticut, and other states, which would phase out the use of certain HFCs in foam products, and in refrigeration equipment in retail establishments, such as supermarkets. The phase out of HFCs will encourage the use of substances with lower GHG emissions. Products with alternatives to HFCs are already available. Other states in the U.S. Climate Alliance, a bipartisan coalition of 25 U.S. states committed to reducing GHG emissions consistent with the Paris Agreement, are expected to take similar actions.

Maryland is currently drafting HFC regulations with plans to adopt a final rule by fall 2020. HFCs are critical to the states' short-term and long-term emission reduction goals as they are highly potent short-lived climate pollutants.

ES.4 Climate Change and the Cost of Inaction in Maryland

Documented climate changes are already occurring and the response of the environment to the current levels of anthropogenic GHG emissions is still being realized.[3,4] However, actions taken at this time are still capable of mitigating the damage of future impacts, and delayed action or inaction may lead to a more severe outcome. An urgent response is critical to minimizing both costs and risks. As with any major adjustment, delaying action is likely to necessitate changes that are more dramatic and economically disruptive.

In the Northeast, the rate of sea level rise already observed is greater than the global average, having increased about one foot since 1990 (average is 8 inches),[5] likely due to both increased ice loss as well as changes in regional currents and land subsidence.[6,7,8] Maryland has experienced an increase in annual average temperature of 1.5°F since the beginning of the 20th century, and a winter warming trend reflected in the average of less than one day per year of nights below 0°F since the mid 1990's, as compared to an average of two nights per year between 1950 and 1994.[9] Annual precipitation, though more variable, increased by approximately 0.39 inches per decade in the Northeast during this same time,[10] with Maryland's annual mean precipitation having been above average for the past two decades. The climate in this region is generally expected to continue trending warmer and wetter over the next century, accompanied by an increase in extreme heat waves and precipitation events.[8,9]

These consequences to the physical systems will reverberate through biological and human systems, the three of which have co-evolved to exist under current conditions. The global climate system is complex, and a large number of variables interact to determine the eventual impact of expected changes to various segments of the natural and built environment. While not every individual change is necessarily harmful, the negative consequences of unmitigated climate change will far outweigh those select benefits. A more detailed examination of these and other projected impacts can also be found in the MCCC 2018 Annual Report[11].

ES.5 Emissions Reductions

Maryland has made significant strides in the reduction of GHG emissions. As illustrated in Figure ES-1, analysis of Maryland's 2017 GHG emissions show that activities in Maryland accounted for approximately 78.49 million metric tons of gross carbon dioxide equivalent emissions ($MMtCO_2e$) in 2017, an amount equal to about a 26.8% reduction of the state's total gross GHG emissions in 2006 (107.23 $MMtCO_2e$).

[3] J. Hansen, L. Nazarenko, R. Ruedy, M. Sato, J. Willis, A. Del Genio, D. Koch, A. Lacis, K. Lo, S. Menon, T. Novakov, J. Perlwitz, G. Russell, G. A. Schmidt and N. Tausnev, "Earth's Energy Imbalance: Confirmation and Implications," Science, vol. 308, pp. 1431-1435, 2005.

[4] D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, B. DeAngelo, S. Doherty, K. Hayhoe, R. Horton, J. P. Kossin, P. C. Taylor, A. M. Waple and C. P. Weaver, "Executive Summary," in Climate Science Special Report: Fourth National Climate Assessment, Volume I, D. Wuebbles, D. Fahey, K. Hibbard, D. Dokken, B. Stewart and T. Maycock, Eds., Washington, DC, U.S. Global Change Research Program, 2017, pp. 12-34.

[5] R. Horton, G. Yohe, W. Easterling, R. Kates, M. Ruth, E. Sussman, A. Whelchel, D. Wolfe and a. F. Lipschultz, "Chapter 16: Northeast," in Climate Change Impacts in the United States, 2014, pp. 371-395.

[6] J. L. Davis and N. T. Vinogradova, "Causes of accelerating sea level on the East Coast of North America," Geophysical Research Letters, vol. 44, no. 10, pp. 5133-5141, 2017.

[7] U.S. Environmental Protection Agency, "Climate Change Indicators in the United States," Washington DC, 2016.

[8] U.S. Environmental Protection Agency, "Climate Change in the United States: Benefits of Global Action," United States Environmental Protection Agency, Office of Atmospheric Programs, 2015.

[9] J. Runkel, K. Kunkel, D. Easterling, B. Stewart, S. Champion, R. Frankson and W. Sweet, "Maryland State Summary," National Oceanic and Atmospheric Administration, 2017.

[10] K. E. Kunkel, L. E. Stevens, L. Sun, E. Janssen, D. Wuebbles, J. Rennells, A. DeGaetano and J. G. Dobson, "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 1. Climate of the Northeast U.S.," National Oceanic and Atmospheric Administration, 2013.

[11] https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/ARWGWorkPlan2018.pdf

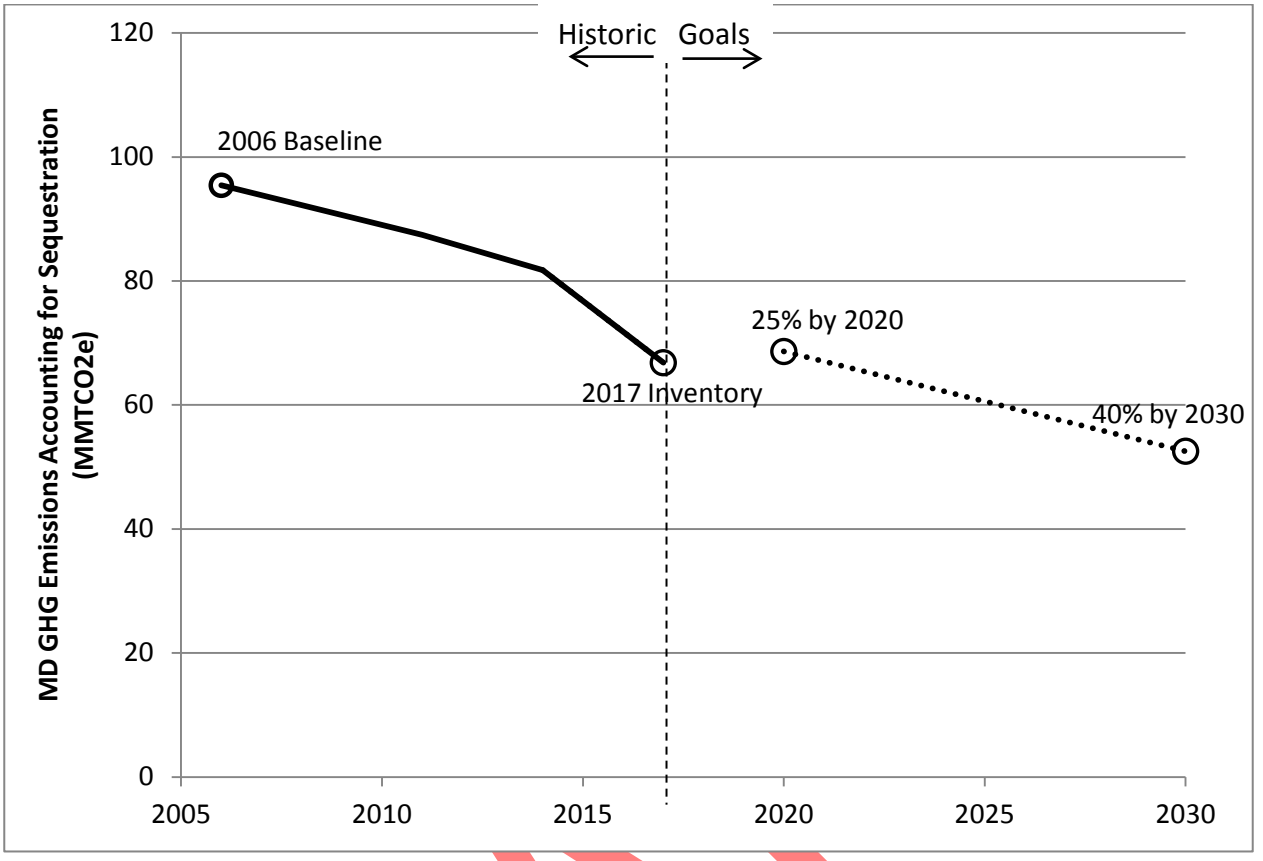


Figure ES-1. Historic decrease in Maryland's GHG emissions compared to GGRA goals.

Estimates of carbon sinks within Maryland's forests, including urban forests and land use changes, have also been analyzed. The current estimates indicate that about 11.72 $MMtCO_2e$ was stored in Maryland forest biomass and agricultural soils in 2017. This leads to net emissions of 66.77 $MMtCO_2e$ in 2017.

The principal sources of GHG emissions in Maryland are: electricity consumption; transportation; and residential, commercial, and industrial (RCI) fossil fuel use. For Maryland's gross GHG emissions in 2017, electricity consumption accounted for 30%, transportation accounted for 40%, and RCI fuel use accounted for 18%.

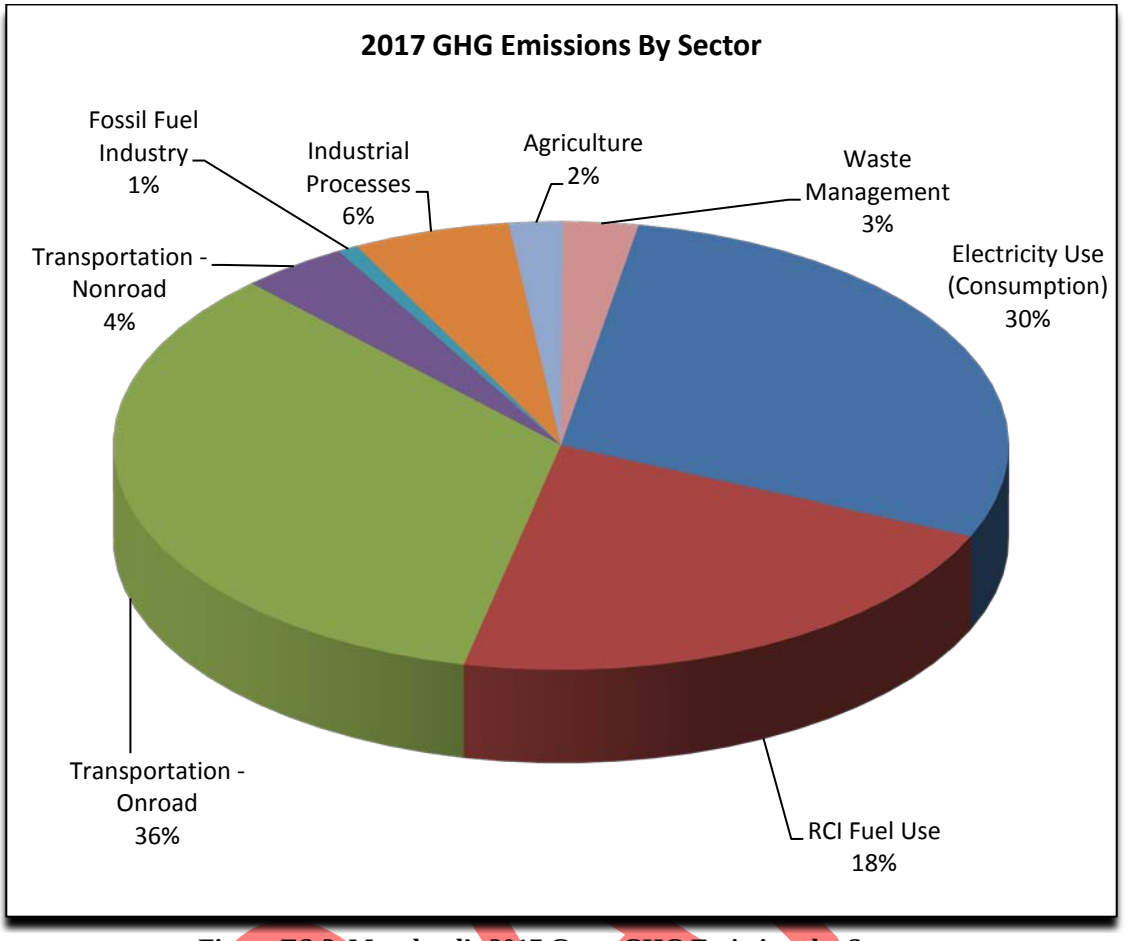


Figure ES-2. Maryland's 2017 Gross GHG Emissions by Sector.

The GGRA of 2016 requires that the state must reduce emissions by 42.89 $MMtCO_2e$ (40% of the state's total gross GHG emissions in 2006) to achieve the 2030 goal. To account for both reductions in emissions and improvements in sequestration from forests and agricultural soils, Maryland's net GHG emissions must be reduced to 52.55 $MMtCO_2e$ (42.89 $MMtCO_2e$ below the state's net GHG emissions in 2006). The combined emissions reductions of all programs in the *2019 GGRA Draft Plan* will yield a total of 47.4 $MMtCO_2e$ in emissions reductions in 2030, compared to 2006. This will result in a total reduction of 44%, achieving 4.5 MMtCO2e of emission reductions more than the 2030 GGRA goal.

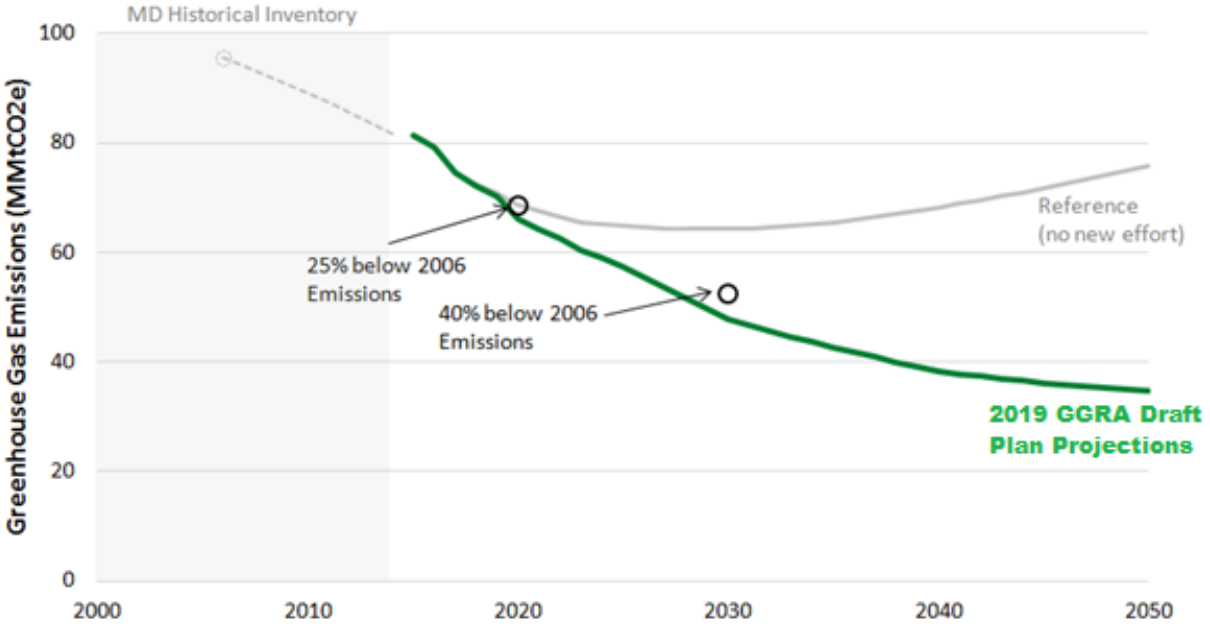


Figure ES-3. *2019 GGRA Draft Plan* Emission Reduction Projections.

ES.6 Emissions Modeling

MDE tasked the Regional Economic Studies Institute (RESI) of Towson University to develop GHG emissions projections, and macroeconomic assessments of Maryland's GHG reduction policies. RESI engaged Energy and Environmental Economics, Inc. (E3) to develop a Maryland-specific emissions model using E3's PATHWAYS model. The *2019 GGRA Draft Plan* provides documentation for the assumptions, methods, and results for the project.

After developing a long-term projection of Maryland's GHG emissions based on existing policies that are in place to reduce emissions, as well as forecasted future economic activity and population in the state, MDE worked with other state agencies and its modeling partners to evaluate the impact of additional and enhanced GHG reduction policies on Maryland's overall emissions, and to establish a set of programs included in the *2019 GGRA Draft Plan* that will reduce the state's emissions below its 2030 goal.

The *2019 GGRA Draft Plan* programs achieve emissions reductions from across multiple sectors (Figure ES-4). Since most of Maryland's emissions come from electricity generation and transportation, those are the source of most of the reductions achieved in the plan, but additional reductions come from building energy use, forestry, and healthy soils management.

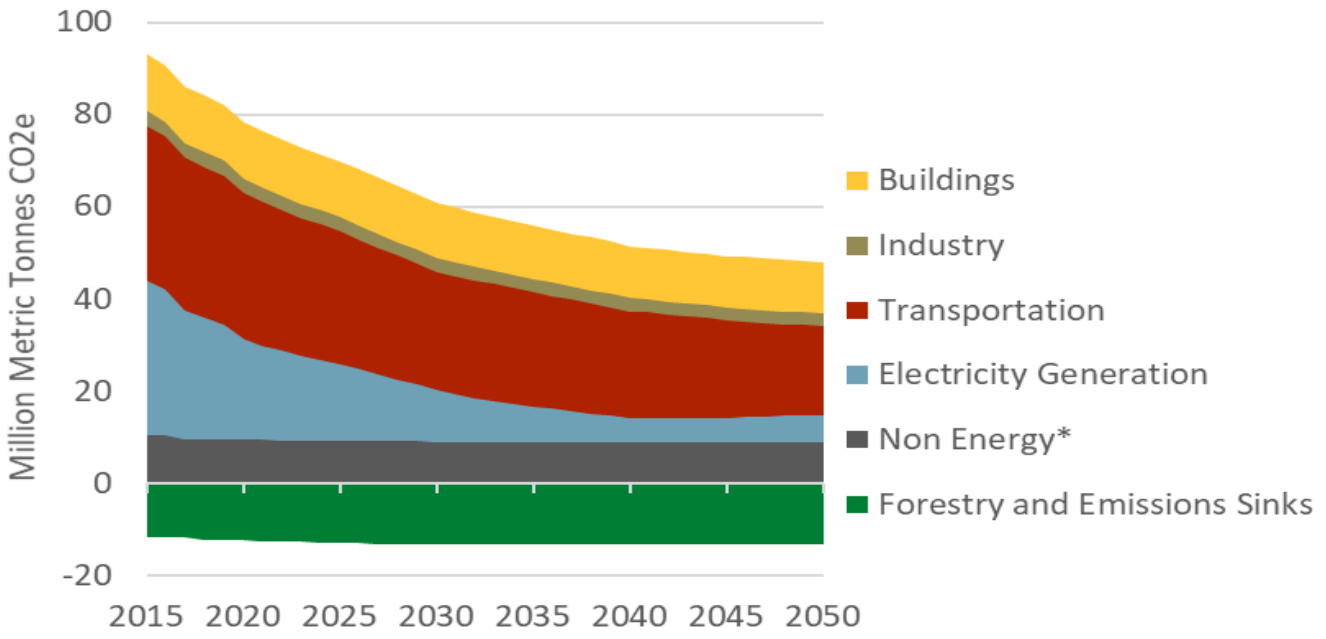


Figure ES-4. Maryland GHG Emissions Projections by Sector under the *2019 GGRA Draft Plan*.
***Non Energy includes Agriculture, Waste Management, Industrial Processes and Fossil Fuel Industry**

MDE, RESI, and E3 also performed sensitivity analyses, where assumptions about federal government programs and consumer behavior were varied to reflect a more difficult environment for achieving the 2030 goal. Specifically, the sensitivity analysis evaluated the effect of:

- U.S. Environmental Protection Agency's proposed rollback of vehicle efficiency standards;
- Lower consumer adoption of EVs (half as many EVs purchased);
- Lower consumer adoption of efficient appliances (half as many efficient appliances purchased); and
- The combined impact of federal efficiency rollbacks and lower consumer adoption.

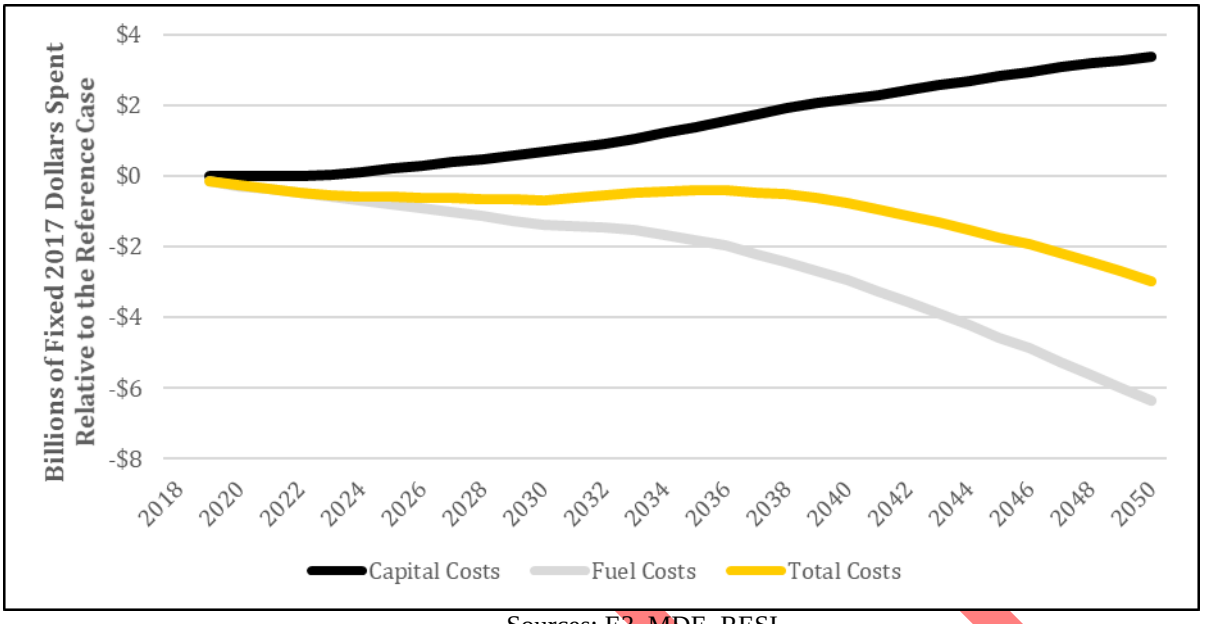
In all cases, the *2019 GGRA Draft Plan* still achieved the 2030 goal, indicating that the *2019 GGRA Draft Plan* is robust to uncertainty in federal actions and consumer adoption.

ES.7 Economic Impacts

MDE and RESI analyzed the economic impacts of the *2019 GGRA Draft Plan* using a dynamic macroeconomic model called REMI PI+. REMI PI+ is a high-end dynamic modeling tool used by various federal and state government agencies in economic policy analysis. To model economic impacts, the team synthesized data from a number of sources, including Pathways output and estimates of program costs from state agencies. Additionally, the team conducted public health modeling to estimate the economic impact associated with improved air quality.

- The analysis estimated the effect on Maryland's economy from:
- The savings enjoyed by consumers and businesses from energy efficiency, EVs, and other clean energy measures;
- Investments in transportation infrastructure, and renewable energy projects;
- The up-front cost of those measures and investments; and
- Improvements in public health.

The combined impact of those effects was a substantial benefit to Maryland's economy, including faster economic growth, greater income for Marylanders, and broadly shared job creation.

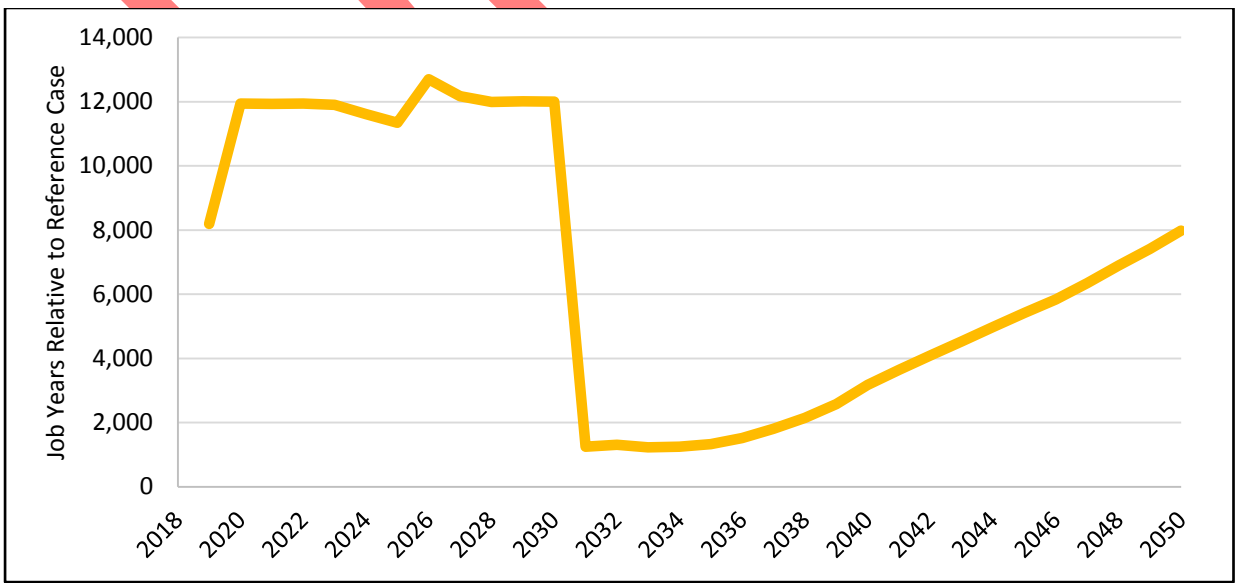


Sources: E3, MDE, RESI

Figure ES-5. Total Costs from *2019 GGRA Draft Plan* programs.

Although consumers and businesses are spending more on capital costs (e.g., new energy-efficient appliances or new EVs) in the *2019 GGRA Draft Plan* (Figure ES-5), fuel savings are greater than this amount every year. This is attributable to three general trends:

- Spending on transportation infrastructure projects is high in the GGRA scenario. These projects are generally due to policies aimed at reducing fuel usage through behavioral changes (e.g., increased mass transit usage or increased use of bike lanes) as well as more direct capital outlays (e.g., truck stop electrification or bus electrification).
- Capital costs are generally low.
- The impacts of infrastructure spending and capital costs can both be seen in Figure ES-6. The GGRA scenario supports an average of 11,649 jobs each year through 2030 relative to the reference case.



Sources: E3, MDE, REMI PI+, RESI

Figure ES-6. Employment in GGRA Scenario Relative to the Reference Case.

Through 2030, these employment impacts are driven by transportation infrastructure projects. After 2030, employment impacts remain positive from continued clean energy programs. The steady increase in employment after 2030 is due, in part, to the relatively low capital costs seen in the GGRA scenario. Because spending on capital is lower, consumers have more money to spend on other goods and services, and businesses are more profitable. These positive impacts, coupled with reductions in spending on fuel, will likely result in a slow albeit steady increase in jobs supported relative to the reference case.

To visualize the impact of spending on transportation infrastructure on the economic impact results for the GGRA scenario, Figure ES-7 below shows employment impacts with and without this spending.

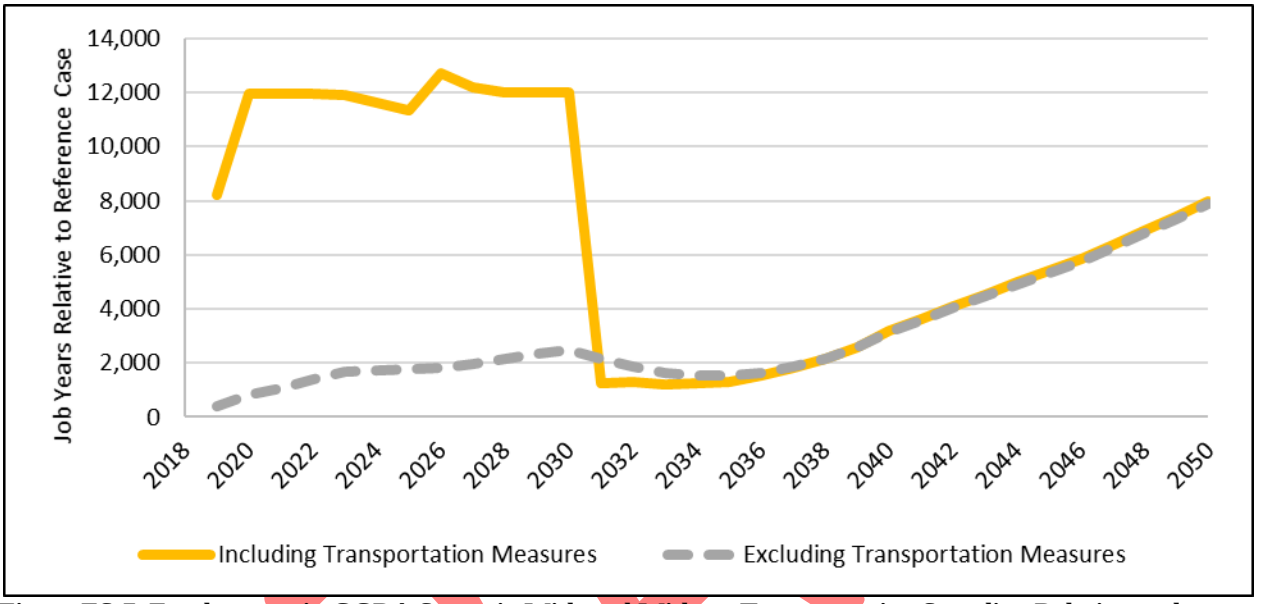


Figure ES-7. Employment in GGRA Scenario With and Without Transportation Spending Relative to the Reference Case.

On average through 2030, transportation infrastructure measures support 10,013 more jobs compared to a scenario without this spending. This is illustrated above as the difference between the two lines. Regardless of the status of the transportation spending, however, employment impacts are steadily positive for the GGRA scenario, which achieves the 2020 and 2030 economic and emissions goals.

The economic analysis included the same sensitivity analysis as the emissions analysis described above. The results indicate that the economic outcomes of the GGRA scenario are robust enough to absorb large changes in policies, consumer behavior deviations, and an uncertain economic environment. Under all the sensitivity analyses, the GGRA's economic goals are met.

ES.8 Equity in the *2019 GGRA Draft Plan*

The state gives full consideration to climate change impacts as they relate to community concerns, and engages this issue through multiple avenues, including the GGRA, the Commission of Environmental Justice and Sustainable Communities, and the MCCC. Input and advice from vulnerable communities has been and will continue to be sought on this, in order to ensure that the concerns of all Maryland stakeholders have been considered. MDE, the Maryland Department of Health (MDH), and DNR have all participated in multiple meetings with vulnerable communities throughout 2017 and 2018. MDE's meetings have focused on mitigation strategies while DNR and MDH have addressed resiliency, and the public health implications of climate change. Other specific examples of community outreach activities that the state is engaged in can be found in Chapter 6 of the *2019 GGRA Draft Plan*.

There are numerous safeguards in the Code of Maryland Regulations related to the GGRA of 2016, which specifically address considerations for a variety of vulnerable populations and historically disadvantaged communities that have been evaluated. These include consideration of the impacts of implementation of the 40% by 2030 plan may have on: electricity costs; the availability of reliable and affordable electrical service and fuel supplies; the state's agricultural and manufacturing sectors; and rural or low-income, low- to moderate-income, or minority communities. Specific protections related to public health, jobs, and the economy has already been discussed earlier.

While equity cannot be completely captured using quantitative modeling, and modeling is unavoidably limited by monetary and financial restraints, MDE did include specific parameters and analyses for the purpose of evaluating the distribution of potential health and economic impacts. Some of the economic parameters evaluated in the modeling included average job growth, cumulative personal income growth, and cumulative gross state product. MDE modeled how job losses or gains would be distributed among various jobs based on type (e.g., construction; sales; transportation; management, business and financial; and maintenance and repair), wages , required education /training (a range from low to high, labeled zones 1-5), distribution across racial and ethnic groups, and distribution across five regions of the state . This was done for each of the policy scenarios modeled, and allowed for comparison of the scenario outcomes through an equity lens.

The *2019 GGRA Draft Plan* has multiple objectives beyond reducing GHG emissions, intended to balance costs and complement benefits to produce net positive results for Maryland overall. As mentioned earlier in this section, the way in which equitable actions are implemented within policies and programs is complex, but critical to achieving our goals of holistic and sustainable climate action. The programs, which form Maryland's *2019 GGRA Draft Plan*, are managed by numerous state agencies, including MDE, DNR, DGS, MDA, MEA, and the Departments of Planning, Housing and Community Development, as well as the Maryland Insurance Administration. The following examples illustrate how equity considerations have been incorporated into specific programs under the *2019 GGRA Draft Plan.*

ES.9 Impact Analysis of GGRA on the Manufacturing Industry in Maryland - 2022

The GGRA of 2016 requires in 2022 an independent study of the economic impact of requiring GHG emissions reductions from the state's manufacturing sector. The GGRA of 2016 also requires that this study be overseen by the MCCC. This study will be included in an update to the *2019 GGRA Draft Plan* once the plan has been completed and implemented.

ES.10 Adaptation and Resiliency

Climate change will affect Maryland in a variety of ways, and in some places the impacts are already being felt. Impacts now and into the future may 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 or shifts in public health challenges due to climate-driven stressors; 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. Climate change raises the stakes in managing these problems by changing their frequency, intensity, extent, and magnitude.

Even as the state moves forward with actions that will reduce GHG emissions, and ultimately result in increased energy efficiency, a more sustainable economy, and cleaner air; impacts will still be felt into the future. Therefore, adaptation, together with mitigation, is necessary to address climate change. Increasingly these actions are no longer independent from one another, and any program or policy to mitigate GHG emissions 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 Academies[12], 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. With that in mind, 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. Maryland is taking action to address a wide range of climate impacts to sectors, such as bay and aquatic environments, agriculture, human health, water resources, population growth, infrastructure, forest and terrestrial ecosystems, and our coastal zone.

ES.11 Meeting Longer-Term Goals (2050 and beyond)

The GGRA of 2016 requires that the *2019 GGRA Draft Plan* be developed in recognition that emissions must be reduced between 80% and 95% from 1990 levels by 2050. The *2019 GGRA Draft Plan* will act as an important and successful stepping stone in achieving this ambitious goal, and provides a strong foundation on which to continue the effort to reduce GHG emissions within Maryland far into the future.

The analysis in the *2019 GGRA Draft Plan* includes several additional "what if" scenarios to estimate the future impact of various energy and climate policies that extend beyond the 2030 goal of the GGRA of 2016, including a scenario that achieves an 80% reduction in GHG emissions by 2050. That analysis identified a number of potential measures and technologies that the state could deploy after 2030 to achieve deeper reductions by 2050.

The *2019 GGRA Draft Plan* proposes a set of measures that are available and economically beneficial today, and that meet the state's 2030 goal. It identifies a number of future measures that should be monitored as technologies mature, and deployed accordingly if they become viable later on, to ensure that Maryland continues to reduce its GHG emissions beyond 2030.

ES.12 Conclusions

The *2019 GGRA Draft Plan* is both ambitious and comprehensive, including over 100 important large and small initiatives to reduce GHG emissions in Maryland. When fully implemented, the *2019 GGRA Draft Plan* will achieve more than the 40% by 2030 emissions reduction required by the GGRA of 2016 law, have a positive impact on Maryland's economy, create and maintain new jobs, and also help Maryland protect public health and meet Chesapeake Bay and air quality goals.

Additionally, the progress made through implementation of the *2019 GGRA Draft Plan* will position the state to achieve longer term goals like reducing GHG emissions between 80% and 95% from 1990 levels by 2050. The state aims to incorporate both traditional strategies (e.g., energy and transportation) and non-traditional strategies (e.g., partnerships, healthy soils) to achieve the goals of the GGRA of 2016. When combined with proposals for several bold new programs like CARES and TCI, the *2019 GGRA Draft Plan* will result in great success for Maryland.

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

Maryland Department of the Environment

Chapter 1

Climate Change, the Cost of Inaction, and GGRA Background

1.1 The Science of Climate Change

The body of scientific evidence for global climate change is both clear and growing, and has demonstrated with a very high degree of certainty that the dominant cause is human activity[1,2,3,4], particularly the emission of heat-trapping greenhouse gases (GHGs) into the atmosphere[1,2,3,4,5,6,7]. Furthermore, experts agree that there is no convincing evidence that natural cycles and variability alone can account for the changes observed over the Industrial era[7,8]. Statements affirming the occurrence, danger, and anthropogenic nature of climate change have been issued by many reputable U.S. scientific organizations and national science academies, making the consensus evident[5,7,8,9,10,11,12,13,14].

The climate of a region is defined by its long-term average temperature and precipitation trends[15], which shape many of the physical, chemical, and biological components of ecosystems as they develop. Significant and rapid

[1] Intergovernmental Panel on Climate Change, Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, R. Pachauri and L. Meyer, Eds., Geneva, 2014.
[2] Maryland Commission on Climate Change Scientific and Technical Working Group, "Appendix 1 of 2015 Maryland Commission on Climate Change Report: Reducing Emissions of Greenhouse Gases Beyond 2020," in 2015 Maryland Commission on Climate Change Annual Report, 2015.
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[4] U.S. Global Change Research Program, Climate Science Special Report: Fourth National Climate Assessment, Volume I, D.J. Wuebbles, D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, T.K. Maycock, Eds., Washington, DC, 2017, p. 470.
[5] American Chemical Society, "Climate Change: ACS Pubilc Policy Statement," 2016. [Online]. Available: https://www.acs.org/content/dam/acsorg/policy/publicpolicies/sustainability/globalclimatechange/climate-change.pdf.
[6] American Geophysical Union, "Human-Induced Climate Change Requires Urgent Action," 2014. [Online]. Available: http://sciencepolicy.agu.org/files/2013/07/AGU-Climate-Change-Position-Statement_August-2013.pdf. [Accessed 9 August 2017].
[7] American Meteorological Society, "Climate Change: An Information Statement of the American Meteorological Society," 2012. [Online]. Available: https://www.ametsoc.org/ams/index.cfm/about-ams/ams-statements/statements-of-the-ams-in-force/climate-change/. [Accessed 9 August 2017].
[8] U.S. Global Change Research Program, Global Climate Change Impacts in the United States, T. Karl, J. Melillo and T. Peterson, Eds., Cambridge University Press, 2009.
[9] National Aeronautics and Space Administration, "Scientific Consensus: Earth's climate is warming," 2017. [Online]. Available: http://climate.nasa.gov/scientific-consensus. [Accessed 27 August 2018].
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[11] American Physical Society, "National Policy 15.3 Statement on Earth's Changing Climate," 14 November 2015. [Online]. Available: https://www.aps.org/policy/statements/15_3.cfm.
[12] The Geological Society of America, "Climate Change," 2015. [Online]. Available: https://www.geosociety.org/gsa/positions/position10.aspx. [Accessed 09 August 2017].
[13] Royal Society and U.S. National Academy of Sciences, "Climate Change: Evidence & Causes," 2014. [Online]. Available: http://dels.nas.edu/resources/static-assets/exec-office-other/climate-change-full.pdf.
[14] U.S. Global Change Research Program, Climate Change Impacts in the United States: The Third National Climate Assessment, J. Melillo, T. Richmond and G. Yohe, Eds., 2014.
[15] National Oceanic and Atmospheric Administration, "What is the difference between weather and climate?," 2014. [Online]. Available: http://oceanservice.noaa.gov/facts/weather_climate.html. [Accessed 17 April 2017].

changes in the climate, therefore, are expected to have pervasive and in some cases devastating impacts to ecosystems, and consequently to the resources and services upon which humans rely.

In order to limit the temperature increase to the established 2°C threshold goal, the Intergovernmental Panel on Climate Change (IPCC) calculated that global GHG emissions must be reduced by 40 percent to 70 percent from 2010 levels by 2050, and further to near or below zero in 2100[1]. It is with this goal in mind that Maryland adopted both the Greenhouse Gas Reduction Act (GGRA) of 2009 to reduce emissions 25 percent from 2006 levels by 2020, as well as the updated and enhanced Greenhouse Gas Emissions Reduction Act – Reauthorization (GGRA of 2016) to reduce emissions 40 percent from 2006 levels by 2030.

1.2 Climate Change and the Cost of Inaction in Maryland

Documented changes are already occurring, and the response of the environment to the current levels of anthropogenic GHG emissions is still being realized[7,15,16,17]. However, actions taken at this time are still capable of mitigating the damage of future impacts, and delayed action or inaction may lead to a more severe outcome[7,15]. An urgent response is critical to minimizing both costs and risks, and increasing the likelihood to survive and thrive in a changing world[6,10]. As with any major adjustments, delaying action is likely to necessitate changes that are more dramatic and economically disruptive.

In the Northeastern U.S., the rate of sea level rise already observed is greater than the global average, having increased about one foot since 1990 (average is 8 inches)[18], likely due to both increased Greenland ice loss as well as changes in regional currents and land subsidence[19,20,21]. Maryland has experienced an increase in annual average temperature of 1.5°F since the beginning of the 20th century, and a winter warming trend reflected in the average of less than one day per year of nights below 0°F since the mid 1990's, as compared to an average of two nights per year between 1950 and 1994[22]. Annual precipitation, though more variable, increased by approximately 0.39 inches per decade in the Northeast during this same time[23], with Maryland's annual mean precipitation having been above average for the past two decades. The climate in this region is generally expected to continue trending warmer and wetter over the next century, accompanied by an increase in extreme heat waves and precipitation events[21,22].

These consequences to the physical systems will reverberate through biological and human systems, the three of which have co-evolved to exist under current conditions. The global climate system is complex, and a large number of variables interact to determine the eventual impact of expected changes to various segments of the natural and built environment. While not every individual change is necessarily harmful, the negative consequences of unmitigated climate change will far outweigh those select benefits[20]. This section contains just a brief overview of those that are most high-profile, and generally well-accepted by the scientific community. A more detailed examination of these and other projected impacts can also be found in the Maryland Commission on Climate Change's (MCCC) *2018 Annual Report*.

[16] J. Hansen, L. Nazarenko, R. Ruedy, M. Sato, J. Willis, A. Del Genio, D. Koch, A. Lacis, K. Lo, S. Menon, T. Novakov, J. Perlwitz, G. Russell, G. A. Schmidt and N. Tausnev, "Earth's Energy Imbalance: Confirmation and Implications," Science, vol. 308, pp. 1431-1435, 2005.
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[18] R. Horton, G. Yohe, W. Easterling, R. Kates, M. Ruth, E. Sussman, A. Whelchel, D. Wolfe and a. F. Lipschultz, "Chapter 16: Northeast," in Climate Change Impacts in the United States, 2014, pp. 371-395.
[19] J. L. Davis and N. T. Vinogradova, "Causes of accelerating sea level on the East Coast of North America," Geophysical Research Letters, vol. 44, no. 10, pp. 5133-5141, 2017.
[20] U.S. Environmental Protection Agency, "Climate Change Indicators in the United States," Washington DC, 2016.
[21] U.S. Environmental Protection Agency, "Climate Change in the United States: Benefits of Global Action," United States Environmental Protection Agency, Office of Atmospheric Programs, 2015.
[22] J. Runkel, K. Kunkel, D. Easterling, B. Stewart, S. Champion, R. Frankson and W. Sweet, "Maryland State Summary," National Oceanic and Atmospheric Administration, 2017.
[23] K. E. Kunkel, L. E. Stevens, L. Sun, E. Janssen, D. Wuebbles, J. Rennells, A. DeGaetano and J. G. Dobson, "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 1. Climate of the Northeast U.S.," National Oceanic and Atmospheric Administration, 2013.

1.2.1 Maryland's Environment

Ecosystems consist of networks of interactions among the biosphere, atmosphere and geosphere (living and nonliving components, including chemical, biological and physical interactions). Human systems, or the "built environment," can be considered a more recently evolved component, which is equally intertwined with and dependent upon these same resources.

As noted earlier, the climate in Maryland and the rest of the Northeastern U.S. is currently trending warmer and wetter, a trajectory that is expected to continue. Heat waves are likely to increase in frequency, intensity and duration corresponding directly to increases in emissions; and Maryland is expected to have a notable increase in days with extreme heat (over 90 degrees Fahrenheit) by 2050, as compared to the late 1900's[18]. The trend in average precipitation is expected to remain seasonal, increasing in the winter and spring, with less change expected in the fall and summer[23]. Combined with the higher summer temperatures, greater evaporation and earlier snowmelt will create a risk of drought during the growing season (significant for both ecosystems and human systems). Additional impacts in Maryland could include increased frequency and severity of other existing problems such as storms, flooding, and forest fires, as well as erosion, saltwater intrusion and inundation of low-lying areas along the State's shoreline and coast[24]. In general, "climate change increases the risk, frequency, and intensity of certain extreme events like intense heat waves, heavy downpours, flooding from intense precipitation and coastal storm surges, and disease incidence related to temperature and precipitation changes"[14]. The direct impacts to Maryland's ecosystems and built environment are assessed in the following sub-section.

Maryland Ecosystems

When attempting to either qualify or quantify the value of ecosystems, a term commonly used is "ecosystem services." These refer to the benefits and resources afforded to people by the normal and healthy functioning of the ecosystem, such as robust fisheries, cleaner air and drinking water, and recreational opportunities[25,26]. As the introduction highlighted, the success of the ecosystem is intimately connected to the success of the human system. People depend on these ecosystem services, and loss or degradation of the ecosystem will have a negative impact on both the quality of life and the economy in Maryland[26], including:

- Maryland's Atlantic coast provides ecosystem services such as fisheries, recreational opportunities, and storm-surge protection.
- The Chesapeake Bay ecosystem is the largest estuary in the United States and an invaluable and iconic part of Maryland, providing a broad range of environmental, recreational, and economic services.
- Maryland's forest ecosystem provides a large number of benefits, which include stormwater management, acting as a sink for atmospheric carbon, and providing essential habitat for wildlife and recreational opportunities for people.

Maryland's ecosystems are threatened in various ways by the changing climate. Depending on the specific traits of a given population of organisms, and the pressures they are exposed to in a changing environment, the population may experience adaptation (e.g., natural selection or behavioral changes), migration to maintain residence in suitable habitat (e.g., expanding or contracting, strict directional movement), phenological shifts (i.e., changes in the timing of seasonal life-cycle events), or even local extinction when other mechanisms are not successful[25,27,28].

[24] Maryland Commission on Climate Change Adaptation and Response Working Group, " Adaptation and Response Working Group Annual Report," in Appendix E of 2016 Maryland Commission on Climate Change Annual Report, 2016.
[25] P. M. Groffman, P. Kareiva, S. Carter, N. B. Grimm, J. Lawler, M. Mack, V. Matzek and H. Tallis, "Chapter 8: Ecosystems, Biodiversity, and Ecosystem Services," in Climate Change Impacts in the United States: The Third National Climate Assessment, J. Melilo, T. Richmond and G. Yohe, Eds., U.S. Global Change Research Program, 2014, pp. 195-219.
[26] Maryland Department of Natural Resources, "Accounting for Maryland's Ecosystem Services: Integrating the Value of Nature into Decision Making," 2018.
[27] M. Staudinger, N. Grimm, A. Staudt, S. Carter, F. Chapin, P. Kareiva, M. Ruckelshaus and B. Stein, "Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment," 2013.
[28] J. L. a. J.-C. Svennig, "Climate-related range shifts: A global multidimensional synthesis and new research directions," Ecography, pp. 001-014, 2014.

In general, rising temperatures are expected to change species distribution by latitude and elevation, a trend that has already been documented in the scientific literature, particularly for temperate locations[29,30,31]; however additional factors such as changes in precipitation regimes may also play a role in the directional nature of these shifts[31,32]. This would not mean that all species in Maryland migrate out of the State; species for which Maryland is in the middle of their range or that are better able to adapt may persist in the area, while the overall composition of the communities they are a part of may change as others migrate or become locally extinct. Furthermore, variable adaptation within an ecosystem or community via habitat shifting or changes in phenology (such as when flowers bloom or animals become active in spring) will result in changes to community interactions. This could lead to novel interactions between species that were not previously associated, or asynchronies in the life cycles and distribution of some species that have key interactions, like plant/pollinator and predator/prey[18,25].

While individual populations may experience many different impacts, positive or negative from the population's perspective, the overall stability and persistence of the community (i.e., resilience to these changes and ability to adapt its complex network of interactions to maintain its productivity and fundamental identity) is far more significant from a broader perspective[33,34]; and from the perspective of maintaining ecosystem services. The following are several highlights of ecosystem-specific changes that are already occurring or are predicted for Maryland, but by no means the only potential impact.

Coastal and Ocean Ecosystems

Coastal and ocean ecosystems are particularly vulnerable to physical and chemical changes brought about by rising ocean temperatures, sea level rise, ocean acidification, and increased precipitation and freshwater inputs from rivers. Sea-surface temperature in the mid-Atlantic has demonstrated a long-term warming trend since the late 1800's, with a steady increase since the mid-1960's[35,36]. Higher ocean surface temperatures are directly impacting the species distribution of marine fish and invertebrates. One study of U.S. coasts found that for over 100 species sampled, the average center of biomass shifted north by approximately 10 miles and deeper by an average of 20 feet since the 1980's[20]. Another study found that bottom-dwelling mid-Atlantic marine species specifically show a northeastern shift, noting that the ocean-floor depth in this region is relatively uniform and shallow[37]. Rising global temperatures also impact dissolved oxygen concentrations in water by decreasing oxygen solubility and increasing respiration rates (and oxygen consumption); exacerbated by changing ocean circulation and, in coastal areas, increased nutrient loading from changes in precipitation[7,38]. Reduced oxygen ultimately impacts productivity and biodiversity through influence over many biological and nutrient-cycling processes[4,38].

[29] I.-C. Chen, J. K. Hill, R. Ohlemuller, D. B. Roy and C. D. Thomas, "Rapid Range Shifts of Species Associated with High Levels of Climate Warming," Science, vol. 333, no. 6045, pp. 1024-1026, 2011.
[30] J. Lenoir, J. C. Gegout, P. A. Marquet, P. de Ruffray and H. Brisse, "A significant upward shift in plant species optimum elevation during the 20th century," Science, 2008.
[31] J. VanDerWal, H. T. Murphy, A. S. Kutt, G. C. Perkins, B. L. Bateman, J. J. Perry and A. E. Reside, "Focus on poleward shifts in species' distribution underestimates the fingerprint of climate change," Nature Climate Change, vol. 3, 2012.
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[34] L. Brandt, H. He, L. Iverson, F. Thompson III, P. Butler, S. Handler, M. Janowiak, P. Shannon, C. Swanston, M. Albrecht, R. Blume-Weaver, P. Deizman, J. DePuy, W. Dijak, G. Dinkel, S. Fei, D. Jones-Farrand, M. Leahy, S. Matthews, P. Nelson, B. Oberle, J. Perez, M. Peters, A. Prasad, J. Schneiderman, J. Shuey, A. Smith, C. Studyvin, J. Tirpak, J. Walk, W. Wang, L. Watts, D. Weigel and S. Westin, "Central Hardwoods Ecosystem Vulnerability Assessment and Synthesis: A Report from the Central Hardwoods Climate Change Response Framework Project," 2014.
[35] R. K. Shearman and S. J. Lentz, "Long-Term Sea Surface Temperature Variability along the U.S. East Coast," Journal of Physical Oceanography, vol. 40, pp. 1004-1017, 2010.
[36] Ecosystem Assessment Program, "Ecosystem Assessment Report for the Northeast U.S. Continental Shelf Large Marine Ecosystem," National Oceanic and Atmospheric Administration, 2009.
[37] K.M. Kleisner, M.J. Fogarty, S. McGee, A. Barnett, P. Fratantoni, J. Greene, J.A. Hare, S.M. Lucey, C. McGuire, J. Odell, V.S. Saba, L. Smith, K.J. Weaver, and M.L. Pinsky, "The effects of sub-regional climate velocity on the distribution and spatial extent of marine species assemblages," PLoS ONE, vol. 11, no. 2, p. e0149220, 2016.
[38] D. Breitburg, L. Levin, A. Oschlies, M. Grégoire, F. Chavez, D. Conley, V. Garcon, D. Gilbert, D. Gutiérrez, K. Isensee, G. Jacinto, K. Limberg, I. Montes, S. Naqvi, G. Pitcher, N. Rabalais, M. Roman, K. Rose, B. Seibel, M. Telszewski, M. Yasuhara and J. Zhang, "Declining oxygen in the global ocean and coastal waters," Science, vol. 359, no. 6371, p. eaam7240, 2018.

Sea level rise threatens the coastline and other marginal habitats, such as marshes and tidal wetlands through inundation and exacerbation of erosion, the latter having a particular impact on the sandy coastline of the mid-Atlantic[39]. In fact, salt-water intrusion/inundation has been identified as the primary cause of wetland losses in the mid-Atlantic region in recent decades[40]. While sea level has changed in the past and coastal environments have adjusted by shifting location, the speed at which the change is occurring and the prevalence of human development will continue contributing to the likelihood of successful habitat migration and the associated impacts[39]. Where tidal marshes become submerged or are eroded, impacts would likely be seen in the populations of birds, fish and shellfish that utilize tidal marsh habitat for spawning, nursery and shelter areas[41].

The Chesapeake Bay Region

Many of the coastal, wetland and marsh impacts discussed for the coast are clearly also applicable to the Bay, but due to its significance, the Chesapeake Bay has drawn the attention of researchers. Estuarine systems are expected to experience some unique impacts due to climate change, and scientists have already identified clear climatic trends for the Bay region, which are influencing its habitats and the species that reside there[42]. Distinctive climatic changes noted over this period include a growing season, which is expanding at an even greater rate than that of the East coast overall. This has been observed as an issue for some migratory species, which reside in the Bay during the spring and summer months, but farther south during the winter. Warmer fall weather has meant that these species are not beginning their migration early enough, lacking the usual indicator of oncoming cold. Then, when the temperature drops suddenly, these species may suffer from cold-shock, resulting in incidents such as the cold-snap-associated death of thousands of Speckled Trout in February of 2014, or 2 million juvenile Spot in 2011[42].

In addition to temperature changes, an increase in total annual precipitation by approximately 12 percent holds particular significance in the Bay region, due to the correlation between precipitation and nitrogen/sediment pollution brought into the Bay with runoff, mentioned earlier[25,42]. Wetlands in the area actually provide ecosystem services that help to mitigate some of the nutrient loads, but excess nutrients that reach the Bay can still cause algal blooms. The blooms, while active, reduce light penetration to the bottom of the bay, and sediment pollution further reduces clarity. Then, as they die off, their decomposition reduces oxygen levels at the bottom of the Bay, compounding the impact of warmer summer temperatures to exacerbate low-oxygen "dead-zones"[43]. Aquatic vegetation, which provides food and habitat for fish, crabs, and waterfowl, tends to be stressed by any combination of these factors (increased temperatures, decreased oxygen, nutrient pollution, and reduced clarity)[42].

Forest Ecosystems

In 2015, it was estimated that about 2.5 million acres of Maryland was covered by forest[44]. Quantified, the value of forests in reducing air pollution alone is $140 million/year for the state; and wetlands and forests together provide value for flood prevention and stormwater mitigation at $3.1 billion/year, and surface water protection at $246 million/year[26]. Climate change may have direct impacts on the distribution of tree species in our forests, or indirect effects through previously discussed changes to other populations within the ecosystem such as pests and pathogens, with the most significant changes expected to appear in the long-term[45,46]. Whether population can shift

[39] K.E. Anderson, D.R. Cahoon, S.K. Gill, B.T. Gutierrez, E.R. Thieler, J.G. Titus, and S.J. Williams, "Coastal Sensitivity to Sea level Rise: A Focus on the Mid-Atlantic Region," The U.S. Climate Change Science Program and the Subcommittee on Global Change Research, U.S. Environmental Protection Agency, Washington DC, 2009.
[40] T.E. Dahl and S.M. Stedman, "Status and trends of wetlands in the coastal watersheds of the Conterminous United States 2004 to 2009," U.S. Department of the Interior, Fish and Wildlife Service and National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 2013.
[41] K. Anderson, D. Cahoon, S. Gill, B. Gutierrez, E. Thieler, J. Titus and S. Williams, "Coastal Sensitivity to Sea level Rise: A Focus on the Mid-Atlantic Region," The U.S. Climate Change Science Program and the Subcommittee on Global Change Research, U.S. Environmental Protection Agency, Washington DC, 2009.
[42] Chesapeake Environmental Communications, "The Changing Chesapeake," 2017. [Online]. Available: http://www.chesapeakedata.com/changingchesapeake/. [Accessed 21 August 2017].
[43] National Oceanic and Atmospheric Administration, "Climate Change and the Chesapeake Bay," 2011.
[44] T. Lister and R. Widmann, "Forests of Maryland, 2015," U.S. Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA, 2016.
[45] P. Butler, L. Iverson, F. Thompson III, L. Brandt, S. Handler, M. Janowiak, P. Shannon, C. Swanston, K. Karriker, J. Bartig, S. Connolly, W. Dijak, S. Bearer, S. Blatt, A. Brandon, E. Byers, C. Coon, T. Culbreth, J. Daly, W. Dorsey, D. Ede, C. Euler, N. Gillies, D. Hix, C. Johnson, L. Lyte, S. Matthews, D. McCarthy, D. Minney, D. Murphy, C. O'Dea, R. Orwan, M. Peters, A. Prasad, C. Randall, J. Reed, C. Sandeno, T. Schuler, L. Sneddon, B. Stanley, A. Steele, S. Stout, R. Swaty, J. Teets, T. Tomon, J.

successfully depends on the interplay of abiotic, biotic, and ecological variables[47]; and for tree species this may include dispersal capacity and generation time, as well as environmental heterogeneity and succession processes[46,48]. Maryland's three different forest "ecological provinces" in the western, central, and coastal regions of the state[49] are each expected to be most impacted by slightly different factors.

Freshwater stream habitat in Western Maryland is also at risk from rising temperatures. From 1960 through 2014, the water temperature increased at 79 percent of all stream sites measured in the Chesapeake Bay region, and several stream gauges in Maryland demonstrated a statistically significant increase in temperature of 2 to 4 degrees Fahrenheit during this time[20]. According to the United States Environmental Protection Agency (EPA), under a business-as-usual emissions scenario, those sites, which are currently coldwater fisheries are projected to become unsuitable for this use by 2100, as is true for most of Appalachia; however, under a 2 degrees Celsius mitigation scenario, this use may be maintained[21].

The Built Environment

Projections from the *Third National Climate Assessment* of the U.S. Global Change Research Program (USGRP) indicate that infrastructure (e.g., roads, bridges, and buildings) in the Northeastern U.S. is expected to be at particularly high risk from the impacts of sea level rise, coastal flooding, and more intense precipitation events brought by climate change[18]. The East Coast infrastructure represents some of the oldest in the U.S., and was designed to a certain standard based on the elements and stressors, which it was expected to withstand. Climate change exposes these already aging structures to increased stress such as extreme temperatures and weather events, which can shorten their useful lifetime, increase maintenance costs, or even render them unusable[14,50,51].

Coastal Hazards

As previously noted, the Northeastern U.S. is actually experiencing a rate of sea level rise greater than the global or national average, and the mid-Atlantic has experienced a disproportionately large increase in the frequency of flooding since the 1950's[20]. In the *2018 Annual Report* from the MCCC, the Scientific and Technical Working Group provided preliminary updated projections on sea level rise impacts in Maryland. They stated that "Maryland should plan for a relative sea level rise of between 0.8-1.6 ft by 2050 and 1.6-3.4 ft by 2100 - considerably more if GHG emissions are not stabilized"[52]. Sea level rise puts the people and infrastructure of Maryland's extensive coastline at increased risk of damage from hazards such as flooding, saltwater intrusion, subsidence, storm surge, and erosion[20].

In addition, higher temperatures and greater air moisture are expected to contribute to Atlantic hurricanes with greater precipitation rates, and more frequent occurrences of the most intense storms[4]. The impacts of storm surge on transportation infrastructure can compound the loss of human life during storm events if major evacuation routes become impassable. It may lengthen the process of community recovery after events, due to a decreased

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Venderhorst, J. Whatley and N. Zegre, "Central Appalachians Forest Ecosystem Vulnerability Assessment and Synthesis: A Report from the Central Appalachians Climate Change Response Framework Project," USDA Forest Service, 2015.

[46] W. Wang, H. He, F. Thompson III, J. Fraser and W. Dijak, "Changes in forest biomass and tree species distribution under climate change in the northeastern United States," Landscape Ecology, 2016.

[47] S. Normand, N. Zimmermann, F. Schurr and H. Lischke, "Demography as the basis for understanding and predicting range dynamics," Ecography, vol. 37, pp. 1149-1154, 2014.

[48] W. Wang, H. He, F. Thompson III, M. Spetich and J. Fraser, "Effects of species biological traits and environmental heterogeneity on simulated tree species distribution shifts under climate change," Science of the Total Environment, vol. 634, pp. 1214-1221, 2018.

[49] D. Cleland, J. Freeouf, J. Keys, G. Nowacki, C. Carpenter and W. McNab, Ecological Subregions: Sections and Subsections of the Conterminous United States, USDA Forest Service, 2007.

[50] S. C. Moser, M. A. Davidson, P. Kirshen, P. Mulvaney, J. F. Murley, J. E. Neumann, L. Petes and D. Reed, "Chapter 25: Coastal Zone Development and Ecosystems," in Climate Change Impacts in the United States: The Third National Climate Assessment, J. Melillo, T. Richmond and G. Yohe, Eds., U.S. Global Change Research Program, 2014, pp. 579-618.

[51] S. L. Cutter, W. Solecki, N. Bragado, J. Carmin, M. Fragkias, M. Ruth and T. J. Wilbanks, "Chapter 11: Urban Systems, Infrastructure, and Vulnerability," in Climate Change Impacts in the United States: The Third National Climate Assessment, J. Melillo, T. Richmond and G. Yohe, Eds., U.S. Global Change Research Program, 2014, pp. 282-296.

[52] Maryland Commission on Climate Change, "2018 Annual Report," Baltimore, Maryland, USA, 2018.

ability to access work or school, or to receive much-needed supplies. These same impacts may directly affect the economic viability of main harbors, airports, and supply chains in coastal areas; and indirectly those locations that rely upon their goods and services[50,53]. In 2017, the Port of Baltimore handled 38.4 million tons of international cargo (worth $53.9 billion), ranking it 9th in all U.S. ports by dollar value; and the Port generates $310 million in taxes, nearly $3 billion in annual wages and salaries, and supports 13,650 direct jobs[54]. Imported and exported product is heavily reliant on not only port infrastructure, but the major highways and railways out of Baltimore City: Domino Sugar alone is estimated to generate 33,000 truck trips and more than 1,100 rail cars per year[55].

Inland Flooding

While Maryland's coastal areas may be considered particularly vulnerable, many areas of the state have infrastructure susceptible to impacts from climate change. Non-coastal (riverine and urban) flooding is a result of multiple factors, including those related to the design of the built environment (e.g., river modifications, drainage, and land use) and climate factors such as precipitation[56]. This type of urban flooding can be caused by high-intensity, heavy rainfall events, which have increased in frequency in the Northeast (71 percent from 1958 to 2012), and are expected to continue to increase with unmitigated climate change3. According to the 2017 USGRP *Climate Science Special Report*, the increased atmospheric water vapor associated with global warming means that when rainfall occurs, the amount of rain falling in a given event tends to be greater than it would have been under previous conditions[4,7]. When combined with the low permeability of the majority of urban surfaces, large quantities of runoff may quickly overwhelm the capacity of stormwater drainage systems[4,21,56], affecting homes, businesses, roads, bridges, public railways, and other infrastructure. Inland bridges are particularly vulnerable to increased riverine storm flow and flooding, and the U.S. Geological Survey hydrologic region, which includes most of Maryland (Hydrologic Unit Code 02, or HUC02) is expected to experience some of the greatest impacts, with 76 percent (more than 20,000) of inland bridges projected as vulnerable by 2100 without mitigation; while a successful 2 degrees Celsius scenario reduces this number to 35 percent[21]. Across HUC02, the cost of damages from inland flooding under a business-as-usual scenario is projected to be between $1 and $2 billion (in 2014 $) in 2100, significantly different from historic numbers[21].

1.2.2 Jobs and the Economy

Damages to natural or built systems may necessitate diversion of public funds for the replacement of ecosystem services or infrastructure repairs. Climate impacts can alter the natural resource productivity or availability in a region, and therefore the viability of the various economic sectors that depended on them. More frequent disruptions to urban and coastal infrastructure caused by extreme weather events may indirectly impact the economy of the region by restricting the flow of goods and impacting days worked. Decisions surrounding the adaptive management of various sectors are critical to the eventual outcome, but complicated by mitigation goals, socioeconomic factors, and concerns regarding uncertainty. This section provides an overview of some of the major economic sectors in Maryland, and the anticipated climate impacts.

Agriculture, Fisheries, and Forestry

Agriculture and forestry are cultivated under human control, yet directly and clearly linked to the impacts of climate change on ecosystems. Common stressors will be experienced among ecosystems, agriculture, fisheries

[53] H. G. Schwartz, M. Meyer, C. J. Burbank, M. Kuby, C. Oster, J. Posey, E. J. Russo and A. Rypinski, "Chapter 5: Transportation," in Climate Change Impacts in the United States: The Third National Climate Assessment, J. Melillo, T. Richmond and G. Yohe, Eds., U.S. Global Change Research Program, 2014, pp. 130-149.

[54] Maryland State Archives, "Maryland at a Glance: Waterways: Port of Baltimore," 2018. [Online]. Available: http://msa.maryland.gov/msa/mdmanual/01glance/html/port.html. [Accessed 25 September 2018].

[55] T. Karpovich, "Domino Sugar in Locust Point Receives Its Largest Shipment of Raw Sugar: Cargo Arrives from Malawi, Mozambique, Swaziland and Zimbabwe," The Port of Baltimore, pp. 22-23, November/December 2017.

[56] A. Georgakakos, P. Flemming, M. Dettinger, C. Peters-Lidard, T. Richmond, K. Reckhow, K. White and D. Yates, "Chapter 3: Water Resources," in Climate Change Impacts in the United States: The Third National Climate Assessment, M. Melillo, T. Richmond and G. Yohe, Eds., U.S. Global Change Research Program, 2014, pp. 69-112.

and forestry, such as those caused by general changes in temperature and precipitation regimes; increased extreme weather events; and increased pressures from weeds, diseases and pests. Maryland's Eastern Shore farmers will be at particular risk from additional issues such as sea level rise, coastal storms, and saltwater intrusion. While not all individual impacts are necessarily negative (e.g., the growing season is expected to lengthen in Maryland, which may initially benefit some crops), issues such as increased temperature extremes and pest activity may negate these benefits[57]; and beyond 2050, impacts are expected to be increasingly unfavorable in most situations[58]. The overall impact, however, will depend in part on the level of adaptation that is achieved at the production level, as well as the response of the global market to these shifts[58].

Although total farm acreage has been decreasing from historic levels[59], agriculture remained the largest single land use (almost one third of the total land area) and the largest commercial industry in the State, employing approximately 350,000 Marylanders[60]. According to the U.S. Department of Agriculture (USDA) survey data, Maryland's total production in 2017 included over $1 billion in broiler chickens, $699 million in field crops, and $169 million in milk[61]. In 2016, the market value of all agricultural products was over $2.3 billion; which, after production costs, translated to a net farm income of about $370 million ($42,091 per farm on average) in that year[60]. Poultry farms, the highest grossing agricultural industry in the state, are expected to see increased summer cooling costs, decreased growth rates, increased mortality and increased risk of Salmonella with increasing temperatures[57]; challenging slim margins. Increased frequency of summer heat stress has the potential to negatively affect both field crops and milk production yields[58], and may amplify water demand, increasing the risk of over pumping groundwater for irrigation. This latter tendency, combined with sea level rise, places unconfined aquifers exposed to the freshwater-saltwater interface on the Eastern Shore at risk from saltwater intrusion. Saline water may also flood fields during storm events, leaving salt behind after evaporation, which can disrupt the soil structure and leach vital trace minerals.

Changes in temperature and precipitation are likely to alter the types of crops that can be grown in a given region, similar to the effects on natural plant populations. Where field crops are grown is generally determined by USDA hardiness zones, and while most of Maryland is currently in zone 7, the USDA predicts that much or part of Maryland may be in zone 8 under various future scenarios, both mid- and late-century[62]. The seasonality of trends in temperature and precipitation is also particularly relevant to the agricultural sector. As noted earlier in this chapter, average precipitation is expected to continue increasing in the winter and spring, with less change expected in the fall and summer[23]. Combined with the higher summer temperatures, this will likely increase the intensity of any droughts during the growing season[22]. Perennial crops such as fruit trees and vines are also at risk, since their life cycles rely on particular seasonal cues. These crops may also become more sensitive to hard freezes, as unusually warm winters can de-harden vines, or cause spring growth to begin prematurely only to be later destroyed by a hard freeze[58]. In 2017, Maryland's apple and peach orchards produced over $11.5 million utilized for fresh eating and in processing[59]. Additionally, the State has 858 acres of vineyards, 70 percent of which are owned by wineries that sold $47 million worth of product in 2015[60].

While the effect on forestry is not predicted to be as substantial as that on agriculture, and increased incidence of wildfires is not expected to be as significant a concern in Maryland as in other regions of the U.S.[18,21], there are still potential threats and changes to the industry that merit attention. An analysis published in 2018 by the BEACON institute of Salisbury University entitled *The Impact of Resource Based Industries on the Maryland*

[57] University of Maryland Center for Environmental Science, "Land Management: Farming in a Changing Climate," 2014. [Online]. Available: https://climatechange.maryland.gov/wp-content/uploads/sites/16/2014/12/ian_newsletter_4061.pdf. [Accessed 11 September 2017].
[58] J. Hatfield, G. Takle, R. Grotjahn, P. Holden, R. C. Izaurralde, T. Mader, E. Marshall and E. Liverman, "Chapter 6: Agriculture," in Climate Change Impacts in the United States: The Third National Climate Assessment, J. Melillo, T. Richmond and G. Yohe, Eds., U.S. Global Change Research Program, 2014, pp. 150-174.
[59] Maryland Department of Planning, "2012 Census of Agriculture For Maryland and its Jurisdictions," U.S. Department of Agriculture, National Agricultural Statistics Service, 2012. [Online]. Available: http://planning.maryland.gov/msdc/S6_Econ_Agri_Census.shtml. [Accessed 12 September 2017].
[60] Maryland State Archives, "Maryland at a Glance: Agriculture," [Online]. Available: http://msa.maryland.gov/msa/mdmanual/01glance/html/agri.html. [Accessed 28 September 2018].
[61] USDA National Agricultural Statistics Service, "Quick Stats," 2017. [Online]. Available: https://quickstats.nass.usda.gov/. [Accessed 28 September 2018].
[62] S. Matthews, L. Iverson, M. Peters and A. Prasad, "Assessing Potential Climate Change Pressures across the Conterminous United States: Mapping Plant Hardiness Zones, Heat Zones, Growing Degree Days, and Cumulative Drought Severity throughout this Century," USDA Forest Service, 2018.

Economy demonstrates that in 2015 the forest industry contributed $3.5 billion annually to Maryland's economy, and $133 million in state and local tax revenue, making it one of the largest contributors. This analysis also found that the forestry industry supports over 15,000 jobs.

As noted in the ecosystem section, changes in average temperature and precipitation have the potential to shift, shrink, or expand the ranges for various species, including trees such as the loblolly pine, oak, and hickory, which are most prevalent in Maryland[63]. On the Eastern Shore, where forestry is the second largest employer[64], sea level rise, storm surge, and salt-water intrusion were discussed as local concerns. The positive contribution to global forestry production from lengthened growing seasons and increased CO_2 concentrations is unclear; though similar to agriculture, it is expected that negative climate impacts such as wildfires, insects and pathogens, heat and water stress, and extreme weather events may eclipse these benefits[63,64]. In Maryland, the Department of Natural Resources (DNR) has already noted that pests such as the gypsy moth, Southern pine bark beetle, loblolly pine sawfly, spotted lanternfly, and fall cankerworm have begun to threaten forests in recent decades[65]. Not only may a changing climate impact the prevalence of these pests, but it may also stress trees or otherwise affect defense mechanisms, making them more susceptible to damage[64]. In addition, forest management will be an important component of mitigation, since forests play a major role as carbon sinks, already having absorbed about 17 percent of anthropogenic CO_2 emissions the past several decades[65]. Depending on the chosen strategies, we may either expand or reduce this capacity.

The Chesapeake Bay fisheries are expected to be impacted by a combination of environmental stressors, including those previously discussed for Bay and coastal ecosystems such as basic water quality issues (e.g., changes in temperature, salinity, and dissolved oxygen), as well as habitat loss due to sea level rise and projected impacts on submerged grasses. Many commercially important fisheries species are projected to move northward as waters warm and suitable habitats shift; and as previously noted, this shift could also bring new pests or increase the damages done by diseases such as bacteria that thrive in warmer waters[66]. According to the Maryland Department of Agriculture (MDA), Maryland's seafood industry contributes nearly $600 million to the state economy each year. In 2016, the commercial landings value of Maryland's seafood industry was $90,361,277. Within the state, the blue crab remained the most lucrative species by far, accounting for over $54 million in revenue in 2015, with the oyster coming in second at $15 million[65]. In addition to concerns regarding ocean acidification, oysters may be at an increased risk of suffocation by sediment loads, exposure to low-oxygen dead zones, and damages from the diseases such as Dermo and MSX; all of which have contributed to the historic decline of the oyster population[67] and may be exacerbated directly or indirectly by the changing climate as previously discussed. For blue crabs, a study of current life-cycle variations across their native range (Maryland/Virginia, North Carolina, and Florida) concluded that since the Chesapeake Bay is towards the northern edge, increased temperatures taken independently may provide certain benefits currently experienced by their more southern populations such as a longer reproductive season with additional broods, increased growth rate and maturation, and decreased deaths over winter[68]. However, the peak summer water temperatures of the three regions studied were very similar, despite the marked differences in temperature the remainder of the seasons, and so the current climates of the southern sites cannot necessarily be considered an accurate representation of those temperature differences expected in the Chesapeake as a result of climate change. Furthermore, many other potential impacts are projected to affect blue crabs negatively, including loss of submerged grass habitat and expanded dead zones[68].

[63] W. H. McNab, M. A. Spetich, R. W. Perry, J. D. Haywood, S. G. Laird, S. L. Clark, J. L. Hart, S. J. Torreano and M. L. Buchanan, "Climate-Induced Migration of Native Tree Populations and Consequences for Forest Composition," in Climate change adaptation and mitigation management options: A guide for natural resource managers in southern forest ecosystems, 2014, pp. 307-378.
[64] A. P. Kirilenko and R. A. Sedjo, "Climate change impacts on forestry," Proceedings of the National Academy of Sciences of the United States of America, vol. 104, no. 50, pp. 19697-19702, 2007.
[65] H. D. Jacoby, A. C. Janetos, R. Birdsey, J. Buizer, K. Calvin, F. de la Chesnaye, D. Schimel, I. Sue Wing, R. Detchon, J. Edmonds, L. Russell and J. West, "Chapter 27: Mitigation," in Climate Change Impacts in the United States: The Third National Climate Assessment, J. Melillo, T. Richmond and G. Yohe, Eds., U.S. Global Change Research Program, 2014, pp. 648-669.
[66] Maryland State Archives, "Maryland at a Glance: Economy," [Online]. Available: http://msa.maryland.gov/msa/mdmanual/01glance/economy/html/economy.html.
[67] Chesapeake Bay Program, "Oysters," [Online]. Available: http://www.chesapeakebay.net/issues/oysters. [Accessed 21 September 2017].
[68] A. H. Hines, E. G. Johnson, M. Z. Darnell, D. Rittschof, T. J. Miller, L. J. Bauer and P. Rodgers, "Predicting Effects of Climate Change on Blue Crabs in the Chesapeake Bay," in Biology and Management of Exploited Crab Populations under Climate Change, G. Kruse, G. Eckert, R. Foy, R. Lipcius, B. Sainte-Marie, D. Stram and D. Woodby, Eds., Alaska Sea Grant, University of Alaska Fairbanks, 2010.

Tourism

Businesses involved in the State's tourism sector are also likely to feel the impact of climate change. In 2016, Maryland visitors spent $17.3 billion dollars, more than 60 percent of which was in the industries of transportation, food and beverage, and lodging[69]. Tourism in the State supported 146,012 direct full-time equivalent jobs in that year, bringing in wages of approximately $6 billion; while visitor spending generated over $2.3 billion in state and local taxes[69,70]. The Maryland Office of Tourism Development often touts Maryland as "America in miniature," with the wide array of regional activities[71]. Without action, all of this and the natural beauty of the State could suffer the effects of climate change, depriving Maryland residents and visitors of a wealth of experiences.

- Snow sports such as skiing are at obvious risk from rising temperatures and longer growing seasons, especially for lower-elevation resorts such as those in Maryland[72]. Wisp Mountain Park has a winter employment of 600, ranking it among the top employers in Garrett County[73].
- Maryland's sizable sport fishing industry has an estimated economic impact of nearly 7,000 jobs and $300 million in income across the State; with 352,000 anglers (nearly half of the total) coming from out-of-state in 2015[72]. Similarly to commercial fisheries, key species will face increasing risks brought by higher temperature surface water, changes in precipitation, and other indirect effects.
- Maryland's beaches will be susceptible to more extreme weather events as well as sea level rise, and are difficult to protect from storms and erosion without negatively impacting their aesthetics[72]. Ocean City generated around $60 million in tourism-related taxes each year from 2014-2017 (60 percent during the months of June, July, and August)[74].
- Tourism in cities and urban centers is also expected to be impacted by climate change, experiencing the effects of extreme heat and precipitation events as discussed surrounding the built environment.

Energy

The energy sector tends to be thought of in terms of its potential impact on emissions; however it is also at risk from negative impacts due to the increasing temperatures, decreasing water availability, and increasing storms, flooding, and sea level rise associated with climate change[75]. Particularly in the Northeast, hotter summer temperatures are expected to increase peak electricity demand in this season due to increased use of air conditioning units; with overall increased demand outweighing the decreased need for heating in winter[21]. This makes it more difficult and potentially more expensive for utilities to meet the immediate peak demand, and also increases the risk of system failure precisely when it is most needed[18]. In a scenario where global average temperature increases by 3.5 to 5 degrees Celsius, it is estimated that a 10 percent to 20 percent increase in total U.S. electric generating capacity will be required by 2050[76]. Beyond mitigation, programs for adaptation such as enhanced urban tree canopies can help increase resiliency by providing shade relief to buildings during the summer, which helps alleviate the demand for electric cooling. Additionally, extreme weather events that threaten coastal and urban infrastructure include direct threats to electricity infrastructure (e.g. transmission lines) throughout the state; as well as indirect impacts already mentioned, such as issues with fuel extraction, processing, and delivery[75,77]. The majority of thermoelectric power plants (e.g. nuclear, coal, oil, and natural gas) are

[69] Maryland Office of Tourism, FY17 Tourism Development Board Annual Report, Maryland Tourism Development Board and Maryland Department of Commerce, 2018.
[70] Maryland Office of Tourism, Tourism Works for Maryland, 2018.
[71] Maryland Office of Tourism Development, "Visit Maryland," 2017. [Online]. Available: http://www.visitmaryland.org/. [Accessed 28 September 2018].
[72] M. Nicholls, "Climate Change: Implications for Tourism," University of Cambridge, 2014.
[73] Maryland Department of Commerce, "Brief Economic Facts: Garrett County, Maryland," 2018.
[74] Maryland Department of Tourism, "Ocean City Maryland Tourism Metrics Report," [Online]. Available: http://ococean.com/media/metrics-reports. [Accessed 28 September 2018].
[75] C. Zamunda, B. Mignone, D. Bilello, K. Hallett, C. Lee, J. Macknick, R. Newmark and D. Steinberg, "U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather," U.S. Department of Energy, 2013.
[76] U.S. Environmental Protection Agency, "Climate Impacts on Energy," [Online]. Available: https://www.epa.gov/climate-impacts/climate-impacts-energy. [Accessed 20 October 2016].
[77] J. Dell, S. Tierney, G. Franco, R. G. Newell, R. Richels, J. Weyant and T. J. Wilbanks, "Chapter 4: Energy Supply and Use," in Climate Change Impacts in the United States: The Third National Climate Assessment, J. Melillo, T. Richmond and G. Yohe, Eds., U.S. Global Change Research Program, 2014, pp. 113-129.

specifically located near bodies of water (since they require constant cooling), which are expected to become more susceptible to flooding. Furthermore, as atmospheric temperatures increase, the temperature of surface water also increases and the water being used for this purpose becomes a less effective coolant, reducing the efficiency of thermoelectric generation[75]. Warmer water would also be discharged back into the Bay, with potentially negative impacts on the ecosystem.

1.2.3 Public Health

In 2009, under section 202(a) of the Clean Air Act, the EPA Administrator issued an endangerment finding that stated that "based on careful consideration of the full weight of scientific evidence and a thorough review of numerous public comments" the cumulative impacts of GHGs endanger the public's health and welfare[78]. Climate change is expected to alter the severity, frequency, and distribution of health problems, which are affected either directly or indirectly by temperature and precipitation[21,79]. Impacts may be related to changes in the natural or built environment, including effects on our food and water supply, air quality, and extreme weather events[21]; and several examples of expected consequences will be discussed in the following section.

Extreme Heat and Air Quality

Extreme heat events have been increasing in frequency over the past several decades at the national level[20], and between 2050 and 2100 the incidence is expected to more than triple under a business-as-usual scenario[21]. These events are directly associated with a greater risk of illness or death due to conditions such as heat stroke, cardiovascular disease, and respiratory disease[20,21], even if only small differences in average seasonal temperature occur. The *Maryland Climate and Health Report* released in 2016 found that, between 2000 and 2012, extreme summer heat events (95th percentile for the baseline day) increased the risk of hospitalization for heart attack by 11 percent statewide and by up to 43 percent in some areas; and increased the risk of hospitalization due to asthma by 22 percent[80].

Air quality is also projected to decline under a business-as- usual scenario, especially in the Eastern U.S.[21], which increases the risk of cardiovascular and respiratory issues. Higher atmospheric temperatures increase the rate of chemical reactions, such as the formation of ground-level ozone, when the pollutants that participate in these reactions (nitrogen oxide and volatile organic compounds) are present in sufficient quantities. All else equal, increased temperatures will make it more difficult for cities in particular to achieve or maintain compliance with ozone standards, and the risk of health impacts associated with non-attainment, including reduced lung function, asthma attacks, and premature death, will increase[21]. Mitigation (2 degree Celsius scenario) is projected to avoid 13,000 premature deaths in 2050 and 57,000 in 2100 nationwide due to impacts from ozone and particulates , with an estimated economic benefit of $160 billion and $930 billion respectively[21]. Additionally, climate change and even increased CO_2 concentrations alone may impact seasonal plant-based allergies through several pathways: altering the distribution of plants, lengthening the growing season, and altering the dispersion or allergenicity of the pollen[81,82]. The season for ragweed pollen, for example, has already begun to lengthen in a large percentage of locations where the trend has been studied, and is expected to continue exhibiting higher pollen counts due to earlier springs, increasing temperatures, later fall frosts, and increased carbon dioxide (CO_2) concentrations[20]. Another recent study predicted increased emergency room visits in the Northeast due to allergic asthma caused by oak pollen under several future climate scenarios that worsened with the severity of change[82]. Increased pollen

[78] U.S. Environmental Protection Agency, "Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act," Federal Register, vol. 74, no. 239, 2009.

[79] U.S. Global Change Research Program, The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment, A. Crimmins, J. Balbus, J. Gamble, C. Beard, J. Bell, D. Dodgen, R. Eisen, N. Fann, M. Hawkins, S. Herring, L. Jantarasami, D. Mills, S. Saha, M. Sarofim, J. Trtanj and L. Ziska, Eds., 2016.

[80] Maryland Institute for Applied Environmental Health and University of Maryland School for Public Health College Park, "Maryland Climate and Health Profile Report," 2016.

[81] U.S. Environmental Protection Agency, EPA's Endangerment Finding: Health Effects, 2017.

[82] S. Anenberg, K. Weinberger, H. Roman, J. Neumann, A. Crimmins, N. Fann, J. Martinich and P. Kinney, "Impacts of oak pollen on allergic asthma in the United States and potential influence of future climate change," GeoHealth, vol. 1, pp. 80-92, 2017.

exposure in general is expected to increased incidence of asthma in sensitive groups, especially when compounded by other air-quality issues[14,16].

Water Quality, Extreme Precipitation, and Infectious Disease

As previously stated, changes to precipitation in the Chesapeake Bay region are expected to increase the pollutant load to the Bay, a trend that is generally true for other water bodies in the State as well. Combined with increasing atmospheric temperatures, these changes are expected to negatively impact water quality parameters and potentially change the viable uses of surface water, such as recreation or human consumption[21]. Warmer winters and springs are associated with increased occurrence of *Vibrio* bacteria, including *V. cholerae*, which causes cholera, and *V. vulnificus*, which can cause similar symptoms or infect open wounds. Over the past century, the likelihood of encountering these bacteria in the Bay has already increased as conditions become more favorable to them[42]. Overall, increased temperatures and nutrient loads are expected to expand suitable habitats for toxic freshwater and marine algae, to which people may be exposed through consuming contaminated seafood or drinking water, or via direct contact in recreational waters[79]. Another potential concern from seafood is accumulated heavy metals, especially methylmercury, which is taken up at greater rates in warmer waters[79].

Extreme precipitation poses a threat to drinking water supplies, and may be one of the largest climate threats to water quality, having preceded 68 percent of waterborne disease outbreaks between 1948 and 1994[79]. Such events may overburden stormwater and drainage systems, which can cause discharge of untreated sewage into waterways, exposing individuals to human pathogens such as those that cause diarrhea. Private wells can also be contaminated by extreme precipitation events, such as by livestock manure carrying the bacteria *E. coli*[79]. In other cases, flooding events may cause direct injury to those caught in its path, or damage to infrastructure, which leads to increased growth of mold or bacteria that can aggravate allergies and asthma[20]. Adaptation or upgrades to stormwater management systems to accommodate for increased peak flow and nutrient removal, or otherwise decrease direct human contributions (such as impervious land-cover), may help alleviate some of these impacts.

As with other plants and animals, climate influences the habitat, population, and active season of ticks, which spread Lyme disease and mosquitoes that spread West Nile virus and other pathogens[79]. According to one recent review, the Gulf Coast Tick, which had a historic range suitable to its name, has expanded its geographic distribution northwards, including into the piedmont and coastal areas of Maryland[83]. The specific influence of climate change on disease incidence is, however, difficult to predict owing to the large number of other factors, which also influence the spread of these diseases[79]. For example, it has been determined that the recent increase in Lyme disease cases in the Northeast is driven by multiple factors[20], though geographic location and seasonal climate variability are very likely to be significant factors in determining when and where exposure is most likely[79]. Adaptation of the human population to this increased risk is again likely to have a strong influence on the eventual outcome of infection rates[79], including factors such as access to air conditioning or vector control measures such as spraying.

Food Security

Climate change is expected to increase the exposure of food and consumers to pathogens, toxins, and chemical contaminants, and to increase the risk of disruptions to distribution systems[79] (Figure 1.2-1). Changes to precipitation patterns in the mid-Atlantic region are likely to increase overland flow and therefore the chemicals and other contaminants discharged into bodies of water, including sources used for irrigation or fisheries[79]. Flooding caused by extreme precipitation further increases the likelihood that fields or fisheries are contaminated by pathogens, such as those released by overwhelmed sewer systems or carried from livestock manure, as noted in the section on water quality. Climate change may alter the range of bacterial and fungal pathogens, which normally

[83] D. Sonenshine, "Range expansion of tick disease vectors in North America: Implications for spread of tick-borne disease.," International Journal of Environmental Research and Public Health, vol. 15, no. 478, 2018.

affect crops, and higher temperatures may improve growing conditions, increasing their concentrations where they exist during various stages of food production and storage[79].

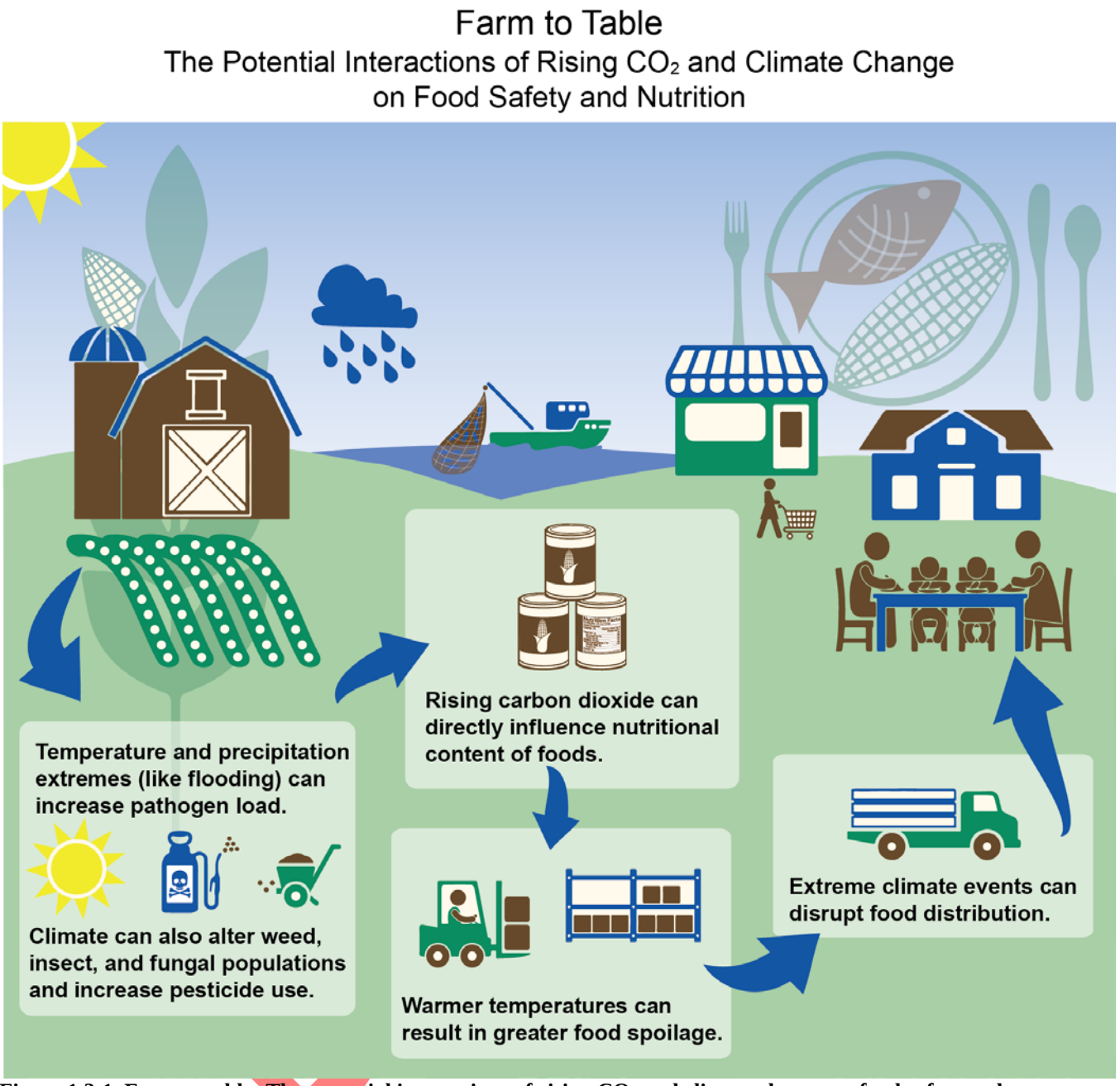


Figure 1.2-1. Farm to table: The potential interactions of rising CO_2 and climate change on food safety and nutrition.

Changes to the climate can increase the risk of damage from pests and competitors; and in an effort to deal with these threats many farmers are likely to increase pesticide use, thereby increasing the level of exposure to consumers[79]. Increased CO_2 levels may even decrease the nutritional content of crops, and has been shown to alter the ratio of macronutrients (decreasing protein concentrations) as well reduce the concentrations of micronutrients (e.g., iron, magnesium and zinc) per calorie[79]. Climate change also threatens the overall yields from agriculture, and decreased yield in other states or countries can still have a significant impact in Maryland. As mentioned in the introduction to this chapter, the State's economy and the other systems on which we rely are not isolated within Maryland. According to an analysis done by the Johns Hopkins Center for a Livable Future, the amount of vegetables produced in Maryland accounts for little more than 10 percent of consumption; dairy production is

estimated to fill almost 30 percent; and fruit approximately 20 percent[84]. Key agricultural import sources for the U.S. include Mexico and Canada (almost 40 percent by dollar value in 2016 combined), followed by the European Union (another 18 percent), China, Brazil, Australia, Chile and Indonesia, among others[85]. These imports are, for the most part, processed goods such as coffee, wine, and cocoa (the top three by dollar value in 2016), however staples such as beef, grains, fruits, vegetables, and dairy products also make the top 25.

1.3 The *2019 GGRA Draft Plan*

The Maryland Department of the Environment (MDE), in coordination with other agencies and stakeholders, has proposed a draft GGRA plan to achieve Maryland's goal of reducing GHG emissions by 40 percent by 2030 while benefiting the State's economy and creating jobs, entitled the *2019 GGRA Draft Plan*. The *2019 GGRA Draft Plan* sets forth a comprehensive set of measures to reduce and sequester GHGs, including investments in energy efficiency and clean and renewable energy solutions, widespread adoption of electric vehicles (EVs), and improved management of forests and farms to sequester more carbon in trees and soils. The *2019 GGRA Draft Plan* will set Maryland on a path to achieve an ambitious goal, and set an example for how the nation can respond to the threat of climate change while growing the economy and creating jobs.

Before finalizing the GGRA Plan, Maryland will be undertaking a significant stakeholder process to ensure that opportunities exist to publicly comment on the *2019 GGRA Draft Plan*. The release of the *2019 GGRA Draft Plan* is the first step in this process. Maryland invites comment on this draft plan, the measures that are being counted on to reduce emissions, the programs to adapt, the analyses completed to show the emission and economic benefits, and other aspects included within. Maryland will consider these comments in the development of the final GGRA Plan.

1.4 The Greenhouse Gas Emissions Reduction Act – Reauthorization of 2016

On April 4, 2016 the GGRA of 2016 was signed into law by Maryland Governor Larry Hogan. Expanding on the requirements of the original law, the GGRA of 2016 requires the State to achieve a minimum of a 40 percent reduction in statewide GHG emissions from 2006 levels by 2030. To achieve this goal, the GGRA of 2016 requires MDE to develop a proposed statewide GHG reduction plan, entitled the *2019 GGRA Draft Plan*. The GGRA of 2016 also requires MDE to solicit public comment on the proposed draft plan from interested stakeholders and the public, and to adopt a final plan by Dec. 31, 2019. The State is also required to demonstrate that the new reduction goal can be achieved in a way that has a net positive impact on Maryland's economy, protects existing manufacturing jobs and creates significant new "green" jobs in Maryland.

The requirements and content of the GGRA of 2016 are summarized below:

Table 1.4-1. GGRA of 2016 Requirements.

Maryland shall reduce statewide GHG emissions by 40 percent from 2006 levels by 2030.
MDE must: ● Submit a proposed draft plan that reduces statewide GHG emissions by 40 percent from 2006 levels by 2030; ● Make the proposed draft plan for public comment; and ● Convene a series of public workshops to provide interested parties with an opportunity to comment on the proposed draft plan.
By 2019, Maryland must adopt a final plan that reduces statewide GHG emissions by 40

[84] Johns Hopkins Center for a Livable Future, Maryland Grown: How What We Grow Compares with What We Eat, Baltimore, 2015.
[85] U.S. Department of Agriculture, "USDA Economic Research Service: Data Products," [Online]. Available: https://www.ers.usda.gov/data-products/. [Accessed 14 September 2017].

percent from 2006 levels by 2030. The plan must: • Include adopted regulations that implement all plan measures for which State agencies have existing statutory authority; • Include a summary of any new legislative authority needed to fully implement the plans, and a timeline for seeking legislative authority; • Ensure no net loss of existing manufacturing jobs; and • Ensure a net increase in jobs and 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.
In 2022, an independent study of the economic impact of requiring GHG emissions reductions from the State's manufacturing sector is due to the Governor and General Assembly, which will be overseen by the MCCC.
In 2022, a report is due to the Governor and General Assembly assessing the progress toward the 40 percent emissions reduction and the GHG emissions reductions needed by 2050 in order to avoid anthropogenic changes to the Earth's climate system. This report also summarizes impacts on the economy.
By 2023, the General Assembly 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 40 percent reduction by 2030.

MDE was previously required by the GGRA of 2009 to submit an updated report, the *2015 GGRA Plan Update*, to the Governor and General Assembly by October 1, 2015. The *2015 GGRA Plan Update* provided updated information contained within the *2012 GGRA Plan*, summarized the State's progress toward achieving the 2020 emissions reduction goal, and satisfied the remaining requirements of the GGRA of 2009.

1.5 The *2019 GGRA Draft Plan* Requirements

In developing and implementing the *2019 GGRA Draft Plan* MDE must:

- Develop the plans in recognition of the finding by the IPCC that developed countries will need to reduce GHG emissions by between 80 percent and 95 percent from 1990 levels by 2050;
- Analyze the feasibility of measures to comply with the GHG reductions required by the GGRA of 2016;
- Consider the impact on rural communities of any transportation related measures proposed in the plans;
- Provide that a GHG emissions source that voluntarily reduces its GHG emissions before the implementation of the GGRA of 2016 shall receive appropriate credit for its early voluntary actions;
- Provide for the use of offset credits generated by alternative compliance mechanisms executed within the State, including carbon sequestration projects, to achieve compliance with GHG emissions reduction required by the GGRA of 2016;
- Ensure that the plans do not decrease the likelihood of reliable and affordable electrical service and statewide fuel supplies;
- Consider whether the measures would result in an increase in electricity costs to consumers in the State;
- Consider the impact of the plans on the ability of the State to attract, expand, and retain commercial aviation services and conserve, protect, and retain agriculture; and
- Ensure that the GHG emissions reduction measures implemented in accordance with the plans:
  - Are implemented in an efficient and cost-effective manner;
  - Do not disproportionately impact rural and low-income, low-to-moderate-income, or minority communities or any other particular class of electricity ratepayers;
  - Minimize leakage;
  - Are quantifiable, verifiable, and enforceable;

- Directly cause no loss of existing jobs in the manufacturing sector;
- Produce a net economic benefit to the State's economy and a net increase in jobs in the State; and
- Encourage new employment opportunities in the State related to energy conservation, alternative energy supply, and GHG reduction technologies.

The *2019 GGRA Draft Plan* is a comprehensive, multi-sector, multi-agency plan developed with assistance and input from more than a dozen state agencies and nongovernmental organizations. Building from the programs developed in the previous GGRA plans, the programs outlined in the *2019 GGRA Draft Plan* provide a blueprint, which if fully implemented, **will achieve reductions greater than the 40 percent GHG reduction required by the GGRA of 2016, with significant positive job growth and economic benefit.** As this is a draft report, 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 *2019 GGRA Draft Plan* can still be modified and improved, and adjustments to the entire plan can still be made, if needed.

Chapter 2

Base Year Emissions and Future Year "Business-As-Usual" Inventory Projections

2.1 Overview

This chapter describes the procedures the Maryland Department of the Environment (MDE) used to project the greenhouse gas (GHG) emissions that would occur in Maryland in the year 2030, under a business-as-usual (BAU) scenario, where no new measures or policies to reduce GHG emissions are implemented. The analysis is provided to assess the amount of reductions necessary to achieve the Greenhouse Gas Emissions Reduction Act (GGRA) – Reauthorization (GGRA of 2016) goal of a 40 percent reduction in GHG emissions by 2030 from a 2006 baseline. Note that this BAU inventory is separate from a 2017 GHG emissions inventory (see Chapter 3) that was mandated by the GGRA of 2009. The 2017 inventory serves a separate purpose, which is to track the State's progress with respect to reducing GHG emissions.

The 2030 BAU GHG emissions projection uses the Maryland 2014 Periodic GHG emissions Inventory as the reference Base Year. Surrogate growth factors were developed and applied to the 2014 Base Year to project the GHG emissions from 2014 to 2030. The Base Year 2014 Inventory documentation[86] divided the State's GHG emission sources into the following eight source sectors:

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

The emission projection estimates outlined in this chapter have been calculated on a State-wide basis and have not been spatially allocated to the county level unless otherwise stated. Emission projections and other information pertaining to each source sector are presented in the following sections.

[86] http://mde.maryland.gov/programs/Air/ClimateChange/Pages/GreenhouseGasInventory.aspx

2.2 Business-As-Usual 2030 Emissions

Maryland's anthropogenic 2030 BAU GHG emissions and anthropogenic sinks (carbon storage) were estimated by projecting Maryland's GHG emissions from a 2014 Base Year using derived growth factors, specific to each of the different sectors. Sector specific growth factors were derived from future growth estimates of activities that are tracked by various regulatory agencies and oversight bodies, including:

- Maryland Department of Planning; "Population and Household Population Projections[87]"
- Maryland Department of Transportation; "On-Road Inventory Development Process[88]"
- Maryland Department of Labor, Licensing and Regulation; "Maryland Industrial Projection Workforce Information and Performance (2014-2024)[89]"
- Pennsylvania Jersey Maryland Interconnection, LLC (PJM) Load Forecast Report[90]
- United States Environmental Protection Agency (EPA) State Inventory Tool (SIT) Projection Tools[91]

Table 2.2-1 shows the surrogate growth factor used for each source sector and where the surrogate growth data was obtained.

Table 2.2-1. GHG Source Categories – Growth Factor Surrogate and Source.

Source Category	Surrogate Growth Factor	Source of Surrogate Data	URL
Electricity Supply	Electricity Consumption	PJM Load Forecast	http://pjm.com/~/media/library/reports-notices/load-forecast/2016-load-report.ashx
Residential Fuel Consumption	Housing Data	Maryland Department of Planning	https://planning.maryland.gov/MSDC/Pages/s3_projection.aspx
Commercial and Industrial Fuel Consumption	Employment Data	Maryland Department of Labor, Licensing & Regulation	http://www.dllr.state.md.us/lmi/iandoproj/industry.shtml
On-Road Transportation	Vehicle Miles Traveled	Maryland Department of Transportation	https://planning.maryland.gov/MSDC/Pages/s3_projection.aspx
Off-Road Transportation	Non-Road MOVES Model Projection Data	Non-Road MOVES Model	https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves
Fossil Fuel Industry	SIT Tool Projections	EPA SIT Projection Tool	https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool
Industrial	SIT Tool Projections	EPA SIT Projection Tool	https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool
Agriculture	SIT Tool Projections	EPA SIT Projection Tool	https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool
Waste	County	Maryland	https://planning.maryland.gov/MSDC/Pages/s3_projection.aspx

[87] https://planning.maryland.gov/MSDC/Pages/s3_projection.aspx
[88] http://mde.maryland.gov/programs/Air/ClimateChange/MCCC/STWG/OnRoadInventoryMDOT.pdf
[89] http://www.dllr.state.md.us/lmi/iandoproj/industry.shtml
[90] http://pjm.com/~/media/library/reports-notices/load-forecast/2016-load-report.ashx
[91] https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool

Management	Population	Department of Planning	

Emissions projections indicate only what the future emissions would be if the assumptions that underpin the projections continue to occur. Some assumptions, such as future gross domestic product, population and economic growth, used in the exercise to estimate emissions are difficult to predict. Projections, however, are generally conservative, as our experience with criteria pollutants has been that long-term actual emission growth is less than projected growth due to the development and implementation of new programs and pollution standards designed to further protect public health and the environment and changes in market forces that affect the economy and energy use.

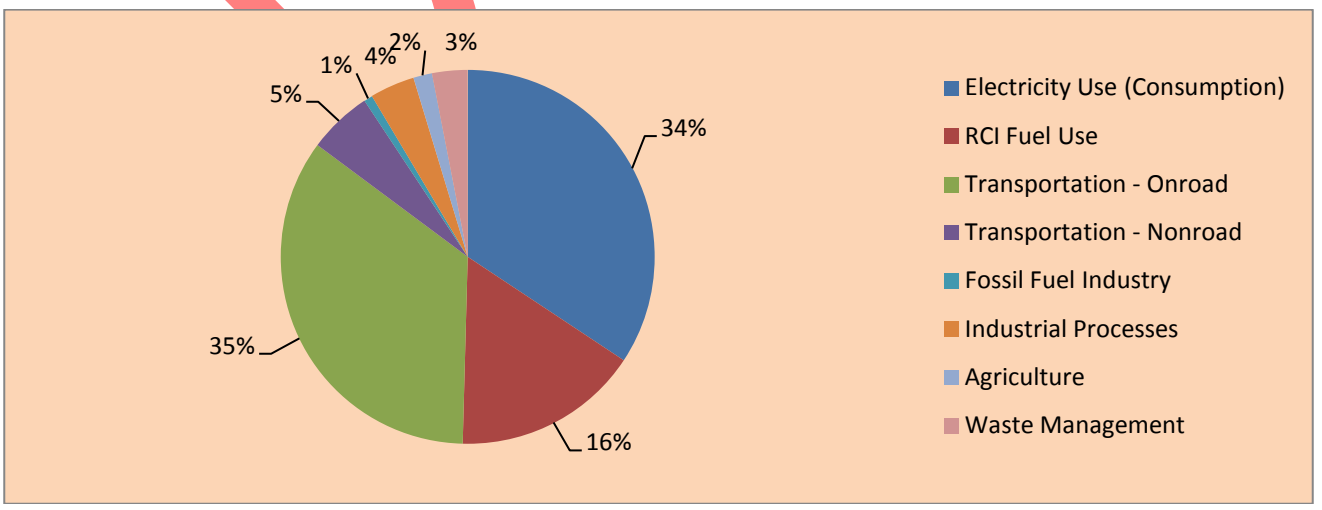
2.3 Projection Results

The projected 2030 GHG BAU emissions in Maryland were based on the Maryland statewide GHG emissions inventory for the base Year 2014 with respect to existing policy and regulations, without any consideration for any new policy or regulation implementation to reduce GHG emissions from the base Year 2014. Year 2030 emissions were estimated to be approximately 106.04 million metric tons (MMT) of *gross*[92] carbon dioxide equivalent (CO_2e) emissions (consumption basis).

Estimates of carbon sinks within Maryland's forests, including urban forests and land use changes, have been kept constant in this projection, as more reliable data capture and estimation tools are still being evaluated. As these tools gain acceptance, they will be incorporated into future inventories. The current estimates of 11.65 $MMTCO_2e$ was retained as the estimated amount of forest biomass and agricultural soils carbon sinks that will be stored in 2030 in Maryland. This leads to *net projected* emissions of 94.40 $MMTCO_2e$ in Maryland in 2030. Table 2.4-1 provides a summary of the projected 2030 GHG emissions for Maryland.

The *net projected* emissions, therefore, for the BAU scenario is 94.40 $MMtCO_2e$ in Maryland in 2030. Table 2.4-1 provides a breakdown by source sector for these net emissions.

A point to note is that three source sectors - electricity consumption; transportation; and residential, commercial, and industrial (RCI) fossil fuel use – account for 90 percent of the GHG emissions in Maryland. Electricity consumption emissions are projected to account for 34 percent of gross GHG emissions in 2030. Transportation is projected to account for 40 percent of Maryland's gross GHG emissions in 2030, while RCI fuel use is projected to account for 16 percent of Maryland's 2030 gross GHG emissions. A graphical representation of the 2030 GHG emissions by all source sectors is presented in Figure 2.3-1.



[92] Excluding GHG emissions removed due to forestry and other land uses.

Figure 2.3-1: Gross Projected GHG Emissions by Sector, 2030, Maryland.

Figure 2.3-1 shows how each sector contributes to the projected 2030 GHG emissions. Below, Figure 2.3-2 shows another representation of how each sector contributes to GHG emissions in $MMtCO_2e$ over time. This graph clearly shows how the energy sector is becoming a smaller contributor to Maryland's emissions while the contribution from transportation is growing.

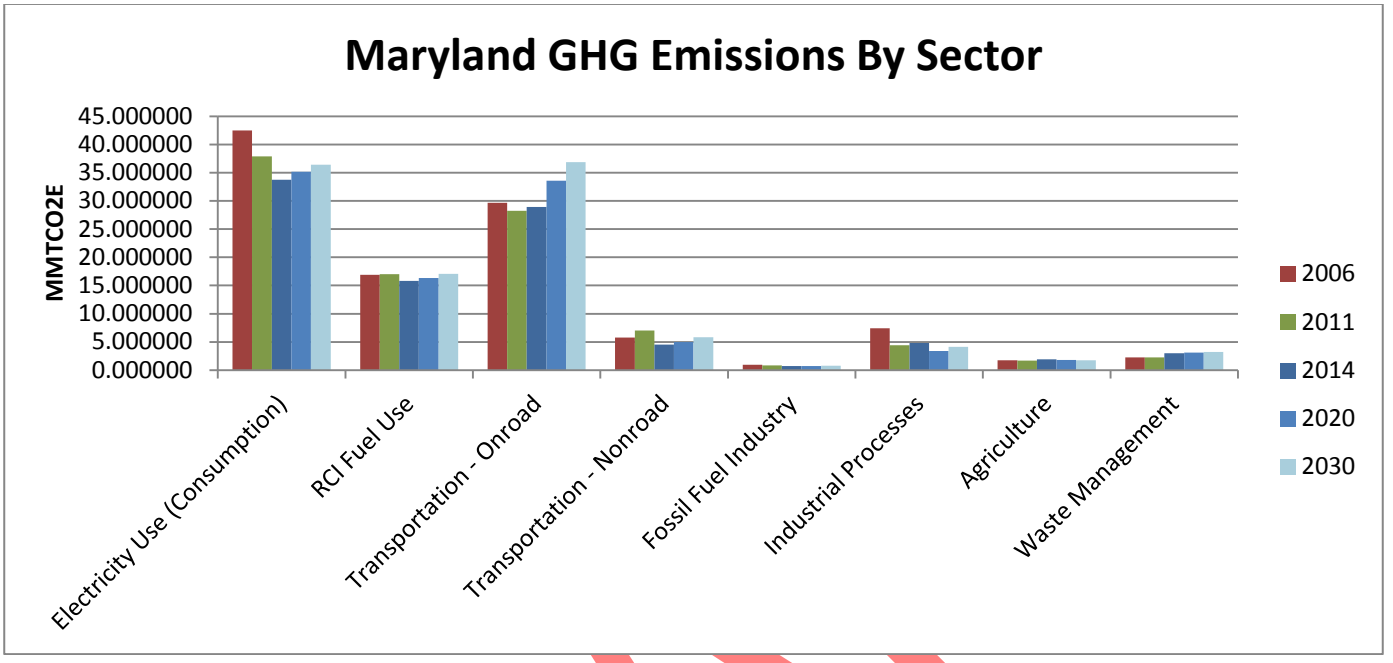


Figure 2.3-2: Maryland GHG Projected Emissions by Sector.

Maryland's projected emissions in 2030 (106.04 $MMTCO_2E$) will represent a slight decline in GHG emission from the 2006 Base Year.

2.4 Emissions Summary

Table 2.4-1 provides a very detailed, category-by-category, summary of GHG emissions for 2006, 2014, and 2030. 2006 is the base year under the GGRA. 2014 is the second occurrence of the "every-three-year" GHG inventory required under the GGRA. 2030 is the year under the GGRE where the 40 percent reduction must be achieved. This table is both informative and a key tool for identifying new opportunities for emission reductions.

Appendix C contains a more detailed analysis and a general description of methodologies used in the emissions calculations of base year and future year "business-as-usual" inventory projections.

Table 2.4-1. Maryland 2030 BAU GHG Emissions Projection, by Sector.

Source Category	Fuel Type	Year		
		2006 ($MMtCO_2e$)	2014 ($MMtCO_2e$)	2030 ($MMtCO_2e$)
Energy Use (CO_2, CH_4, N_2O)		95.75995003	**83.737002**	**96.97318**
Electricity Use (Consumption)[b]		42.**47567455**	**33.760155**	**36.402415**
	Electricity Production (in-state)	**32.16484764**	**19.911764**	**21.4704556**
	Coal	28.27769105	18.395077	19.8347717
	CO_2	28.13057387	18.270289	19.7001826
	CH_4	0.006356915	0.029584	0.03190727
	N_2O	0.140760271	0.095204	0.10268183
	Natural Gas	3.649880813	1.116462	1.20414343
	CO_2	3.64841301	1.083775	1.16888964

Source Category	Fuel Type	Year		
		2006 ($MMtCO_2e$)	2014 ($MMtCO_2e$)	2030 ($MMtCO_2e$)
	CH_4	0.000592766	0.002444	0.00263548
	N_2O	0.000875036	0.030243	0.03261831
	Oil	0.237275776	0.400225	0.43154052
	CO_2	0.236572609	0.399099	0.43032561
	CH_4	0.00017791	0.000309	0.00033312
	N_2O	0.000525257	0.000818	0.0008818
	Wood	0	0.000000	0
	CO_2	0	0.000000	0
	CH_4	0	0.000000	0
	N_2O	0	0.000000	0
	MSW/LFG			
	Net Imported Electricity	10.31082691	**13.848392**	**14.9319594**
Residential/Commercial/Industrial (RCI) Fuel Use		16.87079695	**15.803958**	**17.06540**
	Coal	2.997788692	1.507120	1.71561
	CO_2	2.976126985	1.496749	1.70360
	CH_4	0.007134829	0.003227	0.00374
	N_2O	0.014526878	0.007144	0.00827
	Natural Gas & LPG	9.21041471	**10.710212**	11.46348
	CO_2	9.18802397	10.682922	11.43444
	CH_4	0.016000535	0.019803	0.02109
	N_2O	0.006390205	0.007487	0.00796
	Petroleum	4.576524718	**3.472479**	**3.76789**
	CO_2	4.557477225	3.458150	3.75206
	CH_4	0.008508848	0.006760	0.00730
	N_2O	0.010538645	0.007569	0.00853
	Wood	0.086068834	**0.113322**	**0.11842**
	CO_2	0	0.000000	0.00000
	CH_4	0.061142772	0.087520	0.090688
	N_2O	0.024926062	0.025801	0.02774
Transportation		35.47159388	**33.452999**	**42.7032357**
	Onroad Gasoline	23.7595	22.555441	28.7261932
	CO_2	23.195	22.472039	28.6199748
	CH_4	0.0462	0.006896	0.00878288
	N_2O	0.5183	0.076505	0.09743548
	Nonroad Gasoline	1.044117546	**1.106684**	**1.36134321**
	CO_2	1.039550516	1.083478	1.32505867
	CH_4	0.000920455	0.023206	0.02305543
	N_2O	0.003646576	0.000000	0.00000000
	Onroad Diesel	5.9103	**6.381042**	**8.1267778**
	CO_2	5.907	6.360214	8.10025167
	CH_4	0.0003	0.000096	0.00012165
	N_2O	0.003	0.020732	0.02640448
	Nonroad Diesel	1.503926174	**1.994101**	**2.66266107**
	CO_2	1.488082933	1.993972	2.66252129
	CH_4	0.004221409	0.000130	0.00013978
	N_2O	0.011621832	0.000000	0.00000000
	Rail	0.238839589	**0.187038**	**0.18703846**
	CO_2	0.236600579	0.185304	0.18530411
	CH_4	0.000391175	0.000303	0.00030301
	N_2O	0.001847835	0.001431	0.00143134

Source Category	Fuel Type	Year		
		2006 ($MMtCO_2e$)	2014 ($MMtCO_2e$)	2030 ($MMtCO_2e$)
	Marine Vessels (Gas & Oil)	0.997636149	**0.124965**	**0.1780107**
	CO_2	0.988598138	0.123832	0.17639727
	CH_4	0.00147329	0.000188	0.00026787
	N_2O	0.00756472	0.000945	0.00134556
	Lubricants, Natural Gas, and LPG	0.295955146	**0.279941**	**0.37061003**
	CO_2	0.295955146	0.275343	0.36452274
	CH_4	0	0.00459805	0.00761276
	N_2O	0	0	0.00000000
	Jet Fuel and Aviation Gasoline	1.721319275	**0.823787**	**1.09060121**
	CO_2	1.703343607	0.815404	1.07950256
	CH_4	0.001626024	0.000668	0.00088412
	N_2O	0.016349643	0.007716	0.01021453
Fossil Fuel Industry		0.941884638	**0.719889**	**0.8021223**
	Natural Gas Industry	0.811536367	0.584861	0.65558129
	CO_2	0.000128636	0.000353	0.00039475
	CH_4	0.811336294	0.584313	0.65496732
	N_2O	7.14367E-05	0.000196	0.00021922
	Oil Industry	0	0.000000	0.00000000
	CO_2	0	0.000000	0.00000000
	CH_4	0	0.000000	0.00000000
	N_2O	0	0.000000	0.00000000
	Coal Mining	0.130348272	0.135028	0.14654101
	CO_2	0	0.000000	0.00000000
	CH_4	0.130348272	0.135028	0.14654101
	N_2O	0	0.000000	0.00000000
Industrial Processes		7.441042334	**4.784851**	**4.10595168**
	Cement Manufacture	1.483241728	1.580721	1.96165908
	CO_2	1.483241728	1.580721	1.96165908
	CH_4	0	0.000000	0.00000000
	N_2O	0	0.000000	0.00000000
	Limestone and Dolomite	0.113941192	0.143916	0.18688424
	CO_2	0.113941192	0.143916	0.18688424
	CH_4	0	0.000000	0.00000000
	N_2O	0	0.000000	0.00000000
	Soda Ash	0.04761102	0.039670	0.03172051
	CO_2	0.04761102	0.039670	0.03172051
	CH_4	0	0.000000	0.000000
	N_2O	0	0.000000	0.00000000
	Iron and Steel	3.597116387	0.000000	0.00000000
	CO_2	3.597116387	0.000000	0.00000000
	CH_4	0	0.000000	0.00000000
	N_2O	0	0.000000	0.00000000
	ODS Substitutes	1.971282442	2.972674	1.9013601
	CO_2	0	0.000000	0.0000000
	CH_4	0	0.000000	0.0000000
	HFC, PFC, SF_6	1.971282442	2.972674	1.9013601

Source Category	Fuel Type	Year		
		2006 ($MMtCO_2e$)	2014 ($MMtCO_2e$)	2030 ($MMtCO_2e$)
	Electricity Transmission and Dist.	0.227222585	0.047322	0.02379465
	CO_2	0	0.000000	0.00000000
	CH_4	0	0.000000	0.00000000
	HFC, PFC, SF_6	0.227222585	0.047322	0.02379465
	Semiconductor Manufacturing	0	0.000000	0.00000000
	CO_2	0	0.000000	0.00000000
	CH_4	0	0.000000	0.00000000
	HFC, PFC, SF_6	0	0.000000	0.00000000
	Ammonia and Urea Production (Nonfertilizer Usage)	0.000626981	0.000548	0.00053311
	CO_2	0.000626981	0.000548	0.00053311
	CH_4	0	0.000000	0.00000000
	HFC, PFC, SF_6	0	0.000000	0.00000000
	Aluminum Production	0	0.000000	0.00000000
	CO_2	0	0.000000	0.00000000
	CH_4	0	0.000000	0.00000000
	HFC, PFC, SF_6	0	0.000000	0.00000000
Agriculture		1.771426158	**1.892149**	**1.71831397**
	Enteric Fermentation	0.41906793	0.337974	0.31980921
	CO_2	0	0.000000	0.00000000
	CH_4	0.41906793	0.337974	0.31980921
	N_2O	0	0.000000	0.00000000
	Manure Management	0.32126318	0.320611	0.33708254
	CO_2	0	0.000000	0.00000000
	CH_4	0.091393836	0.090378	0.09502113
	N_2O	0.229869344	0.230233	0.24206141
	Agricultural Soils	1.019673739	0.993803	0.79393854
	CO_2	0	0.000000	0.00000000
	CH_4	0	0.000000	0.00000000
	N_2O	1.019673739	0.993803	0.79393854
	Agricultural Burning	0.006273052	0.234613	0.26147327
	CO_2	0	0.000000	0.00000000
	CH_4	0.003893109	0.143309	0.15971573
	N_2O	0.002379944	0.091304	0.10175754
	Urea Fertilizer Usage	0.005148257	0.005148	0.00601040
	CO_2	0.005148257	0.005148	0.00601040
	CH_4	0	0.000000	0.00000000
	N_2O	0	0.000000	0.00000000
Waste Management		2.257117951	**3.0069**	**3.24201588**
	Waste Combustion	1.292301717	**1.297629**	1.42275964
	CO_2	1.272171161	1.297587	1.42271392
	CH_4	0	0.000009	0.0000009
	N_2O	0.020130556	0.000033	0.000035933
	Landfills	0.388955279	**1.1079**	**1.2147575**
	CO_2	0.151585044	0.313143	0.343339
	CH_4	0.237370235	0.79480	0.8714185

Source Category	Fuel Type	Year		
		2006 ($MMtCO_2e$)	2014 ($MMtCO_2e$)	2030 ($MMtCO_2e$)
	N_2O	0	0.000000	0.0000000
	Wastewater Management	0.542860955	**0.568317**	0.56831654
	CO_2	0	0.000000	0
	CH_4	0.377311419	0.402767	0.40276700
	N_2O	0.165549536	0.165550	0.16554954
	Residential Open Burning	0.033	**0.033000**	**0.0361822**
	CO_2	0.033	0.033000	0.0361822
	CH_4	0	0.000000	0.0000000
	N_2O	0	0.000000	0.0000000
Gross Emissions (Consumption Basis, Excludes Sinks)		**107.2295365**	**93.4209**	**106.03946**
Emissions Sinks		-11.79034917	-11.650369	-11.6504
	Forested Landscape	-10.44657783	-10.4466	-10.4466
	Urban Forestry and Land Use	-1.331309142	-1.2009	-1.2009
	Agricultural Soils (Cultivation Practices)	-0.051420445	-0.0514	-0.0514
	Forest Fires	0.038958248	0.0485	0.0485
	CH_4	0.032452487	0.0404	0.0404
	N_2O	0.00650576	0.0081	0.0081
Net Emissions (Consumptions Basis) (Including forestry, land use, and agriculture sinks)		95.4391873	**81.7705**	**94.38909**

Maryland
Department of
the Environment

Chapter 3

2017 Greenhouse Gas Emission Inventory

3.1 Overview

The Maryland General Assembly enacted into law the Greenhouse Gas Emissions Reduction Act (GGRA), Senate Bill -SB 278 and House Bill - HB 315 in 2009, which is codified in Maryland Annotated Codes, Title 2, Subtitle 1203. The Act requires the Maryland Department of the Environment (MDE) to publish and update an inventory of statewide greenhouse gas (GHG) emissions for calendar year 2006; requires the State to reduce statewide GHG emissions by 25 percent from 2006 levels by 2020; and requires the State to develop and adopt a specified plan, adopt specified regulations, and implement specified programs to reduce GHG emissions.

Additionally, the Act specifically mandates MDE to prepare and publish an inventory of statewide GHG emissions for calendar year 2017. The mandated inventory was released in August 2019 and is available on the MDE website.

The 2017 emissions inventory is divided into seven major sectors that contribute to GHG emissions in Maryland:

- Electricity use and supply
- Residential, commercial and industrial fossil fuel combustion (RCI)
- Transportation
- Industrial processes
- Fossil fuel industry (fugitive emissions – GHG released from leakage)
- Waste management
- Agriculture

The inventory also includes an estimate of the amount of CO_2 that certain land uses and forest management practices sequester in Maryland. Maryland's anthropogenic GHG emissions and anthropogenic sinks (carbon storage) were estimated using a set of generally accepted principles and guidelines developing GHG emissions, relying to the extent possible on Maryland-specific input data. Specifically, Maryland-based data was used for the agriculture, fossil fuel combustion, industrial processes, natural gas transmission and distribution, transportation, solid waste, and wastewater treatment activities in developing the 2017 inventory.

The inventory covers the six types of gases included in the US Greenhouse Gas Inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these GHGs are presented using a common metric, carbon dioxide equivalent (CO_2e), which indicates the relative contribution of each gas, per unit mass, to global average radiative force on a global warming potential- (GWP-) weighted basis (see Section 1.4.1 in Appendix D).

Table 3.2-1 provides a summary of the 2017 GHG emissions for Maryland. Activities in Maryland accounted for approximately 78.49 million metric tons (MMT) of gross CO_2e emissions (consumption basis) in 2017, an amount equal to about 26.80 percent reduction of the total Maryland gross GHG (107.23 $MMTCO_2e$) emissions in 2006.

Estimates of carbon sinks within Maryland's forests, including urban forests and land use changes, have also been included in this report. The current estimates indicated that about 11.72 $MMTCO_2e$ was stored in Maryland forest biomass and agricultural soils in 2017. This leads to net emissions of 66.77 $MMTTCO_2e$ in Maryland in 2017.

There are three principal sources of GHG emission in Maryland: electricity consumption; transportation; and RCI fossil fuel use. Electricity consumption accounted for approximately 30 percent of gross GHG emissions in 2017. Transportation accounted for about 40 percent of Maryland's gross GHG emissions in 2017, while RCI fuel use accounted for approximately 18 percent of Maryland's 2017 gross GHG emissions.

A graphical representation of the 2017 GHG emissions by source sector is presented in Figure 3.1-1.

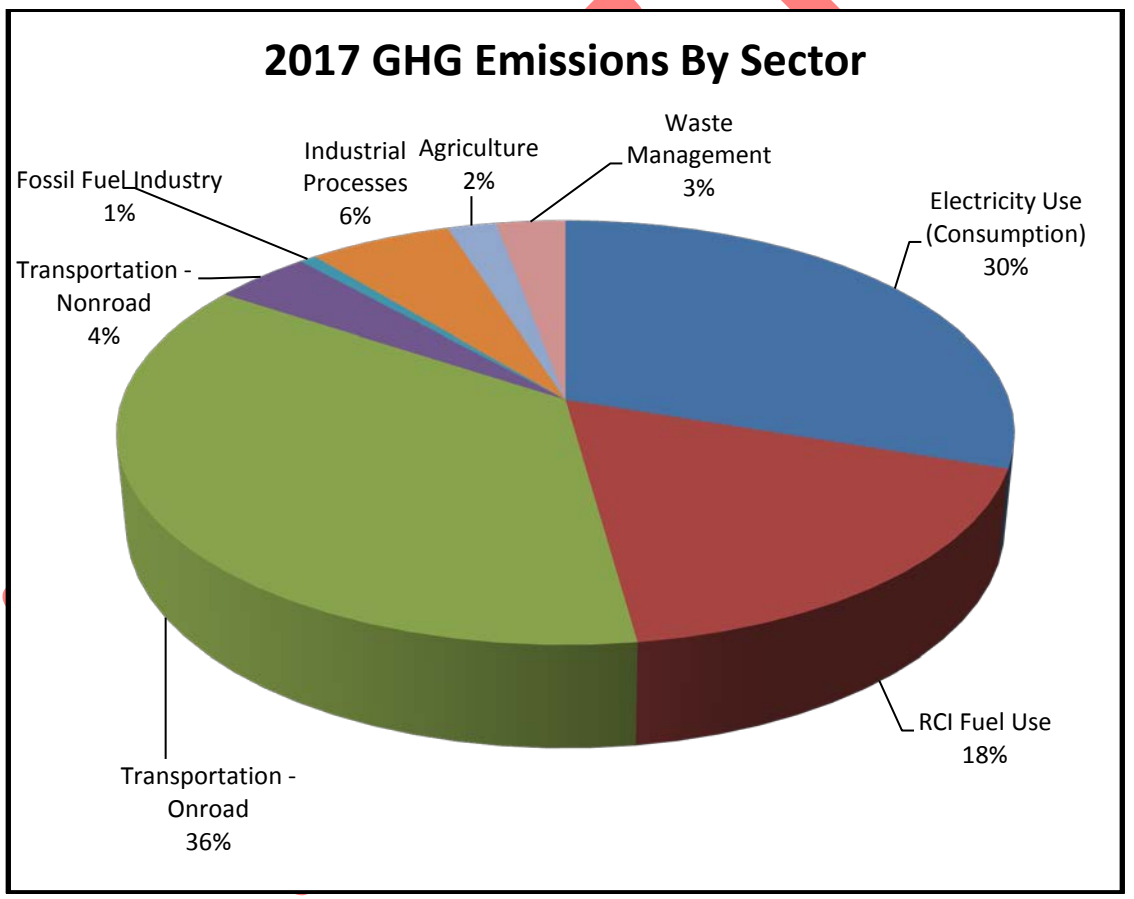


Figure 3.1-1. Gross GHG Emissions by Sector, 2017, Maryland.

A comparison of the 2006 Base Year and 2017 Periodic inventories, as illustrated in Figure 3.2-1 and shown numerically in Table 3.2-1, shows a decline of approximately 27 percent in Maryland's gross GHG emissions in 2017 from the 2006 Base Year.

3.2 Emissions Summary

Table 3.2-1. Maryland Periodic 2017 GHG Emissions by Sector

SOURCE CATEGORY		2006 ($MMtCO_2e$)	2017 ($MMtCO_2e$)
Energy Use (CO_2, CH_4, N_2O)		95.75995003	**69.90456**
Electricity Use (Consumption)		42.47567455	**23.68039**
	Electricity Production (in-state)	32.16484764	**11.6514**
	Coal	28.27769105	8.7510
	CO_2	28.13057387	8.6828
	CH_4	0.006356915	0.0212
	N_2O	0.140760271	0.0470
	Natural Gas	3.649880813	2.7514
	CO_2	3.64841301	2.7470
	CH_4	0.000592766	0.0008
	N_2O	0.000875036	0.0037
	Oil	0.237275776	0.1490
	CO_2	0.236572609	0.1483
	CH_4	0.00017791	0.0004
	N_2O	0.000525257	0.0004
	Wood	0	0.0000
	CO_2	0	0.0000
	CH_4	0	0.0000
	N_2O	0	0.0000
	MSW/LFG		
	Net Imported Electricity	10.31082691	**12.02896**
Residential/Commercial/Industrial (RCI) Fuel Use		16.87079695	**13.87073**
	Coal	2.997788692	1.16917
	CO_2	2.976126985	1.16100
	CH_4	0.007134829	0.00254
	N_2O	0.014526878	0.00563
	Natural Gas & LPG	9.21041471	**9.73527**
	CO_2	9.18802397	9.71068
	CH_4	0.016000535	0.01777
	N_2O	0.006390205	0.00683
	Petroleum	4.576524718	**2.91030**
	CO_2	4.557477225	2.89906
	CH_4	0.008508848	0.00558
	N_2O	0.010538645	0.000565
	Wood	0.086068834	**0.05599**
	CO_2	0	0.000000
	CH_4	0.061142772	0.04061
	N_2O	0.024926062	0.01538
Transportation		35.47159388	**31.80433**
	Onroad Gasoline	23.7595	22.40003
	CO_2	23.195	22.32288
	CH_4	0.0462	0.006379
	N_2O	0.5183	0.070767
	Nonroad Gasoline	1.044117546	**0.959707**
	CO_2	1.039550516	0.942401
	CH_4	0.000920455	0.017306
	N_2O	0.003646576	0.0000
	Onroad Diesel	5.9103	**6.17588**
	CO_2	5.907	6.15662
	CH_4	0.0003	0.00009
	N_2O	0.003	0.01916
	Nonroad Diesel	1.503926174	**0.954964**

SOURCE CATEGORY		2006 ($MMtCO_2e$)	2017 ($MMtCO_2e$)
	CO_2	1.488082933	0.95450
	CH_4	0.004221409	0.000466
	N_2O	0.011621832	0.0000
	Rail	0.238839589	**0.167036**
	CO_2	0.236600579	0.165473
	CH_4	0.000391175	0.000273
	N_2O	0.001847835	0.000129
	Marine Vessels (Gas & Oil)	0.997636149	**0.11507**
	CO_2	0.988598138	0.11444
	CH_4	0.00147329	0.00013
	N_2O	0.00756472	0.00050
	Lubricants, Natural Gas, and LPG	0.295955146	**0.33332**
	CO_2	0.295955146	0.33028
	CH_4	0	0.00304
	N_2O	0	0.0000
	Jet Fuel and Aviation Gasoline	1.721319275	**0.69832**
	CO_2	1.703343607	0.69118
	CH_4	0.001626024	0.00062
	N_2O	0.016349643	0.00652
Fossil Fuel Industry		0.941884638	**0.549117**
	Natural Gas Industry	0.811536367	0.458283
	CO_2	0.000128636	0.000442
	CH_4	0.811336294	0.457596
	N_2O	7.14367E-05	0.000246
	Oil Industry	0	0.0000
	CO_2	0	0.0000
	CH_4	0	0.0000
	N_2O	0	0.0000
	Coal Mining	0.130348272	0.090834
	CO_2	0	0.0000
	CH_4	0.130348272	0.090834
	N_2O	0	0.0000
Industrial Processes		7.441042334	**4.69577**
	Cement Manufacture	1.483241728	1.51184
	CO_2	1.483241728	1.51184
	CH_4	0	0.0000
	N_2O	0	0.0000
	Limestone and Dolomite	0.113941192	0.14589
	CO_2	0.113941192	0.14589
	CH_4	0	0.0000
	N_2O	0	0.0000
	Soda Ash	0.04761102	0.039568
	CO_2	0.04761102	0.039568
	CH_4	0	0.0000
	N_2O	0	0.0000
	Iron and Steel	3.597116387	0.0000
	CO_2	3.597116387	0.0000
	CH_4	0	0.0000
	N_2O	0	0.0000
	ODS Substitutes	1.971282442	2.956638
	CO_2	0	0.0000
	CH_4	0	0.0000
	HFC, PFC, SF_6	1.971282442	2.956638
	Electricity Transmission and Dist.	0.227222585	0.0403671
	CO_2	0	0.0000
	CH_4	0	0.0000
	HFC, PFC, SF_6	0.227222585	0.04037
	Semiconductor Manufacturing	0	0.0000
	CO_2	0	0.0000
	CH_4	0	0.0000
	HFC, PFC, SF_6	0	0.0000

SOURCE CATEGORY		2006 ($MMtCO_2e$)	2017 ($MMtCO_2e$)
	Ammonia and Urea Production (Nonfertilizer Usage)	0.000626981	0.001469
	CO_2	0.000626981	0.001469
	CH_4	0	0.0000
	HFC, PFC, SF_6	0	0.0000
	Aluminum Production	0	0.0000
	CO_2	0	0.0000
	CH_4	0	0.0000
	HFC, PFC, SF_6	0	0.0000
Agriculture		1.771426158	**1.61428**
	Enteric Fermentation	0.41906793	0.38195
	CO_2	0	0.0000
	CH_4	0.41906793	0.38195
	N_2O	0	0.0000
	Manure Management	0.32126318	0.30721
	CO_2	0	0.0000
	CH_4	0.091393836	0.093867
	N_2O	0.229869344	0.213343
	Agricultural Soils	1.019673739	0.908171
	CO_2	0	0.0000
	CH_4	0	0.0000
	N_2O	1.019673739	0.90817
	Agricultural Burning	0.006273052	0.00628
	CO_2	0	0.0000
	CH_4	0.003893109	0.00378
	N_2O	0.002379944	0.0025
	Urea Fertilizer Usage	0.005148257	0.01067
	CO_2	0.005148257	0.01067
	CH_4	0	0.0000
	N_2O	0	0.0000
Waste Management		2.257117951	**2.27859**
	Waste Combustion	1.292301717	**1.187777**
	CO_2	1.272171161	1.187493
	CH_4	0	0.000251
	N_2O	0.020130556	3.28E-05
	Landfills	0.388955279	**0.457213**
	CO_2	0.151585044	0.122958
	CH_4	0.237370235	0.334255
	N_2O	0	0.0000
	Wastewater Management	0.542860955	**0.60060**
	CO_2	0	0.0000
	CH_4	0.377311419	0.407993
	N_2O	0.165549536	0.19261
	Residential Open Burning	0.033	**0.0330**
	CO_2	0.033	0.0330
	CH_4	0	0.0000
	N_2O	0	0.0000
Gross Emissions (Consumption Basis, Excludes Sinks)		107.2295365	**78.49321**
	decrease relative to 2006		26.80 %
Emissions Sinks		-11.79034917	-11.72206
	Forested Landscape	-10.44657783	-10.4466
	Urban Forestry and Land Use	-1.331309142	-1.24056
	Agricultural Soils (Cultivation Practices)	-0.051420445	-0.05142
	Forest Fires	0.038958248	0.016502
	CH_4	0.032452487	0.013746
	N_2O	0.00650576	0.002756
Net Emissions (Consumptions Basis) (Including forestry, land use, and agriculture sinks)		95.4391873	**66.77115**
	decrease relative to 2006		30.04 %

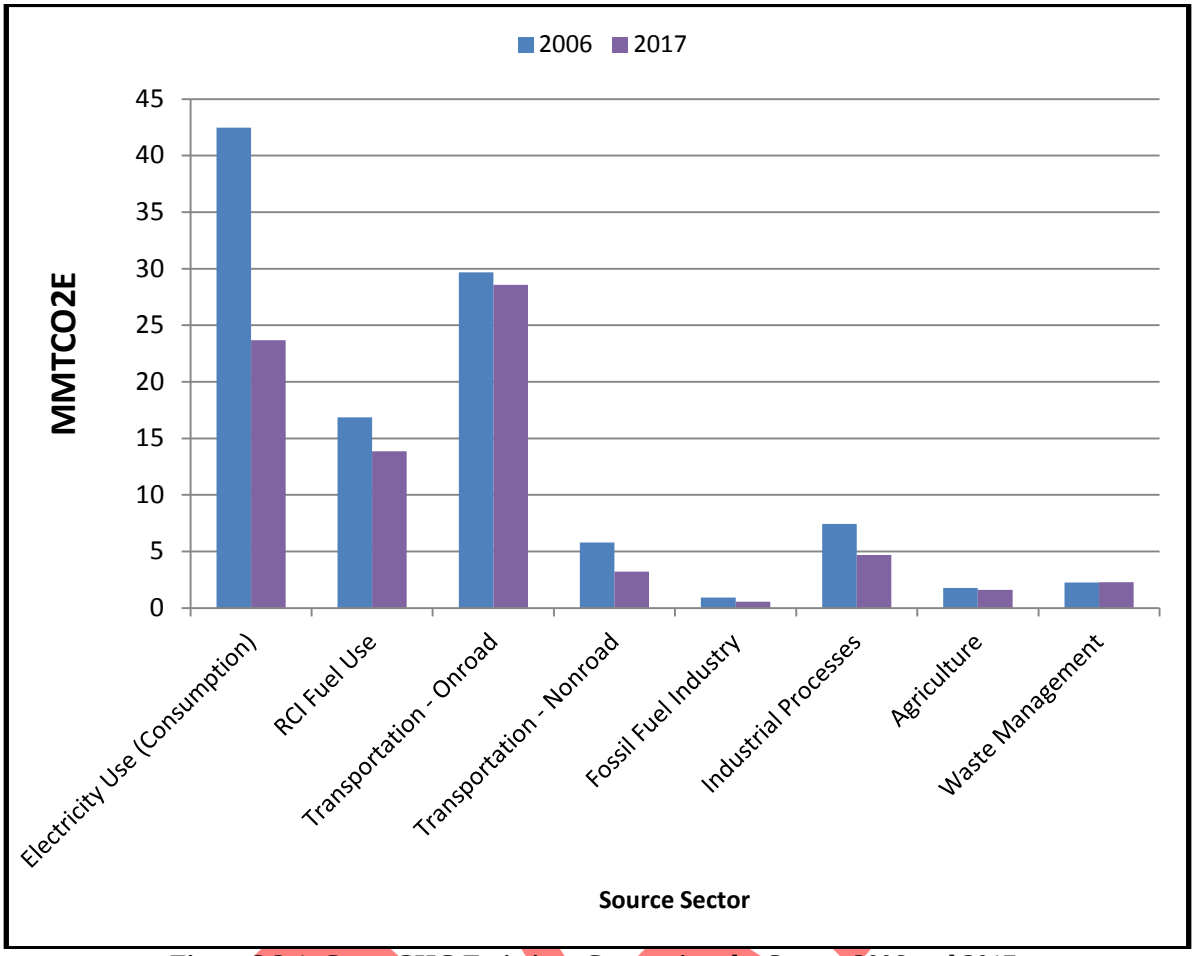


Figure 3.2-1. Gross GHG Emissions Comparison by Sector, 2006 and 2017.

3.3 Source Categories

This chapter describes the inventory procedures that MDE used to compile the 2017 periodic emissions inventory of the GHG pollutants; carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, chlorofluorocarbons (CFC) and hydrochlorofluorocarbons (HCFC). The emission sources are divided into the following eight source categories:

- Electricity Supply
- RCI Fuel Combustion
- Transportation Energy Use
- Industrial Processes
- Fossil Fuel Production Industry
- Agriculture
- Waste Management
- Forestry and Land Use

The inventory procedures outlined in this document have been calculated on a State-wide basis and have not been spatially allocated to the county level unless otherwise stated. Descriptions of each emission source category are presented in the following paragraphs:

3.3.1 Electricity Supply

The electricity supply sector accounts for emissions occurring as a result of the combustion of fossil fuel at electricity generating facilities located both in and outside of the State. CO_2 represented more than 99.37 percent of total sector emissions, with methane and N_2O CO_2-equivalent emissions comprising the balance.

Maryland is a net importer of electricity, meaning that the State consumes more electricity than it produces. For this analysis, it was assumed that all power generated in Maryland was consumed in Maryland and that remaining electricity demand was met by imported power. Sales associated with imported power accounted for 45.76 percent of the electricity consumed in Maryland in 2017. GHG emissions from power produced in Maryland are dominated by coal use, followed by emissions from oil use and natural gas use. As shown in Figure 3.1-1, electricity consumption accounted for about 30 percent of Maryland's gross GHG emissions in 2017 (about 24 $MMtCO_2e$).

In 2017, emissions associated with Maryland's electricity consumption (23.68 $MMtCO_2e$) were about 12.03 $MMtCO_2e$ higher than those associated with electricity production (11.65 $MMtCO_2e$). The higher level for consumption-based emissions reflects GHG emissions associated with net imports of electricity to meet Maryland's electricity demand. The consumption-based approach can better reflect the emissions (and emissions reductions) associated with activities occurring in Maryland, particularly with respect to electricity use (and efficiency improvements), and is particularly useful for policy-making.

3.3.2 RCI Fuel Combustion

This section accounts for emissions associated with direct fossil fuel used in the residential, commercial and industrial sector to provide space and process heating.

3.3.3 Transportation Energy Use

Emissions estimated for this sector are the result of fossil fuel consumed primarily for transportation purposes, both onroad mobile sources and nonroad mobile sources of transportation. Onroad mobile sources include the vehicles traditionally operated on public roadways. These include:

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

Other modes of transportation, such as airplanes, trains and commercial marine vessels are included under the general category of nonroad mobile sources. Nonroad mobile sources also include motorized vehicles and equipment, which are normally not 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 in Figure 3.1-1, the transportation sector accounted for about 40 percent of Maryland's gross GHG emissions in 2017 (about 32 $MMtCO_2e$). Maryland's 2017 Onroad gasoline vehicles accounted for about 70 percent of transportation GHG emissions. Onroad diesel vehicles accounted for another 19 percent of emissions, and air travel for roughly 2 percent. Marine vessels, rail, and other sources (natural gas- and liquefied petroleum gas- (LPG-) fueled-vehicles used in transport applications) accounted for the remaining 9 percent of transportation emissions.

3.3.4 Industrial Processes

Emissions estimated in the industrial sector account for only process related GHG emission from the four main industrial processes that occurs in the State;

1. CO_2 emissions from cement production, soda ash, dolomite and lime/ limestone consumption;
2. CO_2 emissions from iron and steel production;
3. Sulfur hexafluoride emissions from electric power transmission and distribution (T&D) system, transformers use, and
4. HFC and PFC emissions resulting from the consumption of substitutes for ozone-depleting substances (ODS) used in cooling and refrigeration equipment.

3.3.5 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 emission during coal mining are estimated in this section, as well as CO_2 emissions associated with the combustion of natural gas in compressor engines (referred to as pipeline fuel).

3.3.6 Agriculture

The emissions estimated in this section refer to non-energy methane and N_2O emissions from enteric fermentation, manure management, and agricultural soils. Emissions and sinks of carbon in agricultural soils are also estimated in this section. Energy emissions (combustion of fossil fuels in agricultural equipment) are not included in this section, but are already accounted for under the RCI and nonroad transportation sub- sector.

3.3.7 Waste Management

GHG emissions from Maryland's waste management practices were estimated in this section from the three (3) main classes of waste management in Maryland; (1) solid waste management, mainly in the form of methane emissions from municipal and industrial solid waste landfills (including methane that is flared or captured for energy production); (2) wastewater management, including methane and N2O from municipal and industrial wastewater treatment facilities ; and (3) methane and N2O from municipal solid waste incineration.

3.3.8 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. The GHG emissions estimated in this section includes CO_2 emissions from urea fertilizer use, methane and N_2O emissions from wildfires and prescribed forest burns, and N_2O from synthetic fertilizers application to settlement soils. Carbon uptake (sequestration) pathways estimated in this section include; carbon stored in above ground biomass, below ground biomass, dead wood, and litters- (forest carbon flux), carbon stored in the form of landfilled yard trimmings and food scraps, carbon stored in harvested wood product/wood in landfills as well as carbon stored in urban trees.

3.3.9 Natural Gas Life-Cycle Emissions Attributable to Fracked Gas

This section provides an analysis of out-of-State, fracking-related GHG emissions that Maryland may take responsibility for and potentially offset. The analysis includes fugitive leakage emissions and well construction emissions. This section uses the total methane consumption for year 2016 as a baseline and analyzes various scenarios that represent the amount of natural gas consumed due to fracking activities. The first scenario uses the US Energy Information Administration (EIA) statistic that 67 percent of the natural gas consumed is derived from fracking. The other three cases are justified by the fact that before 2006, there was no fracking in Maryland and the surrounding areas.

The analysis found that Maryland will have to offset between 0.08629 and 1.9092 $MMtCO_2e$. This represents roughly 2 percent of the inventory in the worst case.

At the time of writing the 2017 inventory, we were limited to using 2016 consumption data.

3.4 Basic Assumptions

3.4.1 Greenhouse Gas Pollutant GWP

Carbon dioxide has a GWP of exactly 1 (since it is the baseline unit to which all other GHGs are compared). CO_2e is the concentration of CO_2 would cause the same level of radiative forcing as a given type and concentration of GHG. Maryland used the established Intergovernmental Panel on Climate Change (IPCC) global warming potential for the GHG pollutants.

Table 3.4-1. IPCC Global Warming Potential for GHG

GHG Pollutant	GWP
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide (N_2O)	310
Sulfur Hexafluoride (SF_6)	23,900
Perfluorocarbons (PFCs)	9,200
Hydrochlorofluorocarbons (HCFC)	11,700

3.5 Further Information

Detailed descriptions of the specific assumptions, source information, and calculations on which the inventory is based are presented in Appendix D described below:

- Section 2.0 contains more detailed analysis and a general description of methodologies used in the emissions calculations for the electricity supply sector.
- Section 3.0 contains more detailed analysis and a general description of methodologies used in the emissions calculations of the residential, commercial, and industrial fuel combustion sector.
- Section 4.0 contains more detailed analysis and a general description of methodologies used in the emissions calculations of the on-road mobile transportation energy use sector.
- Section 5.0 contains more detailed analysis and a general description of methodologies used in the emissions calculations of the non-road mobile transportation energy use sector.
- Section 6.0 contains more detailed analysis and a general description of methodologies used in the emissions calculations of the industrial processes sector.
- Section 7.0 contains more detailed analysis and a general description of methodologies used in the emissions calculations of the fossil fuel production industry sector.
- Section 8.0 contains more detailed analysis and a general description of methodologies used in the emissions calculations of the agricultural sector.
- Section 9.0 contains more detailed analysis and a general description of methodologies used in the emissions calculations of the waste management sector.
- Section 10.0 contains more detailed analysis and a general description of methodologies used in the emissions calculations of the forestry and land use sector.

Appendix E contains more detailed analysis and a general description of methodologies used in the emissions calculations of natural gas life-cycle emissions attributable to fracked gas in 2017.

Chapter 4
The Draft Plan

4.1 Strategies, Programs and Initiatives

The Greenhouse Gas Emissions Reduction Act (GGRA) – Reauthorization (GGRA of 2016) draft Plan (*2019 GGRA Draft Plan*) utilizes various strategies, programs and initiatives that the State is developing and implementing to meet the GGRA of 2016's greenhouse gas (GHG) emissions reductions and economic benefits goals. Some of these strategies are already being fully implemented, while others are in an earlier phase of the implementation process. The suite of programs encompasses multiple sectors, including the electricity sector, the transportation sector, the agriculture and forestry sector, the buildings sector, the waste management sector, and additional non-specific sectors. The plan also includes numerous partnerships with key stakeholders like the private sector, underserved communities, state universities and the Port of Baltimore.

The core programs of the *2019 GGRA Draft Plan* extend from the suite of programs developed for previous GGRA Plans, specifically the State's plan to reduce GHG emissions by 25 percent from 2006 levels by 2020. These core programs, along with recommended new programs, voluntary and non-traditional programs, outreach efforts to build public awareness and promote voluntary action, additional programs being analyzed, and emerging technologies, will all contribute to the State's goal of reducing GHG emissions by 40 percent by 2030.

This chapter summarizes the various strategies, programs and initiatives that the State is developing and implementing across the six sectors to meet the GGRA of 2016's GHG emissions reductions and economic benefits goals. The emissions inventory and forecast analysis specifies that the State must reduce emissions by 42.89 million metric tons of carbon dioxide-equivalent ($MMtCO_2e$) (40 percent of the State's total gross GHG emissions in 2006) to achieve the 2030 goal. Summarily, this means that Maryland's net GHG emissions in 2030 must not exceed 52.55 $MMtCO_2e$. The combined emissions reductions of all programs in the *2019 GGRA Draft Plan* will yield a total of 47.4 $MMtCO_2e$ in emissions reductions in 2030, compared to 2006. This will achieve a total reduction of 44 percent, exceeding the GGRA of 2016 2030 goal by 4.5 $MMtCO_2e$. Tables 4.1-1 through 4.1-4 below provide an overall summary of GGRA of 2016 programs and the State Agency responsible for implementation.

Table 4.1-1. *2019 GGRA Draft Plan* Programs – Core Programs.

PROGRAM I.D.	PROGRAM NAME	LEAD AGENCY
4.3.1	**EmPOWER Maryland**	MEA
4.3.1.1	EmPOWER Maryland: Utility Responsibility	MEA
4.3.1.2	EmPOWER Maryland: Combined Heat and Power	MEA/MDE
4.3.1.3	Other Energy Efficiency Efforts	MEA
4.3.2	**The Maryland Renewable Energy Portfolio Standard (RPS)**	MEA
4.3.2.1	Fuel Switching	MDE
4.3.2.2	Incentives and Grant Programs to Support Renewable Energy	MEA
4.3.2.3	Offshore Wind Initiatives to Support Renewable Energy	MEA
4.3.3	**The Regional Greenhouse Gas Initiative (RGGI)**	MDE
4.3.4	**Other Energy Programs**	-
4.3.4.1	GHG Power Plant Emission Reductions from Federal Programs	MDE
4.3.4.1.1	Boiler Maximum Achievable Control Technology (MACT)	MDE
4.3.4.1.2	GHG New Source Performance Standard	MDE
4.3.4.1.3	GHG Prevention of Significant Deterioration Permitting Program	MDE
4.3.4.2	Energy Financing for Housing and Communities (formerly Main Street Initiatives)	DHCD
4.3.4.3	Energy Efficiency for Affordable Housing and Limited Income Families (formerly Energy Efficiency for Affordable Housing)	DHCD
4.3.5	**Transportation Technologies**	MDE/ MDOT/ MEA
4.3.6	**Multimodal Freight**	MDOT
4.3.7	**Public Transportation**	MDOT
4.3.8	**Pricing Initiatives**	MDOT
4.3.9	**Bicycle and Pedestrian Initiatives**	MDOT
4.3.10	**Forestry and Sequestration**	-
4.3.10.1	Managing Forests to Capture Carbon	DNR
4.3.10.2	Planting Forests in Maryland	DNR
4.3.10.3	Creating and Protecting Wetlands and Waterway Borders to Capture Carbon	DNR
4.3.10.4	Biomass for Energy Production	DNR
4.3.10.5	Conservation of Agricultural Land for GHG Benefits	MDA
4.3.10.6	Increasing Urban Trees to Capture Carbon	DNR
4.3.10.7	Geological Opportunities to Store Carbon	DNR
4.3.10.8	The Maryland Healthy Soils Program	MDA
4.3.11	**Ecosystems Markets**	-
4.3.11.1	Creating Ecosystems Markets to Encourage GHG Emission Reductions	DNR
4.3.11.2	Nutrient Trading for GHG Benefits	MDA/MDE
4.3.12	**Building and Trade Codes in Maryland**	Dept. of Labor
4.3.13	**Sustainable Materials Management**	MDE
4.3.14	**Maryland's Innovative Initiatives**	-
4.3.14.1	Voluntary Stationary Source Reductions	MDE
4.3.14.2	Buy Local for GHG Benefits	MDA

PROGRAM I.D.	PROGRAM NAME	LEAD AGENCY
4.3.14.3	Pay-As-You-Drive® Insurance in Maryland	MIA
4.3.14.4	Job Creating and Economic Development Initiatives Related to Climate Change	COMMERCE
4.3.15	**Land Use Programs**	MDP
4.3.15.1	Reducing Emissions through Smart Growth and Land Use/Location Efficiency	MDP
4.3.15.2	Priority Funding Area (Growth Boundary) Related Benefits	MDP
4.3.16	**Outreach and Public Education**	MDE
4.3.17	**Federal Measures**	MDE

Table 4.1-2. *2019 GGRA Draft Plan* Programs - Recommended New Programs.

PROGRAM I.D.	PROGRAM NAME	LEAD AGENCY
4.4.1	Maryland Clean and Renewable Energy Standard (CARES) Act of 2020	MDE/MEA
4.4.2	The Transportation and Climate Initiative (TCI) Cap and Invest	MDE/ MDOT/ MEA
4.4.3	In-State Methane Minimization	MDE
4.4.4	RGGI Expansion	MDE
4.4.5	Hydrofluorocarbons (HFCs)	MDE

Table 4.1-3. *2019 GGRA Draft Plan* Programs – Voluntary and Non-Traditional Programs.

PROGRAM I.D.	PROGRAM NAME	LEAD AGENCY
4.5.1	The United States Climate Alliance	MDE
4.5.2	Zero Emission Vehicle (ZEV) MOU Partnership	MDE
4.5.3	Leadership-By-Example – State of Maryland Initiatives	DGS
4.5.4	Leadership-By-Example – State	MDE/DGS
4.5.5	Leadership-By-Example – Federal	MDE
4.5.6	Leadership-By-Example – Local Government	MDE
4.5.7	Leadership-By-Example – Universities and Colleges	MDE
4.5.8	The Climate Champions Program	MDE
4.5.9	Idle Free Maryland	MDE
4.5.10	The Port Partnership	MDE/MDOT
4.5.11	The Volkswagen Mitigation Fund	MDE
4.5.12	The Metropolitan Washington Council of Government's Climate Energy and Environmental Policy Committee (CEEPC)	MDE

Table 4.1-4. *2019 GGRA Draft Plan* Programs – Outreach Efforts to Build Public Awareness and Promote Voluntary Action.

PROGRAM I.D.	PROGRAM NAME	LEAD AGENCY
4.6.1	Education, Communication, and Outreach Working Group	MDE

4.6.2	Climate Ambassadors	MDE
4.6.3	Climate Champions	MDE

Programs of note include:

Clean and Renewable Energy Standard (CARES)

A major component of the *2019 GGRA Draft Plan* to reduce GHG emissions from electricity generation is the proposed Clean and Renewable Energy Standard (CARES), which requires that an increasingly large share of Maryland's electricity be generated by zero- and low-carbon resources.

- *100 percent Clean Electricity*
  - CARES would build off the existing Renewable Portfolio Standard (RPS), and require that 100 percent of Maryland's electricity come from clean sources by 2040, which is among the most ambitious goals in the nation.

- *Market Based and Technology-Neutral*
  - CARES would adopt a technology-neutral approach to achieving 100 percent clean electricity at the lowest cost. By incorporating all available and emerging zero- and low-carbon sources in Maryland, CARES would foster greater competition among available renewable and clean energy resources, which would reduce costs for ratepayers. The broad set of eligible technologies would include:
    - Additional Maryland solar beyond the requirements of the RPS solar carve out
    - New efficient Combined Heat and Power (CHP), cogeneration systems in Maryland
    - Hydropower in Maryland
    - Nuclear Power in Maryland
    - Natural gas power with carbon capture and storage (CCS) technology in Maryland

- *Homegrown Energy and Jobs*
  - CARES would rely on electricity generators in Maryland to make progress beyond the existing goals, ensuring that Marylanders benefit from the direct job creation resulting from investments in clean energy resources.

Continually Stronger Regional Greenhouse Gas Initiative (RGGI) with Geographic Expansion

In 2017 RGGI completed a Program Review, and strengthened RGGI to continue steady, deeper reductions of GHG emissions by 2030.

With the success of the initiative, and as a national leader in the effort to combat climate change, Maryland and the other participating RGGI states are actively working to engage new participants in the program. The first-in-the-nation carbon cap-and-invest program for power plants has been strengthened by implementing the participating states' plan to secure an additional 30 percent reduction in power plant emissions by 2030, and expanding the program to new participating states in the region to reduce pollution from power plants supplying electricity into Maryland.

As the chair of the RGGI, Inc. Board of Directors since 2018, the Maryland Department of the Environment (MDE) led deliberations among the RGGI states to broaden participation to include New Jersey and Virginia. In July 2019, New Jersey finalized regulations allowing it to renew its participation in January 2020. Virginia also finalized regulations, and although they are unable to participate in 2020 due to budget restrictions, MDE is hopeful that they will be able to in the near future. Other states including Pennsylvania have taken important steps that could lead to future participation.

Public Transit Expansion

Maryland continues to devote record levels of funding for public transportation, which emits roughly 40 percent to 50 percent less GHG emissions per passenger mile than an average single occupancy vehicle (SOV). The programs in this policy category include transit initiatives that support a goal of increasing public transit ridership, and intercity transportation initiatives that support Maryland Area Regional Commuter and regional and national passenger rail services such as Amtrak. By providing alternatives to vehicle transit, these initiatives have the potential to reduce vehicle miles traveled (VMT) and GHG emissions. Public transportation strategies analyzed for the Maryland Department of Transportation (MDOT) GGRA plan update are broadly classified into two strategy groups:

- Transition to cleaner and efficient public transportation fleets, and
- Expansion of public transportation or intercity passenger service (new or increased capacity, improved operations)

MDOT works with metropolitan planning organizations (MPOs), transit operators, and other local agencies in Maryland to implement projects aimed at advancing a more efficient and accessible multimodal transport system. These include transportation demand management programs (such as MDOT's Commuter Choice Maryland and Metropolitan Washington Council of Governments' (MWCOG) Commuter Connections, which are detailed further in the pricing policy option), transit-supportive enhancements, including bicycle and pedestrian access projects, bicycle parking and bike racks on buses, and coordination with expanding bike-sharing programs. There is an emphasis on improving service quality and reliability, better aligning of transit service to demand, and improved transit information dissemination to customers. MDOT Maryland Transit Administration is also focused on sustainability and is moving toward a more efficient fleet.

Clean Cars and Zero Emission Vehicle (ZEV) Mandate

The Maryland Clean Cars Act of 2007 required MDE to adopt regulations implementing California's stricter vehicle emission standards. The Clean Cars Program represented the first motor vehicle program to directly regulate carbon dioxide emissions. In addition to regulating GHG from passenger vehicles, the Clean Cars Program includes a Zero Emissions Vehicle (ZEV) mandate that car manufacturers must meet. These vehicles produce zero or near zero tailpipe emissions and include electric vehicles (EVs) and plug-in hybrid EVs. These vehicles will also reduce pollutants from the transportation sector as well as reduce dependence on foreign oil. Since initially adopting the Clean Cars Program, California has developed stricter tailpipe and GHG standards referred to as California's Low Emission Vehicle III (LEVIII), which were adopted by Maryland in 2012. The LEVIII Program when fully implemented in 2025 will reduce GHG emissions from vehicles by 34 percent. The LEVIII Program also strengthens the ZEV mandate, increasing the requirements beginning in 2018.

The ZEV mandate is a technology forcing component and the LEVIII Program's requirements beginning in 2018 are aggressive. Maryland continues to be a national leader in supporting the LEVIII Program, deploying ZEVs, supporting legislation and initiatives to remove barriers, developing EV charging infrastructure, and providing incentives in support of these vehicles. The Clean Cars Acts of 2017 and 2019 are examples of Maryland's commitment. California is in the early stages of developing a regulatory update to the Clean Cars Program that will strengthen the GHG standards beyond 2025. Maryland will continue to work with California and other states that have adopted its program to ensure a robust program that delivers the GHG reductions necessary to meet our climate goals.

Transportation and Climate Initiative (TCI)

TCI is a regional effort of Maryland and 10 other Northeast and mid-Atlantic states and Washington, D.C. 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 VMT, and help build the clean energy economy across the region.

Cooperation continues between Maryland and the other states to develop a regional cap-and-invest program for road transportation fuels that will drive investment in clean transportation infrastructure, and encourage widespread use of EVs powered by increasingly clean electricity. TCI is using many of the successful concepts from RGGI, an energy sector cap-and-invest program, to design the transportation initiative.

Enhanced Forest Management

Maryland forests on both public and private lands are managed to capture carbon through sustainable forest management practices. Enrolling unmanaged forests into management regimes will increase rates of carbon sequestration in forest biomass and increase amounts of carbon stored in harvested, durable wood products, which will results in economic benefits and increased availability of renewable biomass for energy production. The goals of this program are to improve sustainable forest management on approximately 30,000 acres of private land annually, ensure third-party certified sustainable forest management on approximately 200,000 acres of State Forests, support forest markets that keep land in forest use, and provide sustainable management for multiple benefits on other Maryland Department of Natural Resources (DNR) lands when possible.

Enhanced Healthy Soils Incentives

In addition to reducing nutrient and sediment flows into the Chesapeake Bay and its tributaries, many of the agronomic and conservation practices used by Maryland's farmers have the potential to make a significant contribution to the State's climate change goals by sequestering carbon and other GHG emissions.

The 2017 Healthy Soils Act charged the Maryland Department of Agriculture (MDA) with the development of a healthy soils program to improve the health, yield, and profitability of Maryland's soils, and promote the further adoption of conservation practices that foster soil health while increasing sequestration capacity. In support of this initiative, MDA collaborated with stakeholders from the Healthy Soils Consortium to complete a comprehensive scientific literature review to identify those practices that are most effective in improving soil health and building soil carbon stocks, as well as create a menu of Maryland-specific practices. MDA intends to use this information to determine the metrics and tools used to quantify soil carbon, and provide incentives to encourage the additional implementation of climate-friendly soil practices. Exiting programs are also being examined to find ways to capitalize on co-benefits for both water quality and carbon sequestration.

EmPOWER Maryland Expansion

Created by a 2007 Executive Order, codified by the General Assembly in 2008, and updated by the General Assembly in 2017, EmPOWER Maryland successfully met the goal to reduce per capita electricity consumption and peak demand by Maryland consumers by 15 percent by 2015 from the 2007 baseline. While the EmPOWER Maryland suite of energy efficiency programs are funded in part with revenue paid into the SEIF from the auction of RGGI allowances, the vast majority of revenue comes from ratepayers.

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 Maryland Public Service Commission (PSC). In addition to these utility managed programs, Maryland Energy Administration (MEA) programs and other State efforts are

intended to close the gap toward the overall program goal.[93] MEA works 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 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 percent of gross sales[94] through 2023 based on three-year cycles. The General Assembly codified the PSC order in 2017. Savings can come from a variety of sources, including traditional equipment-based measures, "smart meter" enabled analytics, and more efficient distribution grid hardware.

While the PSC order does not specifically contemplate a separate savings goal for non-utility entities, MEA and other agencies will continue to work closely with the PSC and Maryland utilities to ensure that programs are effectively designed and implemented. Additionally, MEA and the Maryland Department of General Services (DGS) continue to work on efforts to reduce energy use in State buildings, including Executive Order 01.01.2019.08.

The current EmPOWER statute requires the PSC to determine what savings targets and methodologies are appropriate to apply after 2023. Without prejudice toward the PSC's process to determine those targets, the *2019 GGRA Draft Plan* proposes that the State continue to invest in energy efficiency through EmPOWER beyond 2023, at levels of effort roughly consistent with those required to achieve the current program cycle goals. The *2019 GGRA Draft Plan* also proposes to begin incentivizing increased deployment of efficient electric heat pumps to heat homes in Maryland, including in homes that currently use a different fuel for heat, in order to improve the efficiency of residential heating systems, and to transition the energy source for home heating toward increasingly clean electricity.

Department of General Services (DGS) State Building Efficiency Executive Order (EO 01.01.2019.08)

On June 25, 2019, Governor Hogan issued an executive order establishing a new energy savings goal for State government. DGS, in cooperation with MEA is to manage a "Maryland Leads by Example" energy savings initiative that will oversee reducing, by the year 2029, the energy use of State-owned buildings by 10 percent compared to a 2018 baseline.

The executive order outlines five specific tasks, one supporting role, and a partnership role to be performed by DGS:

- Task 1 - On an annual basis, the DGS Office of Energy Performance and Conservation, utilizing the Comprehensive Utility Records Management Database (Utility Database), shall analyze the entire inventory of State-owned buildings in order to identify and prioritize the least energy efficient buildings in the State.

[93] 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 % 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% by 2015 and per capita peak demand by 15% 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% reduction in per capita electricity consumption and per capita peak demand by 2015.

[94] 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).

- Task 2 - Every year, a minimum of 2 million square feet of the least efficient buildings will undergo a DGS energy audit to identify low cost measures with a five-year or less payback period. A copy of the energy audit shall be provided to each participating agency's Secretary or Director.

- Task 3 - DGS will measure post-installation energy use for one year following the installation of these measures, which will be normalized and compared to the buildings' pre-installation total energy use to determine energy savings.

- Task 4 - Progress toward the 10 percent savings goal, monitored through the Utility Database, will be reported to the Governor annually each fiscal year by DGS, with the support of MEA.

- Task 5 - DGS, MEA, the Department of Budget and Management, and Department of Information Technology shall collaborate on designing and implementing additional cost-effective and -efficient energy saving programs that may include any combination of technology adoption, management protocols, information technology solutions, and staff education and engagement.

Hydrofluorocarbon (HFC) Regulation

Under a federal Clean Air Act program designed to identify and evaluate alternatives to stratospheric ozone-depleting substances, HFCs have been one of the most common alternatives. However, HFCs are extremely potent GHG emissions. One pound of certain HFCs is potentially as potent as 1,400 pounds of carbon dioxide. After efforts have stalled at the federal level, states have begun their own phase out initiatives. MDE will develop regulations similar to those in development in California, Delaware, New York, Massachusetts, Connecticut, and other states, which would phase out the use of certain HFCs in foam products, and in refrigeration equipment in retail establishments, such as supermarkets. The phase out of HFCs will encourage the use of substances with lower GHG emissions. Products with alternatives to HFCs are already available. Other states in the U.S. Climate Alliance, a bipartisan coalition of 25 U.S. States committed to reducing GHG emissions consistent with the Paris agreement, are expected to take similar actions.

Maryland is currently drafting HFC regulations with plans to adopt a final rule by fall 2020. HFCs are critical to the States short-term and long-term emission reduction goals as they are highly potent short-lived climate pollutants.

4.2 Sectors

4.2.1 The Electricity Sector

The generation and transmission of electricity affects the environment. Nearly all types of electric power plants have an effect on the environment, but some power plants have larger effects than others. Emissions standards for power plants help to substantially reduce emissions, but the sector is still a major contributor to GHG emissions.

The electricity supply sector accounts for GHG emissions occurring as a result of the combustion of fuels at electricity generating facilities located both in and outside of the State. Maryland is a net importer of electricity, meaning that the State consumes more electricity than is produced in the State. In 2006, GHG emissions associated with Maryland's electricity *consumption* (42.48 $MMtCO_2e$) were about 10.31 $MMtCO_2e$ higher than those associated with in-state electricity *generation* (32.16 $MMtCO_2e$). In 2014, GHG emissions associated with Maryland's electricity *consumption* (33.76 $MMtCO_2e$) were about 13.85 $MMtCO_2e$ higher than those associated with in-state electricity *generation* (19.91 $MMtCO_2e$). The higher level for *consumption-based* emissions reflects GHG emissions associated with net imports of electricity to meet Maryland's electricity demand. Projections of electricity sales for 2006 through 2030 indicate that Maryland will remain a net importer of electricity. The GGRA

requires that GHG emissions associated with imported electricity driven by in-state consumption be accounted for in meeting the 40 percent reduction by 2030 goal of the law. Reductions from the electricity sector are critical to achieving the 2030 goal.

4.2.2 The Transportation Sector

GHG emissions from this sector are the result of fossil fuels consumed primarily for transportation purposes, and include both on road and off road mobile sources. On road mobile sources include vehicles traditionally operated on public roadways such as cars, light-duty trucks, vans, buses, medium and heavy-duty trucks and other diesel vehicles. Off road mobile sources include other modes of transportation, such as airplanes, trains and commercial marine vessels, as well as motorized vehicles and equipment not normally operated on public roadways, such as lawn and garden equipment, and airport service equipment.

The majority of CO_2e emissions from the transportation sector are associated with on road gasoline-powered vehicles, with on road diesel-powered vehicles also representing a significant percentage. The transportation sector accounted for 35.47 $MMtCO_2e$ of Maryland's gross GHG emissions in 2006 and 33.45 $MMtCO_2e$ of Maryland's gross emissions in 2014. In both 2006 and 2014, on road gasoline vehicles accounted for about 67 percent of transportation GHG emissions in Maryland. On road diesel vehicles accounted for another 16 percent of the State's transportation emissions in 2006 and 19 percent in 2014. Air travel accounted for roughly 4.9 percent in 2006 and 2.5 percent in 2014. Marine vessels, rail, and other sources, such as natural gas and liquefied petroleum gas-fueled vehicles used in transport applications accounted for 11.5 percent of Maryland's transportation emissions in 2006 and 11.0 percent in 2014.

4.2.3 The Agriculture and Forestry Sector

Although, the agriculture and forestry sectors are a source of GHG emissions, they contribute a small percentage of Maryland's overall GHG emissions. These sectors also offer unique opportunities to act as sinks and remove carbon dioxide from the atmosphere. Forests, grasslands, croplands, and wetlands all possess carbon-reducing and energy-related benefits that are extensive and complex. Activities in Maryland that can contribute to the increase in net GHG emissions include clearing an area of forest to create cropland, tilling and fertilizing crop lands, or draining a wetland.

More significantly, agriculture and forest lands offer carbon sequestration opportunities that are not possible in other sectors. Through appropriate management, technology and energy conscious choices, the potential for carbon sequestration from the atmosphere can be optimized and the net GHG emissions from the agriculture and forestry sector reduced. Trees and plants remove carbon dioxide from the air and store carbon in their trunks and branches.

Sustainable forest and urban forest management is essential for healthy productive forests. Sustainably managed natural resources can maximize carbon sequestration and reduce GHG levels in the atmosphere. Increasing the acreage and enhancing the condition of forests and urban trees is a critical component of mitigating climate change.

Lower surface temperatures of sidewalks and roads resulting from the shade of tree canopies reduce the need for air conditioning in buildings, thereby reducing the need for the production and transmission of electricity. Reduced energy production, in turn, reduces GHG emissions from power plants. Shade and lower surface temperatures reduce maintenance to roadway infrastructure which, in turn, reduces the need for conversion of raw materials to asphalt and concrete, and the production of GHGs from manufacturing plants, transportation and heavy equipment. Shade and lower surface temperatures reduce the evaporation of chemicals from car engines and reduce the need for air conditioning in cars. All of the examples above reduce the combustion of fossil fuels and emissions of GHGs from cars and power plants.

Agricultural lands both sequester carbon dioxide from the atmosphere and release GHGs through tilling and fertilizer applications. Agricultural practices in Maryland accounted for 1.77 $MMtCO_2e$ of Maryland's gross emissions in 2006 and 1.89 $MMtCO_2e$ of Maryland's gross emissions in 2014. Even though this is a small percentage of Maryland's total GHG emissions, there are opportunities for reducing energy use and climate-affecting factors.

Agricultural GHG emissions include methane (CH_4) and nitrogen oxide (NO_x) emissions from enteric fermentation (digestion), manure management, and agricultural soils. Emissions from agricultural soils account for the largest portions of agricultural emissions. The agricultural soils category includes nitrous oxide emissions resulting from fertilizer application (synthetic, organic, and livestock) and production of nitrogen-fixing crops. No-till farming and precision fertilization are among the most effective management practices that reduce GHG emissions during the production of crops.

Opportunities for GHG mitigation in the agriculture and forestry sector involve measures that reduce emissions across other business sectors. For example, production of liquid fuels from biomass can offset emissions from the transportation sector, while biomass energy can replace fossil fuel generated power and the associated emissions in the energy supply sector.

4.2.4 The Building Sector

Since buildings require large amounts of energy to heat, cool, maintain, and operate, it is not a surprise that buildings account for almost a third of the total energy use and carbon dioxide emissions in the U.S. Given the long lifetime of most buildings, it is necessary that both existing and new buildings achieve the greatest energy efficiency possible. This includes all aspects of buildings, including site location and design, the design of the building itself, how the building is constructed, and the type of materials used, among others.

Increasing energy efficiency in Maryland State government's buildings has the potential to reduce Maryland's GHG emissions through decreasing the need for power generation from fossil fuel-fired sources. In addition to reducing GHG emissions, this will create reductions in nitrogen oxides, sulfur dioxide and mercury, all of which are harmful to the environment.

The range of GHG benefits are likely to fluctuate in the face of the following: continued refinement for quantifying GHG benefits, future program decisions on the level of funding, and future advances in technology.

4.2.5 The Waste Sector

Recycling converts used or waste products into new materials; plastics, paper, metal, glass, electronics, cloth, batteries and biodegradable waste are commonly recycled into new materials. In addition to reducing GHG emissions, recycling helps the environment in other ways. Recycling saves energy when materials are recycled instead of new materials being manufactured. Coal, gasoline, and diesel fuel are often used in manufacturing processes, and resulting GHG emissions are avoided through recycling. Additionally, recycling reduces the amount of material ending up in landfills today.

GHG emissions associated from waste include solid waste management, solid waste combustion, and wastewater management. Recycling reduces waste emissions. Actions taken to increase waste recycling can reduce GHG emissions not only in the State, such as landfill methane gas emissions, but also outside the State, such as emissions associated with the energy used to make products from virgin materials versus recycled materials.

4.2.6 Non-Specific Sectors

This sector category contains programs that are not easily delineated, apply to multiple sectors, or do not belong to any sector category described above. As such, this sector category contains many leadership initiatives, non-traditional programs, outreach efforts and programs not yet fully developed.

4.3 Core Programs

4.3.1 EmPOWER Maryland

Lead Agency: MEA

Program Description

Enacted by the General Assembly in 2008, EmPOWER Maryland initially established a goal to reduce per capita electricity consumption and peak demand by Maryland consumers by 15 percent by 2015 from the 2007 baseline. The EmPOWER Maryland suite of energy efficiency programs offered by the participating utilities are funded by ratepayers. Each utility is responsible for procuring or providing programs in its service territory designed to meet the EmPOWER program goals. The PSC monitors and analyzes the impact of the programs and, in consultation with MEA, reports to the General Assembly on the status of the programs, a recommended funding level for the programs, and the per capita electricity consumption and peak demand for the previous calendar year.

EmPOWER programs must be approved in advance by the PSC. In addition to these utility-provided EmPOWER programs, other State efforts, including energy programs offered by MEA, help reduce statewide per capita electricity usage.[95]

In July 2015, the PSC order No. 87082, directing the continuation of utility programs supporting EmPOWER Maryland energy reduction policy, and setting new savings targets that 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 percent of each company's gross retail sales baseline[96] based on three-year cycles. In 2017, the General Assembly codified the energy savings goals and cost-effectiveness measurements in PSC Order No. 87081. Savings can come from a variety of sources, including traditional equipment-based measures, "smart meter" enabled analytics, and more efficient distribution grid hardware. MEA and other agencies will continue to work closely with the PSC and Maryland utilities to ensure that programs are effectively designed and implemented.

The current EmPOWER statute requires the utilities to continue programs focusing on the efficient use and conservation of energy, subject to the review and approval of the PSC, after 2023. Without prejudice toward the PSC's process, the *2019 GGRA Draft Plan* proposes that the State continue to invest in energy efficiency through EmPOWER beyond 2023, at levels of effort roughly consistent with those required to achieve the current program cycle goals. The *2019 GGRA Draft Plan* also proposes to begin incentivizing increased deployment of efficient electric heat pumps to heat homes in Maryland, including in homes that currently use a different fuel for heat, in order to improve the efficiency of residential heating systems, and to transition the energy source for home heating toward increasingly clean electricity.

[95] The SEIF fund was created by legislative act of the General Assembly. "Regional Greenhouse Gas Initiative - Maryland Strategic Energy Investment Program," (Subtitle 20B of the State Government Article). A portion of the fund is allocated to the MEA to administer energy efficiency programs. The utility-provided EmPOWER programs are mandated by the "EmPOWER Maryland Energy Efficiency Act" (§ 7-211 of the Public Utilities Article). The law requires participating utilities to reduce per capita electricity consumption in Maryland by 10% by 2015 and per capita peak demand by 15% by 2015 within their respective service territory by implementing energy efficiency programs targeted to consumers.

[96] 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 recent 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).

MDE is specifically seeking comment on the "post-2023" and "home heating efficiency" issues identified above.

More detail on EmPOWER Maryland's programs is provided below.

4.3.1.1 EmPOWER Maryland: Utility Responsibility

Lead Agency: MEA

Program Description

EmPOWER Maryland initially mandated that the PSC require each participating 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, within the participating utility's respective service territory.

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 percent of gross sales[97] as long as cost-effective savings continue to be available. This goal was later established in statute as well. Savings can come from a variety of sources, including traditional equipment-based measures, "smart meter" enabled analytics, and more efficient distribution grid hardware.

The five participating utilities are Potomac Edison (formerly known as Allegheny Power); Baltimore Gas and Electric (BGE); Delmarva Power and Light; Potomac Electric Power Company (Pepco); and Southern Maryland Electric Cooperative (SMECO). Energy efficiency programs are offered to various d customer rate classes, and programs, including efforts specifically targeted to reach low-to-moderate income customers.

4.3.1.2 EmPOWER Maryland: 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 per unit of energy produced than from a typical system that produces electric and thermal energy separately. Expanding the use of these systems can greatly enhance a facility's energy efficiency and decrease overall energy costs. Moreover, combined heat and power is an efficient, clean, and reliable approach to generating power while also reducing aggregate GHG emissions. The five EmPOWER utilities received approval from the PSC to run combined heat and power programs in the spring of 2012. To date, 17 combined heat and power projects have participated[98].

4.3.1.3 Other Energy Efficiency Efforts

Lead Agency: MEA

[97] 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).

[98] https://www.psc.state.md.us/search-results/?q=9494&x.x=10&x.y=16&search=all&search=case, case file items147, 148, and 151.

In addition to the EmPOWER Maryland energy efficiency programs offered by participating utilities, the State of Maryland also makes other investments in energy efficiency. MEA administers the Strategic Energy Investment Fund (SEIF), which is funded primarily through proceeds from RGGI auctions, as well as funds from settlements overseen by the PSC. MEA and other state agencies implement energy efficiency programs using SEIF funds, these programs contribute to continued reductions in energy use and GHGs by Maryland businesses, local governments, and residential households. The Maryland Department of Housing and Community Development (DHCD) implements the federal Weatherization Assistance Program.

MEA also offers revolving loans for cost-effective energy efficiency projects being completed by eligible non-profit organizations, local governments, businesses, and state agencies through the Jane E. Lawton Conservation loan program. DHCD offers the Be Smart Energy Efficiency Loan Program for homeowners.

4.3.2 The Maryland Renewable Energy Portfolio Standard (RPS)

Lead Agency: MEA

Program Description

The recently expanded RPS, extended under the Clean Energy Jobs Act in the 2019 legislative session, is a law that requires Maryland electricity suppliers to obtain renewable energy credits (RECs) from qualified renewable energy generators for 50 percent of its electricity supply, as defined in the statute, by 2030, with a solar carve-out that requires that 14.5 percent of RECs be obtained from solar energy generation tied to Maryland's electric distribution grid by 2030. Energy suppliers are required to purchase RECs to demonstrate compliance with the RPS.

The State also runs a number of programs to support renewable energy and achieve the RPS goal. Maryland has a net metering law that allows certain renewable projects to generate bill credits during periods of time where the system is producing more energy than is required on site. The PSC is overseeing a community solar pilot that will enable Maryland residents who may not otherwise have access to solar to subscribe to community solar projects within their local electric utility service territory. Finally, MEA offers a number of programs designed to encourage the deployment of in-state renewable energy in support of the State's RPS; as an example, MEA offers a Parking Lot Solar Photovoltaic Canopy with Electric Vehicle Program that incentivizes renewable energy generation, EVs, and a secondary use of the land.

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 the development of a diverse array 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, 2012, 2017, and 2019.[99]

[99] 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

The RPS is implemented through the creation, sale, and transfer of RECs. Each REC represents one megawatt hour of energy generated from a qualified renewable source. Electricity suppliers are required to purchase RECs to demonstrate they have obtained specified percentages of their energy supply from renewable resources. These 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 35.5 percent in 2030. Tier 1 includes a solar set-aside requirement that gradually increases until it peaks at 14.5 percent in 2030. Maryland's Tier 2 source (eligible hydroelectric power) requirement remained constant at 2.5 percent through 2018, at which point it was supposed to sunset; however, this tier was extended through 2020 at the existing level. 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.

Implementation Milestones

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, in coordination with the PSC.

As of the end of 2017:

- 9 million RECs retired in that year, each representing 1 MWh of renewable electricity. This represents approximately 15 percent of total retail sales in Maryland.
- 577,224 SRECs retired alone in Maryland.

Opportunities:

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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 will need to be updated if REC purchases exceed imported electricity and should reflect the contractual rather than physical nature of RECs
- Solar continue to come down in overall price and consumers continue to show growing interest in local solar electricity
- Oversupply of Pennsylvania Jersey Maryland Interconnection, LLC (PJM) RECs is being absorbed, so the increase in Maryland's RPS is driving new projects and affecting CO_2 intensity in PJM
- United States Environmental Protection Agency's (EPA) Clean Power Plan 111(d) may continue to act as an additional driver of renewable energy in Maryland

Challenges:

- The RPS does not directly account for the siting of renewable resources, especially Maryland solar, which requires land that could otherwise be devoted to agriculture, forestry, or other uses.
- RPS GHG reduction is a function of quantity (percent 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 the 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

4.3.2.1 Fuel Switching

Lead Agency: MDE

Program Description

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 $MMtCO_2e$.

4.3.2.2 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 commercial scale facilities to on-site residential distributed generation.

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

4.3.2.3 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. In 2017 the PSC awarded Offshore Wind Renewable Energy Credits (ORECs) to two offshore wind projects totaling 368 MW of capacity. The State is moving forward to develop the supply chain that will support these two projects as well as projects along the entire East Coast.

4.3.3 The Regional Greenhouse Gas Initiative (RGGI)

Lead Agency: MDE

Program Description

The Maryland Healthy Air Act was signed into law on April 6, 2006 and required Maryland to join RGGI by July 2007. MDE subsequently adopted COMAR 26.09.01 to .03, implementing the "Maryland CO_2 Budget Trading Program", which became effective on July 17, 2008. COMAR 26.09.04 ("Auctions") became effective as a permanent regulation on August 25, 2008.

RGGI is comprised of nine states in the Northeast and Mid-Atlantic regions. These states adopted market-based carbon dioxide (CO_2) cap and trade programs designed to reduce emissions of CO_2, a GHG, from fossil fuel-fired electricity generators with a nameplate capacity of 25 megawatts or greater. RGGI currently is comprised of Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont, and Maryland. New Jersey discontinued participation after the end of the first compliance period, 2009-2011. Participating RGGI states each require electricity generators to have acquired, through regional auction or secondary market transactions, one CO_2 allowance for every ton of CO_2 emitted over a three-year compliance period. Auction proceeds fund a number of state programs, including energy efficiency programs that result in lower CO_2 emissions through reduced electricity demand. Further, auction proceeds fund renewable energy projects that reduce the amount of CO_2 emissions generated by fossil fueled electricity generators.

The RGGI program has several unique features unlike other cap and trade programs in the U.S. The allowances are controlled by the states and can be allocated or sold to sources. Most states have opted to auction the allowances to sources through quarterly auctions. Proceeds from the auctions are used to fund energy efficiency programs to reduce demand for electricity and provide a means to lower CO_2 emissions. The states conducted the first quarterly regional auction in September 2008, and the program officially began in January 2009.

RGGI originally set a cap of 188,076,976 tons of CO_2 emissions for the region, based on average 2000 to 2002 CO_2 emissions from eligible electricity generators subject to the program, and Maryland received 37,503,983 CO_2 allowances each year through 2013. After the 2012 Comprehensive RGGI Program Review, changes to the cap

resulted in Maryland receiving 20,360,944 CO_2 allowances in 2014. Between 2015 and 2020, Maryland will annually receive 2.5 percent fewer CO_2 allowances as the RGGI cap reduces by 10 percent during that time. Maryland originally set aside 7,388,491 allowances in four different set aside accounts to account for special needs or programs, but this number and the number of set aside accounts was reduced through the 2016 Comprehensive Program Review.

Table 4.3-1. Maryland CO_2 Allowance Allocation By Year.

Year	Allowances
2018	18,671,045
2019	17,931,922
2020	17,483,623
2021	16,790,271
2022	16,281,475
2023	15,772,679
2024	15,263,882
2025	14,755,086
2026	14,246,290
2027	13,737,494
2028	13,228,698
2029	12,719,902
2030 and each succeeding calendar year	12,211,106

RGGI is composed of individual CO_2 Budget Trading Programs in each RGGI participating state. Each participating state's CO_2 Budget Trading Program is based on the 2008 RGGI Model Rule, which was developed to provide guidance to states as they implemented the RGGI program. RGGI participating states have completed a 2016 Comprehensive Program Review, which is a comprehensive evaluation of program successes, program impacts, the potential for additional reductions, imports and emissions leakage, and offsets.

Amendments to the Model Rule were developed by the RGGI state staff as part of the Program Review. This effort was supported by an extensive regional stakeholder process that engaged the regulated community, environmental nonprofits, and other organizations with technical expertise in the design of cap-and-trade programs.

Implementation Milestones

Auctions

Maryland has successfully participated in all 45 regional auctions of CO_2 allowances with RGGI. Auction proceeds go to the Strategic Energy Investment Fund (SEIF), which is administered by MEA. To date, Maryland has generated $669,571,907.26 in cumulative proceeds.

RGGI 2016 Comprehensive Program Review

On August 23, 2017, after completing a comprehensive 1.5 year review, Maryland and the other RGGI participating states announced a consensus agreement on proposed program changes. A regional emissions cap trajectory is proposed that will provide an additional 30 percent cap reduction by the year 2030 with important new features and innovations. This announcement can be found on the RGGI website at http://www.rggi.org/docs/ProgramReview/2017/08-23-17/Announcement_Proposed_Program_Changes.pdf

The Cap

The RGGI cap was first established during the period from 2005-2007. The participating states decided upon a generation-based program rather than a consumption-based program because the states had authority to control electric generating sources within their jurisdiction. The initial cap was based on the average of 2000-2002 CO_2 emissions and the initial cap was set at 188,076,976 short tons of CO_2. After a stabilization period, the cap would be reduced starting in 2015 by 2.5 percent each year until 2018 for a 10 percent reduction. When New Jersey left the program after 2011, the end of the first control period, the cap was adjusted to 165,184,246 short tons of CO_2 to remove New Jersey's emissions.

As the states tracked emissions to evaluate reductions, the downward trend in emissions became evident. The drop in allowance sales at the regional auctions also signaled an oversupply of allowances, and so the participating states elected to revise the cap as part of the 2012 Comprehensive Program Review. During the review, the states considered a number of potential caps in short tons of CO_2, but ultimately the cap was set at 91 million short tons of CO_2 (91M). The 91M cap put downward pressure on carbon emissions, while receiving support from a wide variety of stakeholders and many generators.

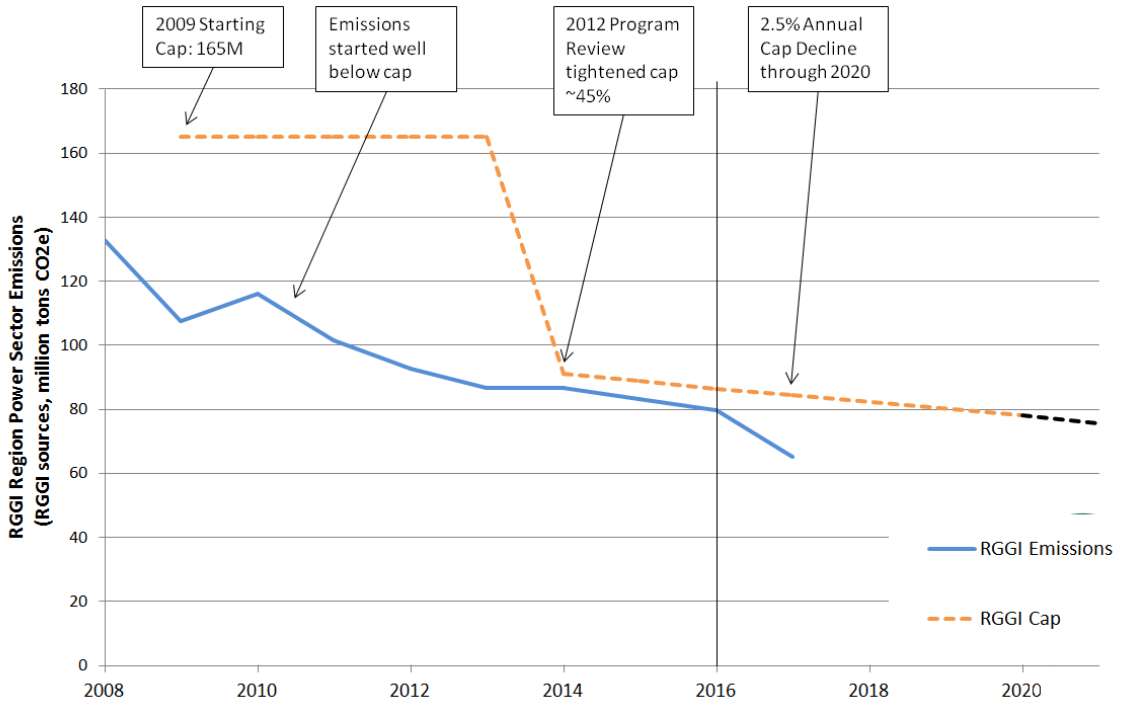

Figure 4.3-1. 2012 Program Review Cap Change.

The RGGI program started in 2009. The figure above shows the actual CO_2 emissions from the participating states and the original and revised cap.

After the significant cap reduction made as part of the 2012 Comprehensive Program Review, actual emission levels in all years continue to trend below the level of the 91M cap. Again, the participating states elected to revise the cap as part of the 2016 Comprehensive Program Review. During the review, the states considered a number of potential cap declines that would continue the downward trajectory of the existing cap, including a 25 percent decline, a 30 percent decline, and a 50 percent decline from 2020 to 2030.

The participating states used the Integrated Planning Model (IPM) to model emissions, future demand, new environmental requirements, changing fuel prices, etc. to predict possible emission reductions, allowance prices and demand for allowances at each cap level against a business as usual reference case. A number of cap declines from 20 percent to 50 percent were investigated with the focus moving to lower levels as emissions continued to

trend downward. The participating states developed a reference case scenario, carefully considering new generation sources on the way, projections of future demand, announced retirements, new regulatory requirements, and current and expected fuel prices.

The selection of a regional cap of 75,147,784 tons of CO_2 in 2021, which will decline by 2.275 million tons of CO_2 per year thereafter, resulting in a total 30 percent reduction in the regional cap from 2020 to 2030, was a difficult but well thought-out decision.

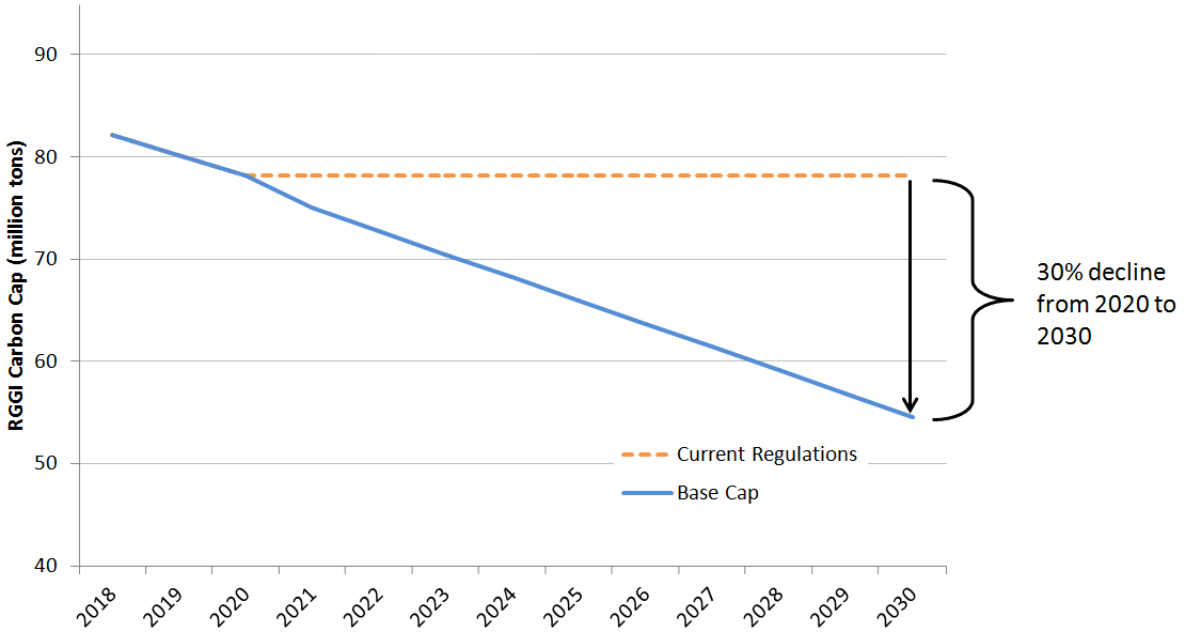

Figure 4.3-2. 2016 Program Review Cap Change.

The Cost Containment Reserve (CCR)

The participating states recognized the possibility of price volatility for allowances. To provide flexibility to affected sources, the participating states developed an offset program and allowed sources to use offset allowances for up to 3.3 percent of their compliance obligation. Additionally, if the cost of allowances exceeded certain prices and remained at those levels for extended periods of time, affected sources could purchase greater percentages of offsets in lieu of purchasing higher priced allowances. Under the condition of even higher prices, international offsets could be purchased instead of allowances. The low price for CO_2 allowances during the first two control periods did not encourage the development of a RGGI offset market, as the cost of sequestering a ton of CO_2 through offsets is significantly more expensive than the cost of a RGGI allowance. A second shortcoming to mitigating price volatility through an offset program is the length of time that may be necessary to achieve price relief. A faster, more effective method of reducing price volatility was needed.

During the 2012 Comprehensive Program Review, the participating states explored the option of adding additional allowances to the allocated supply to reduce price increases through a cost containment reserve. If the cost or clearing price of allowances in an auction reaches the trigger level, additional allowances are added to the auction, both increasing the supply and lowering the price. These allowances are in addition to the allowances in the cap and modeling has predicted that this option will be used sparingly, but will lower prices. The participating states feel this option will be more effective at lowering allowance prices than allowing increased amounts of offsets, which will continue to operate as a separate program.

The CCR is more effective when allowances are added to the cap than when the CCR is included under the cap. If the CCR is triggered, the added allowances do raise the cap for that year but only for that year. The following year the cap returns to its adopted regulatory limit for that year. Emissions from electric generating units do fluctuate due to differences in demand and weather conditions. In an extremely hot or cold year, emissions fluctuations could increase demand for allowances greatly producing price spikes. The CCR helps to lower extreme price spikes.

The 2016 Comprehensive Program Review resulted in additions to Maryland's original allocation of CCR allowances. Maryland initially allocated 1,135,217 CCR allowances for 2014. After review, it was determined that for subsequent years the CCR would be replenished with a sufficient number of allowances to achieve Maryland's 22.6 percent proportional share of the CCR. Further, beginning in 2021 and each subsequent year thereafter, Maryland will allocate a calculated number of allowances to the CCR as outlined in the following table:

Table 4.3-2. Maryland CCR Allocation By Year.

Year	Allowances
2018	2,236,466
2019	2,236,466
2020	2,236,466
2021	1,679,027
2022	1,628,147
2023	1,577,267
2024	1,526,388
2025	1,475,508
2026	1,424,629
2027	1,373,749
2028	1,322,869
2029	1,271,990
2030 and each succeeding calendar year	1,221,110

The CCR allowances are made available immediately in any auction in which demand for allowances at prices above the CCR trigger price exceeds the supply of allowances offered for sale in that auction prior to the addition of any CCR allowances. If the CCR is triggered, the CCR allowances will only be sold at or above the CCR trigger price, and are fully fungible. The CCR Trigger Prices were originally calculated after the 2012 Comprehensive Program Review to be $4 in 2014, $6 in 2015, $8 in 2016, and $10 in 2017.

Following the 2016 Comprehensive Program Review, the CCR trigger prices have been further calculated to include 2018 through 2030. From 2018 to 2020, the CCR trigger price is calculated as 1.025 multiplied by the CCR trigger price from the previous calendar year, rounded to the nearest whole cent. In 2021 the CCR trigger price is calculated to be $13.00. From 2022 to 2030, the CCR trigger price is calculated to be 1.07 multiplied by the CCR trigger price from the previous calendar year, rounded to the nearest whole cent. The calculated values of the CCR trigger prices are outlined in the following table:

Table 4.3-3. CCR Trigger Price By Year.

Year	CCR Trigger Price Amount
2018	$10.25
2019	$10.51
2020	$10.77
2021	$13.00

2022	$13.91
2023	$14.88
2024	$15.93
2025	$17.04
2026	$18.23
2027	$19.51
2028	$20.88
2029	$22.34
2030	$23.90

The Emissions Containment Reserve (ECR)

During the 2016 Comprehensive Program Review, the participating states recognized the need for a mechanism that will respond to supply and demand in the market if emission reduction costs are lower than projected. The ECR was therefore created to facilitate this role. States will withhold allowances from circulation to secure additional emissions reductions if prices fall below established trigger prices. Allowances withheld in this way will not be reoffered for sale. Beginning in 2021 and each subsequent year thereafter, Maryland will allocate a calculated number of allowances to the ECR as outlined in the following table:

Table 4.3-4. Maryland ECR Allocation By Year.

Year	Allowances
2021	1,679,027
2022	1,628,147
2023	1,577,267
2024	1,526,388
2025	1,475,508
2026	1,424,629
2027	1,373,749
2028	1,322,869
2029	1,271,990
2030 and each succeeding calendar year	1,221,110

The annual ECR allowance withholding limit would be 10 percent of Maryland's budget. The ECR trigger price, the price that allowances must fall below for the ECR to be utilized, will be $6.00 in 2021 and rise at 7 percent per year, so that the ECR will only trigger if emissions reduction costs are lower than projected. The calculated value of the ECR trigger prices are outlined in the following table:

Table 4.3-5. Maryland ECR Trigger Price By Year.

Year	ECR Trigger Price Amount
2021	$6.00
2022	$6.42
2023	$6.87
2024	$7.35
2025	$7.86
2026	$8.42
2027	$9.00
2028	$9.63
2029	$10.31

2030	$11.03

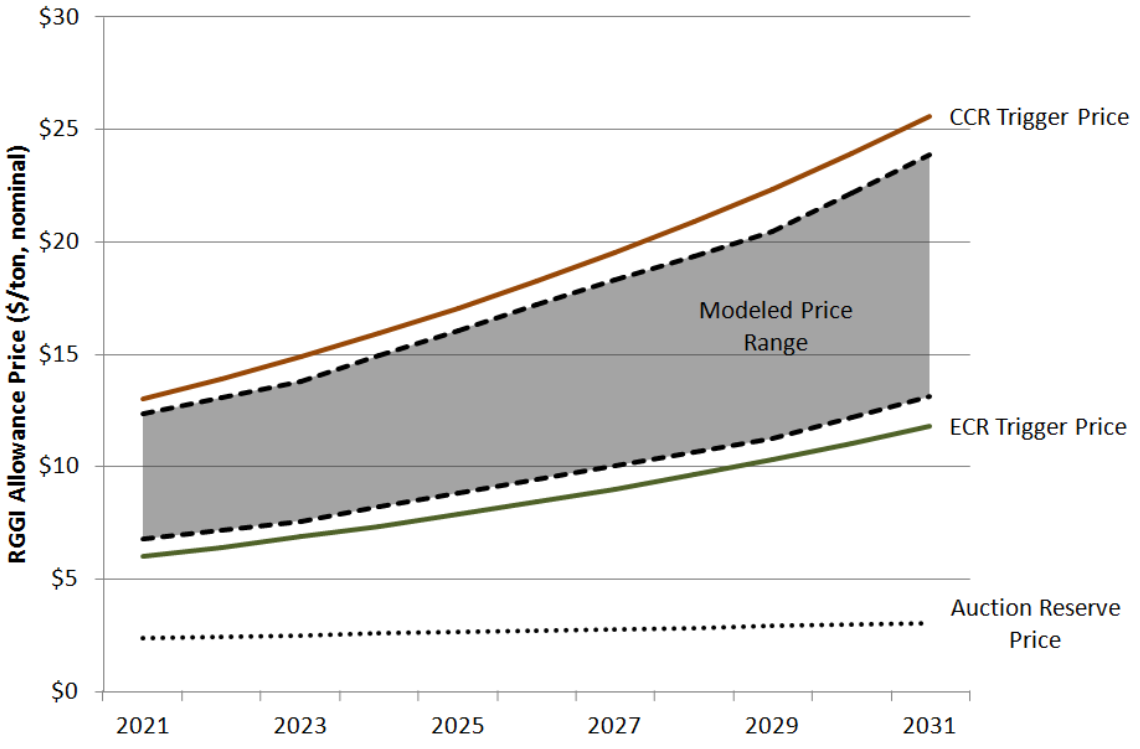

Figure 4.3-3. CCR and ECR Price Triggers.

Budget Adjustments

RGGI allows sources to bank allowances in two ways. Sources can use current vintage allowances to satisfy future compliance obligations. The participating states have also auctioned future vintage allowances in the past. These allowances often sell at prices lower than they would in the future.

The participating states addressed potential large banks of allowances through the 2012 Comprehensive Program Review by adjusting how many allowances will be sold through 2020. The participating states further addressed this issue in the 2016 Comprehensive Program Review through one additional, distinct budget adjustment. The private bank of allowances is now addressed through three distinct adjustments to the state budget. The Adjustment for First Control period Banked Allowances is established as 1,863,361 allowances applicable to allocation years 2014 through 2020. The Adjustment for Second Control Period Banked Allowances is established as 3,106,578 allowances applicable to allocation years 2015 through 2020. The newly created Third Adjustment for Banked Allowances adjusts the budget for allocation years 2021 through 2025. The third adjustment timing and algorithm is spelled out in the regulations. This addition helps to create a binding cap in light of the opportunity sources have to accumulate low cost allowances while states implement the regulatory changes needed to establish the lower cap.

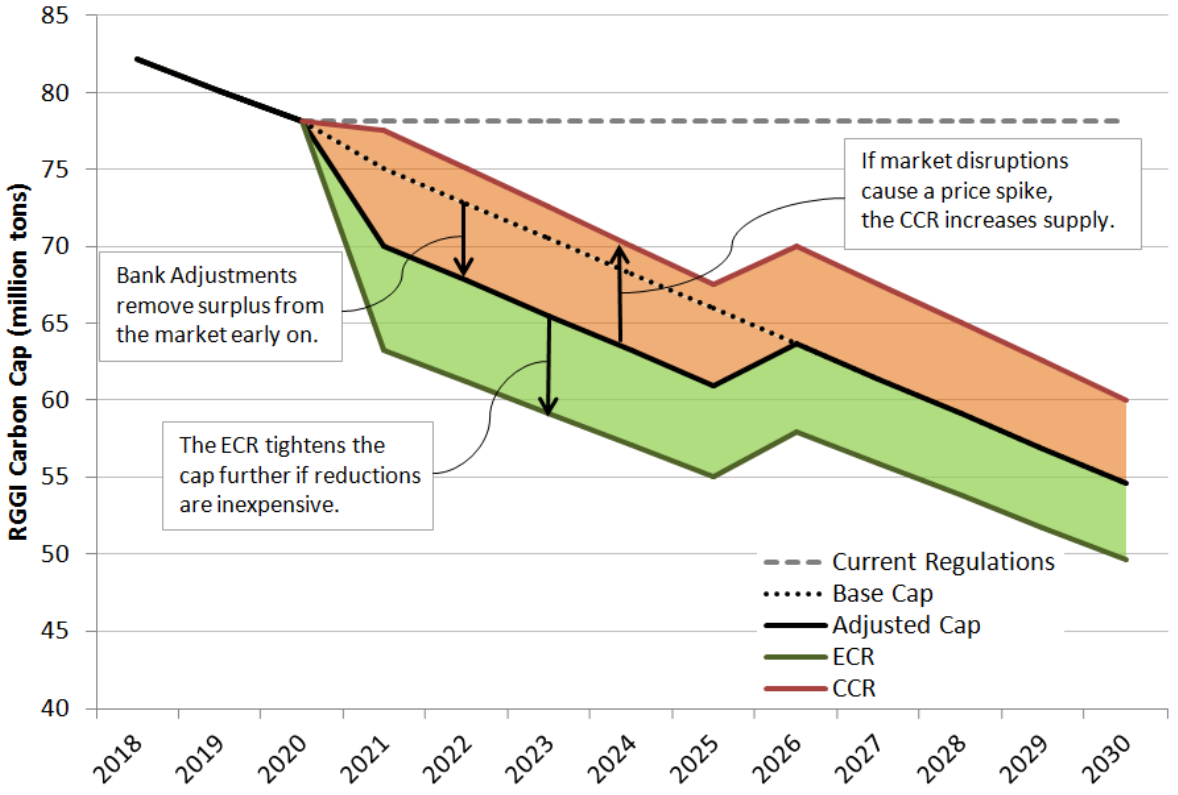

Figure 4.3-4. Adaptive Cap.

Offsets

The RGGI regulations contain language that eliminates two of the five current offset categories; 1) Reduction in Emissions of Sulfur Hexafluoride (SF_6) due to obsolescence, and 2) Reduction or Avoidance of CO_2 Emissions from Natural Gas, Oil, or Propane End-Use Combustion Due to End-Use Energy Efficiency due to improvements and availability of energy efficiency technologies. While these two offset categories were removed, the three remaining offset categories were maintained and updated. Any awarded offset allowances would remain fully fungible across the participating states.

4.3.4 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.

4.3.4.1 GHG Power Plant Emission Reductions from Federal Programs

Lead Agency: MDE

Program Description

GHG emissions from the energy supply sector in Maryland include emissions from fossil fuel-fired electricity generation and represent a substantial portion of the State's overall GHG emissions. 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 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 (4.3.4.1.1 Boiler Maximum Achievable Control Technology; 4.3.4.1.2 GHG New Source Performance Standard; and 4.3.4.1.3 GHG Prevention of Significant Deterioration Permitting Program) are expected to reduce GHG emissions from Maryland and out-of-state power generators.

4.3.4.1.1 Boiler Maximum Achievable Control Technology (MACT)

Lead Agency: MDE

Program Description

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 Hazardous Air Pollutant (HAP) of 25 tons per year of any combination of HAPs. The Boiler MACT rules require operators to conduct a boiler tune-up to improve efficiency, minimize fuel consumption, and reduce emissions.

Program Objectives

The Boiler MACT program's purpose is to reduce GHG emissions from both Maryland and out-of-state power generators.

Implementation Milestones

EPA adopted new air emissions requirements for industrial, commercial, and institutional boilers under two separate rulemakings. Specific implementation milestones include:

- January 2013: established national emission standards for Hazardous Air Pollutants (HAPs) for major sources
  - The rule affects thousands of boilers and process heaters at facilities nationwide that are considered as major sources
- February 2013: EPA issued a Boiler MACT rule for smaller "area sources"
- March 2014: All boilers demonstrate compliance with emission limits and perform compliance reports as mandated
- January 2016: 18 new boilers have obtained permits and are subject to the MACT

Enhancement Opportunities

This program has the potential to be enhanced every time new control technology is developed through new regulations and standards.

Funding

According to the Regional Economic Studies Institute (RESI) at Towson University's 2015 Study, the Boiler MACT program is expected to use $94,374,000 from 2010 to 2020. The Boiler MACT program 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.

Challenges

While it does not necessarily experience a major "challenge," the Boiler MACT program is instead limited by the availability, effectiveness, and overall viability of current control technology.

4.3.4.1.2 GHG New Source Performance Standard

Lead Agency: MDE

Program Description

EPA is using the New Source Performance Standard's authority under the federal Clean Air Act to promulgate new regulations to reduce GHG emissions from fossil fuel-fired power plants. These standards apply to new electric generating units and are 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.

Program Objectives

The GHG New Source Performance Standard is designed with the intent to lower GHG pollution from fossil fuel-fired power plants.

Implementation Milestones

The New Source Performance Standard is fully enforceable through the federal Clean Air Act. MDE will implement the federal rules by adopting it into Maryland state regulations. The MDE Air Quality Compliance Program will then insure that the utilities comply with the requirements. Based on certified emissions reports, the MDE will be able to determine the amount of GHG reductions achieved.

Enhancement Opportunities

The New Source Performance Standard is tied to the Clean Air Act, thus, any enhancements are likewise tied to the authority granted by the Clean Air Act.

Funding

RESI's 2015 study estimated that from 2010 to 2020, New Source Performance Standard is expected to use $4,800,000. 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, all in Maryland.

Challenges

The main challenge to this standard will lie in finding these emissions solutions that reduce multiple pollutants at once. Once solutions are found that are applicable to the standard power plant, the program's success will ultimately just be a matter of proper communication.

4.3.4.1.3 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. It applies to new major stationary sources and major modifications at existing sources. PSD requires the application of Best Available Control Technology (BACT) to control emissions of certain pollutants, which now include GHGs. Sources subject to the requirements of PSD program must evaluate and apply currently available measures and future technology as it develops to reduce GHG emissions.

The PSD program's "increment" is the amount of pollution an area is allowed to increase. The PSD program's increments prevent the air quality in clean areas from deteriorating to the level set by the National Ambient Air Quality Standards. The National Ambient Air Quality Standards is a maximum allowable pollution amount. A PSD program increment, on the other hand, is the maximum allowable increase in concentration that can occur above a baseline concentration for a pollutant. The baseline concentration is defined for each pollutant and, in general, is the ambient concentration at the time that the first complete PSD permit application affecting the area is submitted. Significant deterioration is said to occur when the amount of new pollution would exceed the applicable PSD increment. It is important to note, however, that the air quality cannot deteriorate beyond the concentration allowed by the applicable National Ambient Air Quality Standards, even if not all of the PSD increment is consumed.

Program Objectives

The PSD program aims to limit the emissions of pollutants and GHGs by mandating that stationary sources use BACT. BACT determination is designed to be fair, as it considers the cost-effectiveness and relative energy and environment impacts of the controls.

Implementation Milestones

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

Specific implementation milestones include:

- January 2011: Requirements will apply to sources' GHG emissions only if the sources are already subject to the PSD due to their non-GHG pollutants
    - Therefore, EPA will not require sources or modifications to evaluate whether they are subject to this program's requirements solely on account of their GHG emissions
    - The PSD program's BACT will apply to projects that increase net GHG emissions by at least 75,000 tons (CO_2 equivalent) per year, but only if the project also significantly increases emissions of at least one non-GHG pollutant
- July 2011: the PSD program's BACT will apply to either new sources that have the potential to emit 100,000 tons (CO_2 equivalent) per year or existing sources modified to increase net emission of CO_2 equivalent by at least 75,000 tons per year
- July 2013: additional sources will be included under the PSD program requirements and a possible permanent exclusion from permitting will be determined for some source categories
- April 2015: EPA will establish an enforceable commitment stating that EPA will complete a streamlining study to evaluate the status of the PSD program for GHG emitting sources
    - No sources with emissions below 50,000 tons (CO_2 equivalent) per year and no modification resulting in net GHG increases of less than 50,000 tons (CO_2 equivalent) per year will be subject to this program's permitting before at least 6 years from now until April 30, 2016

Enhancement Opportunities

The PSD will be naturally enhanced as new control technologies are developed. As the BACT changes with new advances, the PSD requirements will adjust and improve.

Funding

RESI's 2015 study estimated that the total cost for the program between 2010 and 2020 is expected to be $1,210,500. The GHG PSD 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.

Challenges

As mentioned above, PSD will naturally be enhanced as control technology improves. However, this will require continued funding and research. If money and time is shifted away from finding new techniques and technology to limit GHG emissions, the PSD program will be stalled and may stagnate with a lack of new control technologies.

4.3.4.2 Energy Financing for Housing and Communities (formerly Main Street Initiatives)

Lead Agency: DHCD

Program Description

DHCD implements housing policy that promotes and preserves homeownership and creates community development initiatives to meet the challenges of a growing Maryland. These programs cover rental housing, business lending, homeownership, affordable housing development, and energy conservation and efficiency. Within DHCD's Community Development Administration (CDA), the division of Housing and Building Energy Programs manages a suite of loan and grant programs that fund energy projects for Maryland homeowners, renters and other building owners. *(*Section 4.3.4.2 includes energy financing programs. Section 4.3.4.3 includes energy grant and deferred loan programs for limited income families in single family and multifamily housing.*)*[100]

The BeSMART Home Energy Loan Program offers financing to homeowners across the state for energy efficiency replacement and/or upgrade of appliances, heating, cooling and ventilation systems and whole house envelope improvements. The product in CY18 was 4.99 percent APR unsecured loan with a term of 10 years.

DHCD has also developed new finance programs that use EECBG revolved funds, SEIF, and/or general fund appropriations. *The Net Zero Construction Loan Program* funds the construction of new or existing single and multifamily housing in Maryland. The project must be Net Zero or Net Zero Ready.

Implementation Milestones

The original EECBG grant was a competitive grant award and was fully expended. Since inception to the end of FY18, the BeSMART program has closed 182 home loans at a total of $3.1 million, $737 thousand in business loans, and $9.6 million in multifamily loans.

In FY18 DHCD closed 39 BeSMART loans with homeowners for energy efficiency improvements from revolved EECBG loan payments. DHCD also continued construction on a Net Zero loan project at the Perry Point Veterans

[100] Section 4.3.4.2 was formerly titled after a $20 million grant award from the U.S. Department of Energy's (DOE) Better Buildings/Energy Efficiency Conservation Block Grant (EECBG) program. The American Recovery and Reinvestment Act of 2009 (ARRA) award was a one-time source that funded the creation of a revolving loan fund for energy efficiency financing for homeowners, businesses and multifamily buildings as well as grant and training programs. This fund continues to revolve in the BeSMART programs.

Housing Project, using funding from the SEIF and leveraged with the EECBG loan program for efficiency measures.

Enhancement Opportunities

In FY19 DHCD will analyze its BeSMART home loan and Net Zero Construction loan programs and plan to begin reporting energy savings associated with these programs in outgoing years.

In FY19, DHCD is starting a review of other DHCD programs to identify opportunities and progress in reducing GHG emissions for future reporting. For example, the CDA's Multifamily Rental Financing Program requires its projects to perform an energy audit for rehabilitation projects, pursue measures to reduce energy by 15 percent over baseline condition, or fund all measures from the audit that have a savings to investment ratio of at least 2 (lifetime savings are twice as large as the investment cost). This is a potentially significant source of GHG reductions that DHCD has not previously reported.

Funding

For the BeSMART (EECBG) Home Loan program, DHCD uses revenue from interest earned on outstanding principal to maintain administrative costs for the program. Returned principal is required to be revolved into new loans.

The Net Zero Construction Loan Program received $1.1 million in funding from the SEIF and $500,000 in general fund appropriations in FY18. The Program received $1 million in general fund appropriations in FY20.

Challenges

Limited administrative resources for BeSMART restrict opportunities for outreach, education for borrowers, and training for contractors.

4.3.4.3 Energy Efficiency for Affordable Housing and Limited Income Families (formerly Energy Efficiency for Affordable Housing)

Lead Agency: DHCD

Program Description

DHCD's division of Housing and Building Energy Programs includes the following energy grant and deferred loan programs for limited income families and affordable multifamily housing:

The *Weatherization Assistance Program* installs energy conservation measures for eligible limited income households. These measures also reduce GHG emissions and the cost of maintenance for these homes. Funding is provided by the U.S. Department of Energy and the Strategic Energy Investment Fund. DHCD works with Local Weatherization Agencies.

The *EmPOWER Low Income Energy Efficiency Program* and the *Multifamily Energy Efficiency and Housing Affordability Program* provide grants and deferred loans to limited income households and individually-metered affordable housing managers respectfully. These awards fund installation of energy conservation measures in homes and buildings. Funding is provided by ratepayers of the five (5) participating EmPOWER Maryland utility companies. These funds are regulated by the PSC.

The *Targeted and Enhanced Weatherization Program* combined typical weatherization improvements with measures that reduced health and safety risks in the home. This program for limited income homeowners in the Baltimore Gas & Electric territory outside of Baltimore City was funded through the Customer Investment Fund created during the merger of Constellation and Exelon. *The Improved Efficiency for Affordable Multifamily Housing Program* was funded through the Customer Investment Fund and it covers the costs of energy conservation measures for master-metered affordable multifamily projects in the Baltimore Gas & Electric territory. These programs have closed.

Program Objectives

Among other drivers, the division's program support Maryland's effort's to:

1. Reduce the energy cost burden on Maryland residents
2. Increase energy efficiency and reduce GHG emissions
3. Create and preserve affordable housing opportunities, and
4. Create jobs.

Implementation Milestones

In CY17, DHCD's energy programs installed upgrades that saved 0.008 $MMTCO_2e$ in the first year of installation. In prior years DHCD reported only on the GHG reductions from projects installed in their first year. Taking into account the average lifetime of energy measures at 8 years, DHCD's programs realized a reduction of 0.06 $MMTCO_2e$ in CY17 from projects completed from CY11 to CY17. Finally, from CY11 to CY17, the cumulative savings from all projects was 0.2 $MMTCO_2e$.

Table 4.3-6. Success Metrics – Limited Income Weatherization in Single and Multifamily Units.

	CY11	CY12	CY13	CY14	CY15	CY16	CY17	TOTAL
First Year Savings								
Units	6,317	3,222	3,788	6,517	5,828	5,517	4,695	35,884
MMBtu	84,027	84,608	114,262	109,752	72,248	89,632	88,857	643,386
MTCO2e	10,331	10,218	11,782	10,169	7,346	8,164	7,971	65,981
Sustained Savings (8 Year Average Useful Life est. 2011)								
MMBtu	84,027	168,636	282,897	392,649	464,897	554,529	643,386	2,591,022
MTCO2e	10,331	20,124	32,229	42,301	46,832	54,200	60,366	266,383

For the projects installed in CY17, these projects will continue to reduce GHG emissions every year until 2024. Some measures will provide savings beyond 2030.

The Customer Investment Fund's Enhanced Weatherization program and Improved Efficiency for Affordable Housing Program were one-time grants and are fully expended as of the end of CY18. DHCD is conducting an evaluation of these programs in FY19 and FY20.

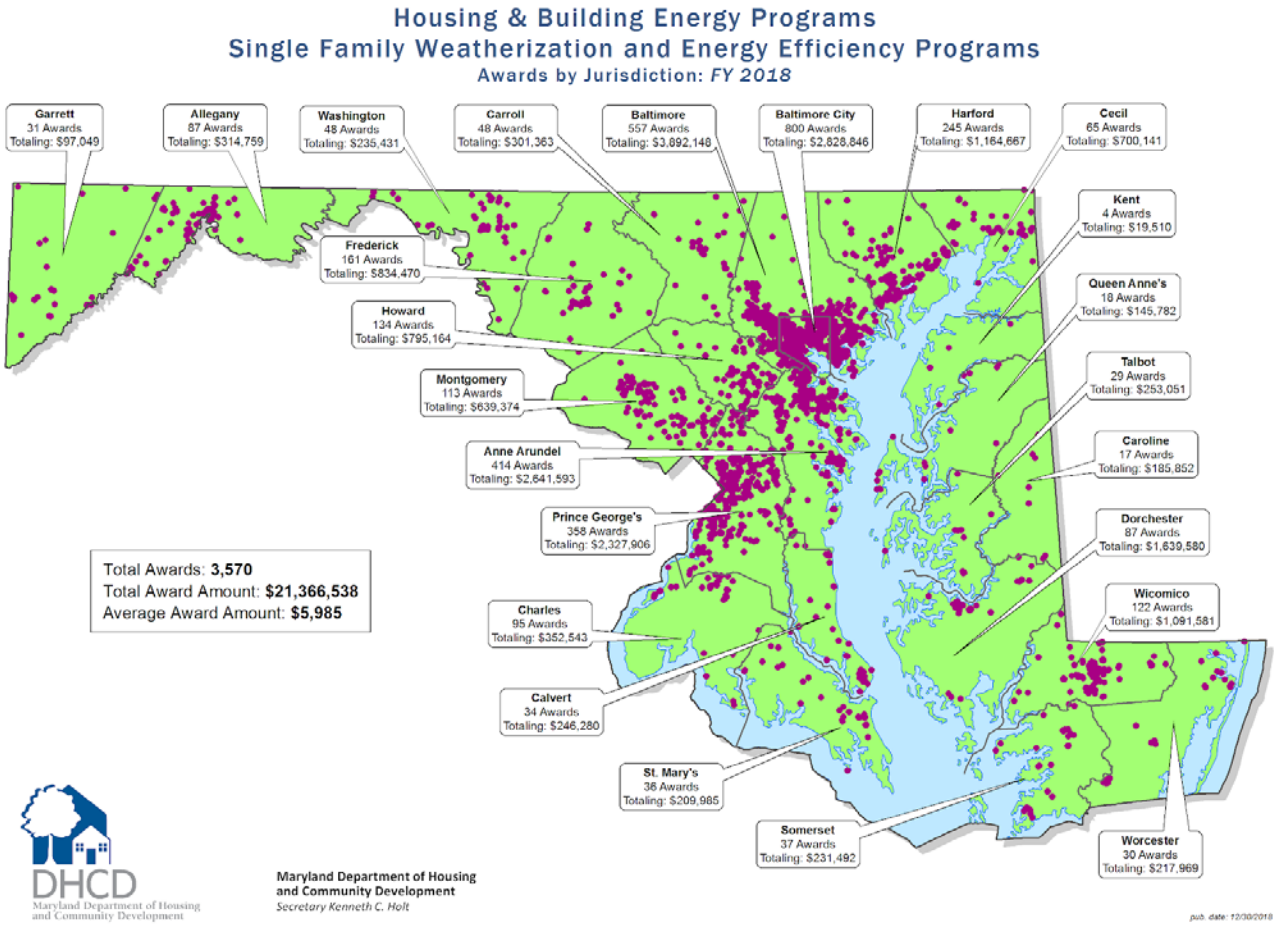

Figure 4.3-5. Housing and Building Energy Programs. Single Family Weatherization and Energy Efficiency Programs. Awards by Jurisdiction: FY18.

Enhancement Opportunities

DHCD continues to pursue opportunities to expand its loan and grant programs. DHCD sees an opportunity from leveraging the experience of its multifamily, single family, and business lending to grow the energy programs.

Funding

In each of the last three fiscal years, the division's financial commitments (direct benefits to Marylanders and administrative costs) averaged $25 million. This is largely supported by EmPOWER funding that requires renewal every three years and the Customer Investment Fund, where customer benefits were expended in FY18.

Challenges

At the current time DHCD is not slated to receive SEIF funds from RGGI proceeds in FY 2019. These funds allow DHCD to maximize savings per project. DHCD also fully expended the Customer Investment Fund award as of the end of FY18, which leaves a gap for Maryland residents with energy efficiency opportunities but higher cost health and safety hazards.

4.3.5 Transportation Technologies

Lead Agency: MDE, MDOT, and MEA

Program Description

State and federal initiatives in transportation technologies that affect fuel economy standards significantly contribute to the 2030 transportation sector GHG reductions. The technology advances are designed to improve vehicle fuel economy, reduce average GHG emissions per mile, and develop lower GHG transportation options. The federal emission standards have been adopted through EPA Final Rulemakings and include light-duty vehicles, medium- and heavy-duty trucks, and fuel standards. Benefits from these programs represent the largest contributor to GHG reductions in the transportation sector. The benefits will increase over time as newer vehicles enter the fleet and older vehicles are removed from the fleet.

Additionally, Maryland has adopted the California Clean Cars Program, ensuring that Maryland receives the cleanest fossil fuel burning vehicles on the market as well as a growing percentage of ZEVs. The adoption of California's GHG Program by thirteen other states and the District of Columbia has proven to be an effective driver for many of the federal GHG and fuel economy programs.

Maryland, through the combined efforts of MDE, MDOT and MEA, has made significant progress in advancing the deployment of plug-in electric hybrid vehicles and battery EVs.

Light-Duty Vehicle (Passenger Cars and Trucks) Standards

- **The Maryland Clean Car Program (Model Year 2011)** – The Maryland Clean Cars Act of 2007 required MDE to adopt regulations to apply California's Low-Emission Vehicle (LEV) standards to vehicles purchased in Maryland. The California program also includes a mandate for the sale of ZEVs (adopted 2007).
- **Corporate Average Fuel Economy (CAFE) Standards (Model Years 2008-2011)** – Vehicle model years through 2011 are covered under existing CAFE standards that will remain intact under the new national program.
- **National Program (Model Years 2012-2016)** – The light-duty vehicle fuel economy standards for model years between 2012 and 2016. The fuel economy improvements increase over time until an average 250 gram/mile CO_2 standard is met in the year 2016. This equates to an average fuel economy near 35 mpg (published May 2010).
- **National Program Phase 2 (Model Years 2017-2025)** – The light-duty vehicle fuel economy standards for model years between 2017 and 2025. The standards are phased-in and projected to result in an average 163 gram/mile of CO_2 by model year 2025. This equates to an average fuel economy of 54.5 mpg (published October 2012).

Medium/Heavy-Duty Vehicle (Trucks and Buses) Standards

- **Phase 1 National Medium and Heavy Vehicle Standards (Model Years 2014-2018)** – Fuel efficiency and GHG standards for model years 2014 to 2018 medium- and heavy-duty vehicles. The new rulemaking adopted standards for three main regulatory categories: combination tractors, heavy-duty pickups and vans, and vocational vehicles. (published September 2011)
- **Phase 2 National Medium and Heavy Vehicle Standards (2018 and Beyond)** – The Phase 2 fuel efficiency and GHG standards for medium- and heavy-duty vehicles for model year 2018 and beyond. The standards apply to four categories of medium- and heavy-duty vehicles: combination tractors, heavy-duty pickups and vans, vocational vehicles and trailers to reduce GHG emissions and improve fuel efficiency. The standards phase in between model years 2021 and 2027 for engines and vehicles, and between model years 2018 and 2027 for trailers. (published October 2016)

Fuel Standards

- **Tier 3 vehicle and fuel standards** – The rule establishes more stringent vehicle emissions standards and will reduce the sulfur content of gasoline from current average level of 30 ppm to 10 ppm beginning in 2017. The gasoline sulfur standard will make emission control systems more effective for both existing and new vehicles and will enable more stringent vehicle emission standards. The vehicle standards will reduce both tailpipe and evaporative emissions from gasoline powered vehicles, yielding minor improvements in vehicle efficiency, resulting in GHG emission reductions. (published April 28, 2014)
- **The Federal Renewable Fuel Standard Program** – Mandates the use of 36 billion gallons of renewable fuel annually by 2022 (published March 2010). Based on an approach utilized by MWCOG, the use of renewable fuels will represent a 2 percent reduction in total on-road gasoline CO_2 emissions in 2030.
- **Electric Vehicles (EVs)** – Initiatives to encourage the use of electric and other low and zero-emitting vehicles are part of Maryland's efforts to reduce emissions of GHGs and other air pollutants from mobile sources by providing alternatives to conventional internal combustion engine vehicles. EVs include plug-in all-electric vehicles, battery EVs (BEVs), and plug-in hybrid EVs.

MDOT, working with MEA, has assumed a leadership role in facilitating the deployment of EVs and EV charging infrastructure in the State. With the passage of the Clean Cars Act of 2017, the new law provided the following changes:

- Extended the Electric Vehicle Recharging Equipment Rebate Program and authorization to issue motor vehicle excise tax credits for qualified PEV vehicles through FY20.

- Increased the total amount of equipment rebates from up to $600,000 to a maximum of $1,200,000 per fiscal year, increasing the amount required to be transferred from the Strategic Energy Investment Fund to the Transportation Trust Fund.

- Increased the amount of motor vehicle excise tax credits that may be issued during a fiscal year. The credit value was reduced to $100 per kilowatt-hour (kWh) of battery capacity of the vehicle up to $3,000.

- Added additional eligibility requirements, capping qualifying vehicle purchase prices at $60,000, and requiring a minimum battery capacity of 5 kWh.

- Drivers of approved plug-in EVs can use Maryland's high occupancy vehicle (HOV) lanes even if they are traveling solo.

Program Objectives

Maryland is a leader in adopting strategies to advance cleaner vehicles and fuels, via the Maryland Clean Car Program, starting in 2011. The Clean Cars Program continues to be the driver for many of the Federal motor vehicle standards that have recently been adopted. Further improvements in vehicle technologies and fuels are anticipated to play a key role in significantly improving air quality and GHG emissions.

MDE, MDOT, and MEA have different roles in reducing GHG emissions from the transportation sector. The three agencies work together to facilitate programs that promote advanced technology vehicles and alternative fuels.

MDE implements the Clean Cars Program, ensuring Maryland stays in compliance with the requirements to maintain California's emission standards and updating the regulations as necessary to remain consistent with

California. MDE enforces the GHG and ZEV requirements of the Program and ensures the vehicle manufacturers remain in compliance.

For emerging and innovative technologies, MDOT plays the role of a facilitator and a policy regulator. In this role, MDOT helps provide a safe and conducive environment for Maryland residents and businesses to adopt new technologies that are reshaping mobility choices and providing cleaner alternatives to single occupant vehicle travel. Emerging and innovative strategies are inherently characterized by uncertainty in the technological and policy maturity that is necessary for widespread acceptance and adoption. Examples that need this maturity are CAV technologies, zero emission truck corridors, and Superconducting MAGLEV (SCMAGLEV) or Hyperloop. MDOT will continue to nurture the growth of these emerging and innovative technologies.

MEA spurs the adoption of new vehicle technologies and alternative fuels by providing rebates and incentives for the purchase of alternative fuel vehicles and the construction of alternative fuel stations. This includes rebates for EV charging infrastructure and incentives for petroleum reducing fuel stations, such as compressed natural gas and Fast Charging EV stations.

Implementation Milestones

Maryland Clean Cars Program/Federal Vehicle and Fuel Standards

Implementation of these state and federal vehicle and fuel standards yields a significant GHG emissions benefit for on-road emissions from cars and trucks through 2030. Ultimately, vehicle turnover rates, vehicle purchase and operating costs, and other economic factors will impact exactly what the on-road fleet looks like in 2030. The federal programs are managed by EPA and the National Highway Transportation Safety Administration (NHTSA) through partnerships with vehicle manufacturers.

Electric Vehicles (EVs)

Vehicle manufacturers will attain fleet-wide GHG emission requirements through a mix of different vehicle models and technologies. The fleet-wide mix will include PHEVs and BEVs, along with traditional gasoline and diesel-powered vehicles. Achieving the goals within Maryland's participation within the ZEV mandate (300,000 EVs by 2025) reflects a commitment to a low-emissions fleet that goes beyond what the federal standards require. The path from nearly 20,000 PHEVs and BEVs registered in Maryland in April 2019 to 300,000 vehicles by 2025 and 600,000 vehicles by 2030 will require a combination of challenging factors to come together. Maryland is rising to this challenge through an aggressive approach to the deployment of EVs and the charging stations necessary to support their adoption.

Maryland has also been a leader in offering incentives for the purchase and use of plug-in EVs. Plug-in vehicles are allowed to use the HOV lanes in Maryland regardless of the number of passengers. Time-of-use (TOU) energy rates are available to some residents of the state depending on their energy provider. TOU rates allow plug-in vehicles to charge during off-peak hours at a reduced energy rate, thereby saving on the cost of energy to recharge their vehicle. Certain utilities throughout the state have begun a program to provide rebates to customers who purchase a qualifying smart EV charger. This program will complement MEA's Electric Vehicle Supply Equipment (EVSE) rebate program by providing an additional incentive for the purchase of residential and multi-unit dwelling charging stations. Owners and operators of EVSE are not subject to regulations as an electricity supplier and therefore are allowed sell the electricity they provide to vehicle owners.

Maryland also offers an excise tax credit for the purchase of a plug-in EV. Financial incentives have proven to be one of the most effective means for increasing the adoption rate of EVs and Maryland has consistently offered this

incentive. Recently, two pieces of legislation have worked to improve the excise tax credit as well as the charging station rebate by extending and increasing the amount of funding available for both incentives.

The Clean Cars Act of 2017 extended the EVSE rebate and vehicle excise tax credit through fiscal year 2020. The total amount of funding available for the charging equipment rebate increased from $600,000 to $1,200,000. The amount available for the vehicle tax credit increased from $1,800,000 to $3,000,000 and vehicles with an MSRP over $60,000 were no longer eligible for the tax credit.

The Clean Cars Act of 2019 increased the amount of funding available for the vehicle tax credit from $3,000,000 to $6,000,000 and included fuel cell vehicles for the first time as an eligible vehicle to receive the tax credit. The law increased the MSRP cap for vehicles to $63,000.

The Zero Emission Vehicle Memorandum of Understanding (ZEV MOU)

On June 20, 2018, nine Northeast and West Coast states reaffirmed their strong commitment to a clean, low-carbon transportation sector with the release of a new Multi-State ZEV Action Plan for 2018-2021 to support the successful implementation of the states' ZEV programs.

The Action Plan, which builds on the successes and lessons learned from implementation of an earlier 2014 ZEV Action Plan, presents 80 market-enabling action recommendations for states, automakers, dealers, utilities, charging and fueling companies and other key partners to rapidly accelerate mainstream consumer adoption of ZEVs, including plug-in hybrid, battery electric and hydrogen fuel cell vehicles.

The updated ZEV Action Plan is the work of the Multi-State ZEV Task Force, which was formed in 2013 under a Memorandum of Understanding (MOU) signed by the Governors of California and seven other states that have adopted California's ZEV program – Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island and Vermont. New Jersey became the ninth ZEV state to join the coalition when they signed the MOU in May. Together, the nine ZEV MOU states represent nearly 30 percent of the new car sales market in the United States.

Key Action Plan Recommendations

While many of the recommendations in the 2014 Action Plan remain valid today, the new Action Plan represents a redoubling of state efforts to accelerate electrification of the light-duty vehicle market, and recognition of the important role that public-private partnerships involving the automakers, dealers, utilities and others play in the effort. Recommendations for states and other key partners in the updated Action Plan are focused on five priority areas:

- Raising consumer awareness and interest in EV technology;
- Building out a reliable and convenient residential, workplace and public charging/fueling infrastructure network;
- Continuing and improving access to consumer purchase and non-financial incentives;
- Expanding public and private sector fleet adoption; and
- Supporting dealership efforts to increase ZEV sales.

In his support of this Action Plan Governor Hogan stated, "The new Multi-State ZEV Action Plan recognizes the catalytic role utilities can play in advancing transportation electrification through investments in charging infrastructure, consumer outreach programs and new rate structures that benefit the grid and reduce charging costs for consumers." Governor Hogan also added that "Maryland's four largest utilities have proposed major investments in a statewide portfolio of infrastructure and other transportation electrification programs totaling

more than $100 million. If approved, these utility investments will go a long way toward closing the existing charging gap in Maryland."

The full Multi-State ZEV Action Plan is accessible at:
http://www.nescaum.org/documents/2018-zev-action-plan.pdf

Figure 4.3-6 below presents the projected ZEV deployment curve through 2030 based on a 2017 base year. Maryland costs to facilitate this level of deployment includes up to $1.2 million annually through 2030 for the Electric Vehicle Recharging Equipment Rebate Program and other costs associated with matching federal grants to expand public EV charging infrastructure throughout Maryland.

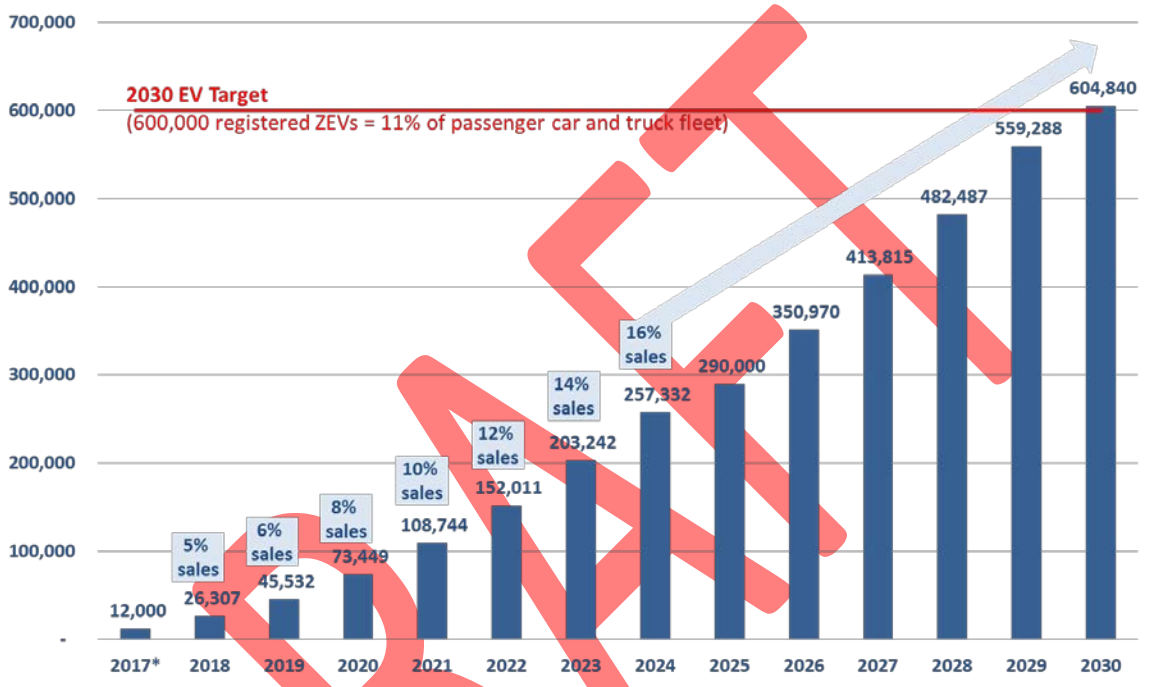

Figure 4.3-6. Electric Vehicle Deployment Approach.

The Clean Cars Act of 2019 made changes to the Electric Vehicle Infrastructure Council (EVIC), renaming it the Zero Emission Electric Vehicle Infrastructure Council (ZEEVIC) and broadened the focus of the Council to include hydrogen fueling stations and fuel cell vehicles. The law charged the Council with developing a plan to facilitate the integration of hydrogen fuel cell vehicles along with plug-in EVs into the State's transportation network. MDOT chairs the legislatively established body, comprised of a diverse group of stakeholders who are dedicated to attaining Maryland's ZEV goals. ZEEVIC brings this group together with the goal of creating opportunities, developing financial incentives, promoting ZEVs, and the installation of the infrastructure necessary to support the State's ZEV goals.

- ZEEVIC has made progress on several vital initiatives and is continuing to work on removing barriers to the adoption of ZEVs. In 2018, the Electrification Coalition recognized Maryland's work by designating Maryland as a top tier, or Tier 1, EV State when they issued their inaugural, ZEV Scorecard. Maryland was second only to California and ranked highly based on the State's work on incentives, publicly available EVSE, and public outreach.
- ZEEVIC produces annual reports on the progress of developing, evaluating and recommending strategies to facilitate the successful integration of ZEVs and ZEV infrastructure into Maryland's existing transportation infrastructure.
- ZEEVIC supported the passage of the Clean Cars Act of 2017, which increased and extended funding that support rebates and incentives for EV purchases.

- MDOT is working to complete an EV Signage Plan, focusing first on the acquisition, installation, and maintenance of EV signage on Maryland's 10 Federal Highway Administration (FHWA) designated alternative fuel corridors.

PC44 EV workgroup

With a goal of ensuring that Maryland's electric grid is customer-centered, affordable, reliable and environmentally sustainable, the PSC initiated a proceeding, titled Public Conference 44 (PC44) to launch a targeted review of electric distribution systems in Maryland.

The Commission outlined a series of potential actions that could be pursued by a newly-formed EV Work Group in the context of a statewide grid modernization proceeding (i.e. PC44). Specifically, the Commission tasked the PC44 EV Work Group with, at a minimum, pursuing desired outcomes that generally correspond to the following goals: (1) increasing and diversifying EV tariff offerings across multiple service territories and customer classes; (2) planning for a limited utility infrastructure investment in EVSE; (3) developing a strategy to address grid-related costs associated with vehicle fleet electrification; (4) facilitating and encouraging equitable access to benefits derived from vehicle fleet electrification, especially in underserved market segments; and (5) developing a customer education, outreach, and engagement strategy in coordination with other state agencies to promote the outcomes of the PC44 EV Work Group proceeding.

The Utilities were then tasked with developing programs that would accomplish these goals. Once developed, the Utilities presented their proposed plans for review and approval. These proposals were reviewed and finalized in 2018 and will begin implementation in the 2019/2020 timeframe.

The Volkswagen Mitigation Plan

As a result of a 2016 settlement between EPA, the California Air Resources Board (CARB) and Volkswagen for violations of the Clean Air Act that involved software designed to defeat emissions standards, Volkswagen is required to spend $2.7 billion on emission reduction programs nationwide. This software or "defeat device" allowed cars to meet emissions standards in a laboratory or a testing station, but during normal operation those vehicles emitted nitrogen oxide at up to 40 times the standard. Approximately 16,000 of the affected vehicles were sold in Maryland, negatively impacting our air quality.

Under the Environmental Mitigation Trust established in the 2016 settlement, Maryland is eligible to receive $75.7 million for use on specifically defined mitigation projects to remediate the excess nitrogen oxide emissions. MDE was the lead agency tasked with developing Maryland's mitigation plan in accordance with the list of eligible projects and matching fund requirements required under Appendix D-2 of the Settlement. The draft plan placed priority on EV charging infrastructure – allocating the full 15 percent that is allowed for this category – and the replacement of older, dirty diesel engines with new, cleaner technologies. Electric buses and heavy-duty equipment such as trucks, boats and locomotives are potential projects that are eligible for funding.

MDE requested public comments on the draft plan and held public meetings in August 2018. Changes made to the draft plan in response to public comments include an increase in funding for local government projects, and the addition of a pilot program of electric school buses. The plan has been finalized and approved by the Trustee. Vehicle replacement project proposals were accepted until May 6th, 2019 and are currently being evaluated for funding potential.

Additional information on Maryland's Plan can be found at: https://mde.maryland.gov/programs/Air/Mobile-Sources/Pages/MarylandVolkswagenMitigationPlan.aspx

Maryland participates on TCI's Clean Vehicles and Fuels Workgroup that supports the deployment of clean vehicles and fueling infrastructure throughout the TCI states to maximize the economic opportunities and emissions reductions that these vehicles bring to the region.

MDOT Efforts

- Traffic Relief Plan: MDOT continues to work on some major congestion mitigation initiatives including the Traffic Relief Plan, highlighting the importance of fuel optimization and GHG mitigation as a result of improved travel speeds, which have an eventual impact on quality of life for all Marylanders. The relationship between vehicle travel speeds and CO_2 emissions is shown in Figure 4.3-7**.** For example, a car traveling at 20 mph (corresponding to congested or slow speed) emits 25 percent more CO_2 than a car traveling at 50 mph.

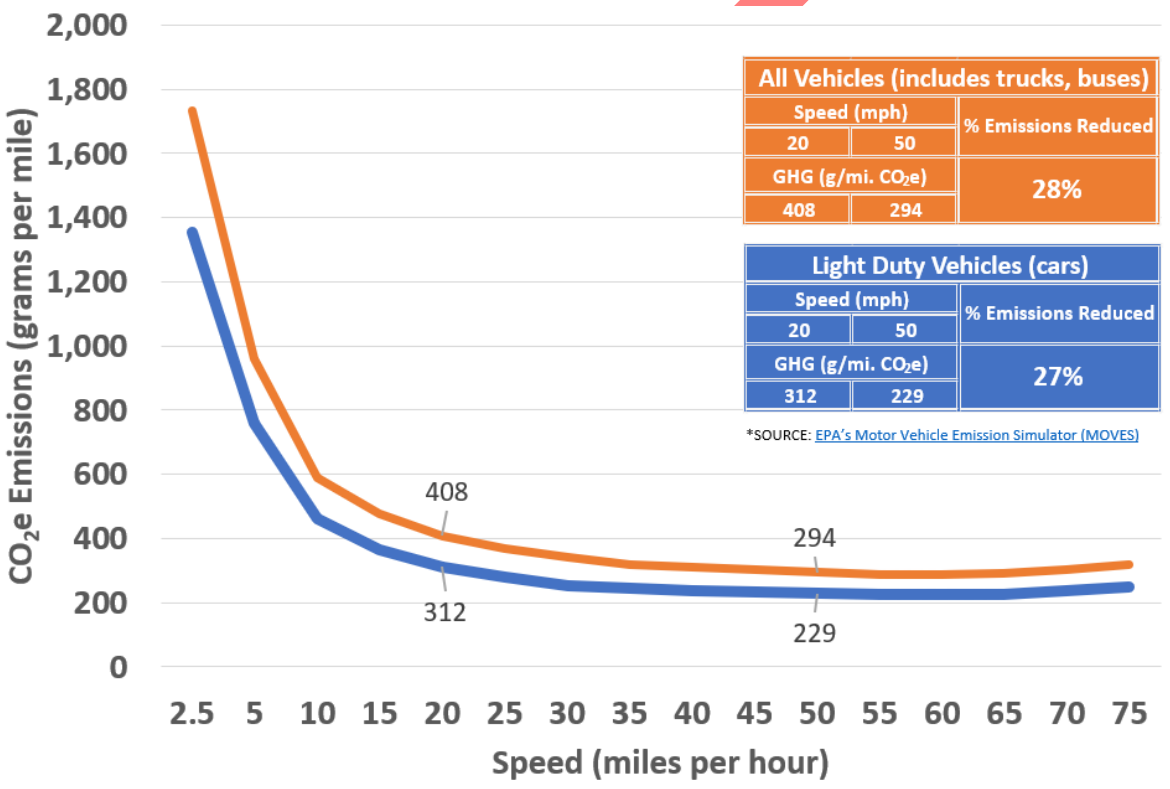

Figure 4.3-7. CO_2e emissions (grams/mile) by vehicle type as a function of speed (mph).

- **Integrated Corridor Management:** MDOT State Highway Administration (MDOT SHA) is a recognized national leader in the testing and deployment of real time technologies to adjust signal operation to maximize throughput and reduce delay. The system uses real-time traffic conditions and artificial intelligence to adjust the timing of traffic signals and synchronize the entire corridor. Phase I of the Traffic Relief Plan will improve traffic operations for 700,000 drivers per day on 14 major corridors across the state ($50.3 million in the FY18-2023 CTP). MDOT SHA's investment into a "progressive" design-build approach to improve reliability and reduce congestion in the I-270 corridor is an example of a project that will utilize technology to manage congestion.
- **MDOT SHA's Coordinated Highway Action Response Team (CHART):** MDOT released the Maryland Transportation Systems Management and Operations Strategic Plan in October 2018 aimed to address capacity limitations due to recurring and non-recurring congestion through business processes, ITS technology and collaboration. The CHART management and operations program continues to yield substantial GHG reductions associated with the efficient management of incidents, provision of traveler information, and deployment of other on-road infrastructure technologies. CHART efforts cleared more

than 30,000 incidents and assisted approximately 42,000 stranded motorists on Maryland roadways in 2017. The effectiveness of CHART in detecting and managing incidents provides measurable benefits in delay, fuel consumption, emissions reductions and cost savings.

- **MDOT Solar Initiative:** MDOT issued Master Services Agreements (MSAs) to six qualified contractors to design, construct, commission, finance, operate and maintain photovoltaic (PV) energy facilities at MDOT locations throughout Maryland. The MSAs provide MDOT with the flexibility of developing PV energy systems quickly and efficiently. The GHG benefit has increased by 10 percent over the last year and resulted in 15 metric tons of reductions.

Enhancement Opportunities

Emerging and innovative technology strategies will require additional investments to expand or accelerate deployment of previously planned strategies, deployment of new best-practice strategies, and capitalizing on the opportunities created by new transportation technologies. Potential enhancement opportunities include:

- **Arterial System Operations and Management** strategy includes expansion of signal coordination and control, consistent with MDOT SHA's current Integrated Corridor Management approach on most urban principal and minor arterials by 2030. Only urban arterials are being assumed to be covered as part of this strategy through 2030 as they experience the majority of non-highway congestion in Maryland.
- **Managed Lanes (I-270/I-495 Traffic Relief Plan Implementation)** adds express lanes to the routes of three of Maryland's most congested highways — the Interstate 495 Capital Beltway, the I-270 spur connecting Frederick to D.C., and the Baltimore-Washington Parkway between the two cities. The congestion affects 260,000 motorists daily on I-270, 240,000 motorists daily on I-495 and 120,000 motorists each day on the Baltimore-Washington Parkway.
- **Lead by example - Alternative Fuel Usage in State Fleet** is tracked as part of MDOT's Excellerator program and includes deployment of alternative fuel vehicles and fuels including ultra-low Sulphur diesel, biodiesel, and E-85 as the proposed as alternatives. It is assumed that the program continues to be implemented at current levels resulting in reduced diesel and gasoline fuel use as it is replaced by blended fuels.
- **Regional Clean Fuel Standard** provides a similar approach to the 2015 TCI analysis, with implementation of a regional clean fuels standard to achieve a 15 percent reduction in the carbon intensity of carbon-based fuels by 2030.
- **Additional 100K EV Ramp Up (total of 704,840 EVs)** are assumed to be rolled-out into Maryland's fleet from 2025 along the same splits of BEV and PHEV shares to make up a total of 704,840 total EVs on the road in the year 2030.
- **Variable Speeds/Speed Management on Freeways** is a strategy of speed limit enforcement and enhanced awareness and signage on urban restricted roadways. This assumes applying speed management strategies during both peak and non-peak periods. Enforcement may come about more through automated vehicle technology rather than traditional means.
- **Zero-Emission Trucks/Truck Corridors** strategy to establish infrastructure and vehicle replacements for implementation of zero emission corridors connecting to the Port of Baltimore, comparable to electrification technologies deployed in the I-710 Calstart Corridor at the Ports of Los Angeles and Long Beach. This strategy assumes participation of 700 dray trucks in Maryland that operate in the Port of Baltimore area only.
- **Connected and Automated Vehicles (CAV):** MDOT is developing Maryland's vision for a CAV future and deploying technologies to manage congestion. MDOT has established a CAV Working Group, including MDOT's TBUs and other planning partners, as the central coordination point for these emerging technologies. The Aberdeen Test Center has been recognized as a federal testing location for AV and US 1 was selected to pilot an innovative technology corridor. Maryland is emerging as a national leader in CAV technology and is building on this progress by developing CAV strategic plans that documents

opportunities, challenges, priorities, strategies, and recommendations to help guide the State in planning and implementing CAV technology.

- **Ride-hailing/Mobility-as-a-Service (MaaS)** services not only encourage cost-saving and emission reducing measures like carpooling (the price savings of services like Uber pool and Lyft Line), but also as a first/last mile connection between users and other modes, reducing the needs for single occupancy vehicle ownership, such as through bike share and electric scooters (or other forms of micro-mobility). Impacts could include reduced vehicle ownership and reduced travel activity, with national literature pointing to a range of anywhere between 10 percent to 20 percent adoption of car sharing by 2030.

Funding

The transportation technology standards are implemented by the vehicle manufacturers at no cost to the State of Maryland. There may be additional costs to the consumers purchasing new vehicles, but the costs can be offset by reduced fuel costs over the life span of the vehicle.

In the near-term, Maryland will continue to invest in EV and EVSE incentives while exploring the potential of hydrogen fuel cell vehicles. Under the federal Volkswagen Settlement, Maryland has submitted proposals and is seeking opportunities to enhance EVSE availability through the National ZEV Investment Plan and the Maryland Volkswagen Mitigation Plan.

As part of Volkswagen settlement resulting from their excess nitrogen oxide emissions, Volkswagen created a subsidiary company, Electrify America that is installing DC Fast Chargers throughout the county for use by EVs. Electrify America has announced two cycles of funding for which it outlined cities and other locations it targeted for fast charging installations. The Washington D.C. area was targeted during the first cycle of funding and the Baltimore Metro Area was targeted during the second cycle of funding.

MDOT has committed $15.8 million for FY18 and $111.2 million over the next six years to improve, maintain, and enhance the CHART program with on-road operational technologies and strategic capacity / operational enhancements. In total, in the 2018-2023 CTP, MDOT estimates that $330.2 million is committed to projects that will enhance transportation technologies, including CHART, or relieve critical bottlenecks at intermodal facilities, which will result in overall better management and operations of Maryland's multimodal transportation system.

In addition, in the 2018-2023 CTP, there is $1.82 billion committed to MDOT SHA projects that relieve key bottlenecks on Maryland's roadway network through strategic capacity enhancements and operational improvements. In the short term, these projects are expected to mitigate delay and the additional GHG emissions generated by inefficient and low-speed travel by passenger and commercial vehicles.

The projected scenario for funding is based on the best information we have at this time (over the next six years), which may be subject to change as the State responds to changes in mobility choices and travel patterns, and technological advancements that may alter some funding priorities and allocations. These assumptions are based on trends from the last few CTPs and are modeled on the latest version of the adopted CTP. Major technology projects and programs funded include:

- $405 million for Traffic Relief Plan implementation, including Phase 1 innovative congestion management on the I-270 corridor and, Phase 2 implementation of smart traffic signals on 14 corridors throughout Maryland, and Phase 3 implementation of peak hour shoulder use on I-695.
- Over $300 million for MDOT MTA bus procurement for fleet replacement and efficiency improvements.
- $63.6 million in funding to implement the next generation electronic tolling system that would represent the technology platform enabling a conversion to all-electronic tolling (AET), which brings a significant opportunity to eliminate vehicle idling and delay at Maryland's toll plazas.

Challenges

While technologies offer the most significant GHG emissions reduction potential for the transportation sector, the full potential of GHG benefits will not be fully achieved until the fleet turns over with newer fuel efficient and GHG beneficial vehicles. The federal technology standards will not be fully implemented until model years 2025 and 2027 for light-duty and medium- / heavy-duty vehicles, respectively. That pace of adoption of new technologies is the primary determinant for emissions reductions from the transportation sector by 2030.

EPA issued a proposed rulemaking in August 2018, *The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rules for Model Years 2021-2026 Passenger Cars and Light Trucks.* This rule will roll back the national fuel economy standards for post-2020 model years to 2020 standards. This will reduce the GHG benefits as the fleet continues to turnover. By freezing at the 2020 fuel economy standard, the fleet will not meet the 54.5 mpg equivalent standard by 2025. This could result in a loss of two million metric tons of GHG benefits in Maryland alone. Many states, including Maryland, have sued EPA to block the weakening of vehicle emissions standards. It is also unclear how manufacturers, who have generally been supportive of the Federal standards, would respond to this change.

When EPA released their roll back rulemaking in 2018, California updated their Clean Cars Program to remove a "deemed to comply" provision that allowed manufacturers to meet California's GHG standard by meeting the EPA's GHG One National Program. Removing this provision means vehicle manufacturers will now have to meet California's GHG standard, independent of the One National Program should EPA's SAFE rule be adopted. At the end of 2018, MDE adopted the regulatory changes necessary to remove the "deemed to comply" provision as well, ensuring Maryland will receive the GHG benefits it needs.

While we have made significant progress in EV adoption and the installation of EVSE, our work is not complete. We must continue to address known barriers to EV acceptance including ensuring that charging is available to those who live in urban environments, multi-unit dwellings, or in homes governed by homeowner's associations.

Technological strategies including EVs, CAVs, and MaaS, are at various points along their technological maturity for widespread adoption. For example, EV technology continues to grapple with barriers like range anxiety, perceptions about availability of charging infrastructure, and cost parity. While barriers for EVs are slowly being overcome, newer technologies like CAVs are still undergoing a transition from the research realm to the real-world. Continued advancements in these technologies are critical to ensuring that the GGRA of 2016 goals are met.

Economic growth or decline and its impact on personal and commercial travel activity, choice, and vehicle ownership can influence GHG emissions. Innovation in new technologies is often fostered in times of higher economic output, when increased investment in research and development are more typical.

Estimated Emission reductions, Costs, and Cost Effectiveness

- With the full implementation of final federal vehicle and fuel standards through 2030, total on-road GHG emissions could decrease by 7.04 $MMtCO_2e$, bringing 2030 emissions 20 percent below 2006 emissions.
- If the federal rulemaking of the SAFE Vehicles Rule for rolling back or freezing the federal light-duty vehicle standards to 2020 standards is approved, the GHG emissions for 2030 may increase by 2.07 $MMtCO_2e$. This result represents a potential worst-case scenario associated with the SAFE Vehicles Rule. Ultimately, the emissions impact of this potential standard change is highly uncertain given that auto manufacturers may choose to exceed federal standards, particularly in states like Maryland that are committed to the California standards.

- Presuming the current federal vehicle standards are fully implemented, and Maryland meets the ZEV mandate market share goals by 2030, total on-road GHG emissions could decrease another 1.61 $MMtCO_2e$, bringing 2030 emissions to 25 percent below 2006 emissions.

The following table shows estimated GHG emission reduction potential of the innovative and emerging transportation technology strategies and estimated costs for implementation:

Table 4.3-7. Transportation Technologies Estimated Emission Reductions and Costs.

Strategy	GHG Emission Reduction ($mmtCO_2e$)	Estimated Costs ($M)
Funded "On-the-books" Strategies		
Federal and State Vehicle Fuel Economy Standards	7.04	Nominal§
Electric Vehicles	1.61	$16
On-Road Technology (CHART, Traveler Information)	0.163	$246
Freeway management/Integrated Corridor Management	0.052	$506 to $760
Arterial System Operations and Management	0.049	$453 to $680
Limited Access System Operations and Management	0.023	$108 to $152
Managed Lanes (I-270/I-495 Traffic Relief Plan Implementation)	0.051	$6,650 to $9,840
Lead by example – Alternative Fuel Usage in State Fleet	0.004	Nominal §
Regional Clean Fuel Standard	0.382	$148
Additional 100K Ramp Up (total of 704,840 EVs)	0.322	$54
Emerging and Innovative Strategies (unfunded)		
Autonomous/Connected Vehicle Technologies	0.647	$43 to $62
Variable Speeds/Speed management on Freeways	0.083	$7 to $14
Zero-Emission Trucks/Truck Corridors	0.059	$34 to $128
Ride-hailing/Mobility-as-a-Service (MaaS)	0.256	Nominal §
Pay-As-You-Drive (PAYD) Insurance	0.062	Nominal §
Total Transportation Technologies	**2.245**	**$8,265 to $12,100**

§ Nominal costs are program implementation, regulatory facilitation, and support costs for implementing emission reduction strategies, where MDOT has limited control.

4.3.6 Multimodal Freight

Lead Agency: MDOT

Program Description

Ensuring the safe and efficient movement of freight is critical to Maryland's businesses and the economy. Freight contributes to nearly every aspect of the lives of people living, visiting, and working in Maryland. Freight goods include sensitive high-cost products, such as medicines and technology, household items purchased online, items found in grocery, convenience and retail stores, industrial goods, raw materials, finished goods, and even new vehicles. Industries in Maryland that compete on the global market, such as mining, agriculture, retail and wholesale trade, manufacturing, construction, and warehousing, depend on freight movement and account for over one million jobs in Maryland.

Program Objectives

Maryland's multimodal freight planning is done under the Maryland's Strategic Goods Movement Plan (2017 Update), which targets development of specific strategies to address the forecasted doubling of freight activity throughout the mid-Atlantic region by 2030. MDOT developed a Corridor Priority Tool to evaluate truck volumes, freight density, intermodal connections and bottlenecks to identify Maryland's critical urban and rural freight corridors and to prioritize freight-related projects.

The Strategic Goods Movement Plan noted reducing freight bottlenecks, enhancing port operations and throughput, and improving freight infrastructure through technology enhancements and capacity as the path forward to maintain Maryland's market position. One of the priorities of the Plan is to ensure that the network of highways, railways, waterways, and airports are ready to handle the current level and anticipated growth of goods movement.

Among the emerging and innovative strategies that have been analyzed for estimation of their impact in reducing GHG emissions, there are those that increase the efficiency in goods movement through trip/materials consolidation, capacity enhancements, transition to a low-carbon and more efficient fleet.

Implementation Milestones

Maryland's freight industry is a key driver of the economy employing over 1.5 million people and contributing over $123.0 billion (37 percent of the total) to the state's annual GDP.

Truck, rail, water, and air modes moved nearly 631 million tons of freight worth $835 billion, to, from, within, and through Maryland in 2012. By 2040, more than 1 billion tons of freight, worth close to $1.6 trillion, is expected to move within and through Maryland.

Over 95 percent of freight shipments (approximately 76 percent by tonnage) are moved by trucks on Maryland's interstate highway and freight system.

The Port of Baltimore continues to see its investments in its facilities pay dividends as it is ranked as the top port among all U.S. ports for handling autos and light trucks, farm and construction machinery, and imported sugar. The Port of Baltimore handled 31.8 million tons of international cargo worth $49.9 billion in 2016 and is ranked ninth for the total dollar value of international cargo and 14th for international cargo tonnage for all U.S. ports.

Funding

In the 2018-2023 CTP, there is $1.82 billion committed to MDOT SHA projects that relieve key bottlenecks on Maryland's roadway network through strategic capacity enhancements, which also impact freight movement across the state. In the short term, these projects are expected to mitigate delay and the additional GHG emissions generated by inefficient and low-speed travel by passenger and commercial vehicles.

The National Freight Program (NFP) provided new sources of funding for Maryland with the passage of the FAST Act. Over the next five years, Maryland's NFP allocation will be $95.6 million. In addition, the new federal Infrastructure for Rebuilding America (INFRA) discretionary grant program will help to fund larger projects supporting freight. The Strategic Goods Movement Plan identified Maryland's segments within the National Highway Freight Network that are eligible for the NFP.

Multimodal freight projects typically have high capital costs and involve private parties including shippers and carriers. Public private partnerships (P3s) are increasingly seen as instruments of funding such projects, though there has been uncertainty and delay in progression – for example in the case of Howard Street Tunnel expansion

involving CSX funding, which has experienced varied levels of engagement to come to an agreement for implementation.

Challenges

Multimodal freight capacity enhancement projects are typically high capital-intensive projects and involve high up-front costs and involve private and public partners to collaborate and contribute towards the funding of the planned projects. Fleet replacement and technology installation strategies traditionally have been funded by federal grants and the assumption that these programs will continue through 2030 might not be taken for granted. These projects also have a more modest cost-effectiveness for reducing GHG reductions compared to some of the other emerging and innovative strategies.

Estimated Emission Reductions, Costs and Cost Effectiveness:

The following table shows estimated GHG emission reduction potential of the multimodal freight strategies and estimated costs for implementation:

Table 4.3-8. Multimodal Freight Strategies Estimated Emission Reductions and Costs.

Strategy	GHG Emission Reduction ($mmtCO_2e$)	Estimated Costs ($M)
Funded "On-the-books" Strategies		
Freight and Freight Rail Programs (MDOT MTA rail projects and National Gateway)	0.072	$31
Port of Baltimore Dray Track Replacements	0.005	$18
Emerging and Innovative Strategies (unfunded)		
Intermodal Freight Centers Access Improvement	0.017	$2,240 to $3,136
Freight Rail Capacity Constraints/Access	0.072	$300
Commercial Vehicle Idle Reduction, Low-Carbon Fleet	0.055	Nominal §
Truck Stop Electrification	0.007	$9 to $38
Zero-Emission Trucks/Truck Corridors	0.059	$34 to $128
Total Multimodal Freight	**0.287**	**$2,632 to $3,651**

§ Nominal costs are program implementation, regulatory facilitation, and support costs for implementing emission reduction strategies, where MDOT has limited control.

4.3.7 Public Transportation

Lead Agency: MDOT

Program Description

Public transportation emits roughly 40 to 50 percent less GHG emissions per passenger mile than an average SOV. The programs in this policy option include transit initiatives that support a goal of increasing public transit ridership, and intercity transportation initiatives that support MARC and regional and national passenger rail services such as Amtrak. By providing alternatives to vehicle transit, these initiatives have the potential to reduce

VMT and GHG emissions. Public transportation strategies analyzed for this plan are broadly classified into two strategy groups:

- Transition to cleaner and efficient public transportation fleet, and
- Expansion of public transportation or intercity passenger service (new or increased capacity, improved operations)

MDOT works with MPOs, transit operators, and other local agencies in Maryland to implement projects aimed at advancing a more efficient and accessible multimodal transport system. These include transportation demand management programs (such as Commuter Choice Maryland and MWCOG's Commuter Connections, which are detailed further in the pricing policy option), transit-supportive enhancements including bicycle and pedestrian access projects, bicycle parking and bike racks on buses, and coordination with expanding bike share programs. There is an emphasis on improving service quality and reliability, better aligning of transit service to demand, and improved transit information dissemination to customers. MDOT MTA is also focused on sustainability and in moving towards a more efficient fleet.

Program Objectives

To maintain and enhance operations of the current public transportation system while strategically expanding services to provide access for more Marylanders, systematic and coordinated actions are needed. These actions increase the availability, attractiveness and convenience of public transportation, improve operational efficiency and safety of the system, and increase system capacity. Two different types of investments within this program aimed at meeting our GHG reduction goals are the Purple Line and BaltimoreLink. Each of these projects help address high priority operational and capacity needs within the densely populated Washington, DC and Baltimore metro regions through different project investment and delivery approaches. Other ongoing actions include the implementation of innovative transit solutions such as transit signal prioritization, bus-rapid-transit (BRT), off-board payment, and improved real time arrival information for riders.

Actions related to land use planning and development, including Maryland's commitment to transit oriented development (TOD), enhanced financial incentives for riding transit, and non-motorized access improvements are necessary to continue to enable Maryland's residents and commuters to have safe, efficient, and affordable transportation options.

- **Intercity Transportation Initiatives** – Improvements to Maryland's intercity passenger transportation systems helps address multimodal barriers to efficient intercity travel. Improvements to MARC are helping to enhance connectivity, reliability, and access to intercity passenger rail, for both commuting and leisure trips for millions of Maryland residents, employees, and visitors. In addition, through coordination with the Northeast Corridor Commission, the Federal Railroad Administration, and Amtrak, Maryland is supporting planning to address key bottlenecks to enhance the reliability of high-speed rail. This program includes the continued maintenance, operations, and expansion of intercity passenger rail, high-speed rail, and intercity bus services in Maryland as well as improved passenger connections between air, rail, intercity bus, and regional or local transit systems.
    - MDOT MTA continues to work with CSX and Amtrak to improve infrastructure on the MARC Brunswick, Camden, and Penn Lines, including improved signals, track improvements, and station area enhancements, including at Baltimore Penn and Washington Union stations. The launch of BaltimoreLink added and enhanced several Commuter Bus routes to improve regional mobility including connections between Baltimore and Annapolis as well as between Baltimore and Anne Arundel County.

Implementation Milestones

Support for public transportation and intercity transportation investments are presented in MDOT's annual capital program, the CTP. Highlighted projects recently implemented or planned through the CTP include:

- After the signing of a $900 million Full Funding Grand Agreement and a $5.6 billion public-private contract, construction has begun in the Purple Line project corridor between Bethesda and New Carrolton. The Purple Line will include direct connections to Metrorail in four locations (serving three Metrorail lines), all three MARC Train lines, Amtrak, and local bus services. The segment between Bethesda and Silver Spring will include a parallel hiker/biker trail as well. This project will improve transit accessibility for anyone working in, living in, or visiting the Washington metro area while supporting economic development and reducing the environmental impact of transportation in the region. The Purple Line will have 21 stations and provide direct connections to the Metrorail. It will also connect to MARC, Amtrak, and local bus services and is projected to have 74,000 daily riders by 2040.
- Following 18 months of planning and public outreach, BaltimoreLink successfully launched on June 18, 2017. Key features of this enhanced service include essential connections to job centers, and better integration between MDOT MTA transit services, such as CityLink, LocalLink, MetroLink, Light RailLink and MARC. BaltimoreLink network is providing more people with access to transit, jobs, and services in the region with an estimated 130,000 additional people within a ¼ mile access to frequent transit operating every 15 minutes or less during peak and midday periods. Eleven percent more jobs are accessible within 30 minutes and BaltimoreLink is adding a number of public schools, libraries, pharmacies, hospitals, and supermarkets to the frequent transit network.
- New technologies are supporting MDOT MTA bus system operations and reliability including automatic vehicle locator system deployment, enhancements to MDOT MTA's Central Control Center, and improvements and expansion to camera systems for safety and security. MDOT's 2018-2023 CTP includes a total of $5.17 million for replacement of CAD/AVL systems as part of mobility improvements for FY18 and 2019.
- MDOT MTA's construction program is undertaking an ongoing replacement and mid-life overhaul of Light Rail, Metro, and MARC rail cars to improve passenger comfort, vehicle reliability and overall performance.
- MDOT MTA is developing a grant application and selection process for an upcoming Transit Innovation Grant aimed at incorporating innovative transit-related investments to modernize Maryland's transit options. It will be a competitive, state funded program to support locally planned, designed, and constructed or operated transit projects including transit signal prioritization schemes, separate right of way, off-board fare payments, and intelligent transportation systems.
- MARC BWI Rail Station upgrades and repairs will provide a more passenger-friendly station with additional seating and a new pedestrian overpass connecting the garage and station.
- MDOT in partnership with the Montgomery County Department of Transportation, conducted a corridor planning study to identify transportation needs and evaluate alternatives to accommodate high frequency, reliable BRT service on US 29 between Burtonsville Park and Ride and the Silver Spring Transit Center (approximately 14 miles). The study resulted in a successful joint application to the USDOT Transportation Investments Generating Economic Recovery (TIGER) program and a groundbreaking for the project was held in October 2018.
- MDOT and Baltimore City submitted a successful joint application to the USDOT TIGER program to support a $27.3 million program of improvements to the North Avenue corridor, in Baltimore City. The $10 million from the TIGER grant compliments $14.7 million in funds committed by MDOT, $1.6 million from USDOT's FHWA, and $1 million from Baltimore City. The North Avenue Rising project is a unique suite of proposed transportation investments intended to improve corridor and regional mobility and leverage these transportation improvements with other city, state, and private development initiatives to revitalize the surrounding area. The North Avenue Rising project includes dedicated bus lanes, new bike

facilities, enhancing MTA Metro and Light Rail stations, targeted improvements at major bus stops, improved sidewalks, streetscaping, and needed roadway re-pavement along the corridor.

- The Washington Metropolitan Area Transit Authority (WMATA) Capital Improvement Program (CIP) includes $1.2 billion of funding from Maryland to match federal formula funds received directly by WMATA as well as Maryland's share of additional funds for WMATA capital projects. The CIP is focused on safety, infrastructure rehabilitation and replacement and maintaining the region's transit system in a state of good repair. Starting in FY20, the Governor is to include a State budget appropriation of $167 a year million from revenues available for the State capital program in the transportation trust fund as a grant to be used to pay WMATA capital costs. The Governor has authority to appropriate general funds for this purpose. The Act also calls for an increase of 3 percent a year of the existing WMATA funding.
- MDOT MTA and locally operated transit services (LOTS) continue to regularly update and renew their bus fleets to maintain the average age of the fleet, yielding reliability benefits and environmental benefits through reduced emissions, fuel consumption, and noise.

Enhancement Opportunities

Implementation of BaltimoreLink provides a good example of how to expand transit service and enhance efficiency with a comparatively low capital commitment. Another example, through support from the MDOT Bikeways Program, is our effort to retrofit our fleet of bi-level MARC cars to accommodate two full size bicycles per car. Investments like this help address first/last-mile access to transit issues.

Enhancements to the currently funded program will create opportunities to increase transit service and reliability, which can increase ridership, in terms of capturing choice transit riders, but also create economic opportunity for Maryland residents with limited transportation options. BaltimoreLink, North Avenue Rising, and US 29 BRT are all examples of innovative partnerships for service expansion and improvements in developing areas and corridors, where the investment in transit can help to spur further mixed-use and transit-supportive development. These projects are also using existing infrastructure and new technologies to optimize service delivery and reliability. Ongoing planning by MDOT MTA and MDOT SHA for BRT, and MDOT MTA and WMATA activities regarding transit signal priority, bus-only lanes, and other on-board bus communication and location technologies will help maintain service quality while meeting public demand for reliable service.

The State continues to incorporate responsive and innovative investments, such as the inclusion of a public-private partnership contract for the Purple Line and the establishment of a transit grant for innovative transit projects. Other longer-term transit investments include continued implementation of the MARC Growth and Investment Plan and the under development Cornerstone Plan, and replacements for two major bottlenecks on the Amtrak Northeast Corridor, the Baltimore & Potomac Tunnel and Susquehanna River Bridge.

MDOT MTA has been leading ongoing and new studies since 2017, with a focus on improvements to the Baltimore Metro/Light Rail network connectivity and service, ongoing BRT corridors studies in partnership with Montgomery and Howard counties and MDOT SHA, transit development plans for multiple local operators, and an evaluation of bus-on-shoulder effectiveness and opportunities in the Washington D.C. region.

There are other areas of implementation that could be targeted for more aggressive implementation through 2030. These strategies could receive additional funding through the Consolidated Transportation Program, as well as funding through other non-transportation sources and possible legislative support. These include:

- Continued bus replacement to cleaner alternatives and hybrid technologies (as part of the MDOT MTA bus replacement program, the delivery of 172 40-foot clean diesel buses was completed in FY17 and an additional 140 buses have been ordered for delivery in FY18 and FY19),

- Ongoing technical support to local jurisdictions and partnerships (such as MDOT and WMATA joint development agreements) to help promote and create TOD projects,
- Piloting new partnerships and potential service opportunities afforded by transportation network companies, and
- Enhancing multimodal connections, particularly for bicycles and pedestrians.

There are several strategies that have been identified as emerging and innovative strategies under consideration within this policy option. They are framed as an accelerated expansion of service expansion and transformation of public transit fleet to cleaner and more efficient alternatives.

- For example, one of the strategies estimates the GHG reduction benefits and costs involved in transforming the Maryland transit bus fleet to 50 percent EV buses by 2030.
- Another strategy assesses the benefits and costs associated with accelerating transit projects identified in the TPB and BRTB's most recent long-range transportation plans for implementation after 2030. These projects primarily include build out of bus-rapid-transit systems in Montgomery, Prince Georges, Howard, and Anne Arundel counties. In addition, this strategy considers the advancement of the complete build-out of the MARC Growth and Investment Plan by 2030 and complete development of all identified TOD locations in Maryland.
- One of the strategies also envisions the potential impacts of an expanded high-speed rail system serving Maryland using current or new technology advances. This strategy estimates the potential impacts and costs of a potential build-out of the NEC Vision, or construction of the SCMAGLEV and/or Loop, to facilitate intercity passenger rail travel through 2030.

Funding

Transit investments are strongly supported in the FY18–FY23 CTP, including MARC maintenance and service expansion, BaltimoreLink operations, support of WMATA and MTA capital expansion, and support of LOTS across Maryland.

- MDOT MTA directs funding and statewide assistance to LOTS serving each of Maryland's 23 counties, providing approximately $130.5 million in grants in FY18.
- The Purple Line presents a new and innovative approach to transit infrastructure funding by using a P3 agreement. The innovative P3 project delivery creates a predictable, transparent, and streamlined approach, incorporating best practices and lessons learned from other states and countries, while addressing the transportation and economic development needs of Marylanders.
- In total, in the 2018-2023 CTP, MDOT estimates that $3.381 billion is programmed to be spent on transit projects that help increase transit reliability, convenience, and accessibility, resulting in a more competitive system that helps to reduce emissions through mode shift from vehicle trips in addition to reducing emissions from transit service.
- An estimated $392 million is programmed to be spent on intercity passenger service, particularly MARC service, commuter bus service, and overall improvements to the Northeast Corridor that will provide a more competitive travel option in the I-95 corridor.
- No other projects apart from those that are "on-the-books" have appropriated funding or a funding source currently identified for implementation. Notable strategies that may require fairly substantial capital investment includes procurement of an all electric transit bus fleet, fiscally unconstrained transit capacity expansion consistent with post-2030 projects identified in MPO long-range plans, and the SCMAGLEV/High Speed Rail/Loop.

Challenges

The State works to provide multi-modal connections throughout the State's transportation system so that users have a variety of options including public transit. Bicycling and pedestrian modes, while they are now being measured more consistently than in previous years, are developed to supplement use of public transit with other non-SOV alternatives. First and last mile connectivity is an area that is constantly changing as Maryland focuses on innovative transit planning and "complete streets" functionality. Land-use and transportation coordination is another issue that requires constant collaboration between state agencies like MDOT and the Maryland Department of Planning (MDP), along with other local partners who have the authority on land-use planning.

As national trends continue to show an increase in VMT and decrease in transit ridership, it is important that the State continue to develop solutions that address modern preferences, such as mobile applications that offer riders real-time bus tracking, or investment in travel time reduction and facility-wide comfort. These customer-oriented services and investments are intended to soften the environmental impact of transportation in the region amid shifting attitudes concerning transportation. These shifting attitudes include mainstream acceptance of ridesharing apps such as Uber or Lyft or use of car sharing services such as Zipcar. The potential impacts of future transportation technologies and services, including transportation network companies like Lyft and Uber, and CAVs, and their role in maximizing accessibility, mobility and connectivity within the larger transportation system are being considered.

In cases of strategies involving consideration of MAGLEV/Loop, technology maturity, testing and passenger acceptance are also issues that policymakers should consider as mobility needs crystallize towards mass transit options and revenue options are evaluated for funding those options.

Estimated Emission Reductions, Costs, and Cost Effectiveness

The following table shows estimated GHG emission reduction potential of public transportation strategies and estimated costs for implementation:

Table 4.3-9. Public Transportation Estimated Emission Reductions and Costs.

Strategy	GHG Emission Reduction ($mmtCO_2e$)	Estimated Costs ($M)
Funded "On-the-books" Strategies		
Public Transportation (new capacity, improved operations, BRT in MPO MTPs by 2030)	0.033	$2,144
Public Transportation (fleet replacement/technology based on current procurement)	0.024	$256
Land-Use and Location Efficiency (MDP assumptions)	0.318	N/A
BWI Airport parking shuttle bus replacements	<0.001	$52
Emerging and Innovative Strategies (unfunded)		
Transit capacity/service expansion (fiscally unconstrained)	0.069	$2,307 to $2,659
MARC Growth and Investment Plan/Cornerstone Plan completion	0.052	$1,078
Expanded TDM strategies (dynamic)	0.314	$15 to $30
50 percent EV Transit Bus Fleet	0.036	$93
SCMAGLEV/Hyperloop**	0.056	$45,300 to $47,300
Total Public Transportation Strategies	**0.902**	**$51,245 to**

		$53,612

4.3.8 Pricing Initiatives

Lead Agency: MDOT

Program Description

The State supports multiple alternative commute programs including ride sharing, guaranteed ride home, travel demand management (TDM) and marketing, outreach and education programs, parking cash-out subsidies, transportation information kiosks, local car sharing programs, telework partnerships, parking fees, and vanpool programs, among others. These programs encourage use of alternative transportation modes through pricing incentives (or disincentives) along with information for employers and employees. The pricing program also includes expanded and enhanced technologies for electronic toll collection on tolled facilities operated by the MDTA.

As part of emerging and innovative pricing strategies, the impacts of expanding the current TDM strategies and facilitating Pay-As-You-Drive insurance (PAYD), which is already being offered by the private sector insurance providers, was assessed.

Program Objectives

Pricing initiatives are targeted towards reducing SOV travel by providing incentives, alternative travel options that are not as carbon intensive as SOV travel – like carpool, vanpool, and transit options by providing incentives like cash subsidies for travel and parking. Other initiatives also include easy-payment options that reduce wait times for toll payment and collection by using electronic tolling alternatives.

PAYD Insurance is a usage-based insurance program where charges are based on usage and driver behavior, which is offered by several auto insurance companies in the US. This strategy involves adoption of PAYD insurance, which has been observed in multiple studies to reduce VMT. There is potential for up to 5 percent of Maryland drivers being enrolled in PAYD by 2030. The assumed VMT reduction associated with PAYD insurance premiums is 8 percent based on national studies. The role of MDOT in this area is to provide regulatory or policy enabling framework to make these pricing schemes more competitive.

Implementation Milestones

Operational, management, and financial support for a broad range of TDM programs (also known as Transportation Emission Reduction Measures[101] is documented in the CTP. These investments support emission reductions in air quality nonattainment and maintenance areas in Maryland through congestion mitigation, ridesharing and commuter incentive programs. Programs include the Commuter Connections program (managed by MWCOG) and the Commuter Choice Maryland program (managed by MDOT). Both programs offer commuters and students in the Washington and Baltimore regions access to financial incentives, ride sharing, guaranteed ride home, and traveler information to support carpooling and transit use. The State also supports the Telework Partnership, transit marketing and subsidy programs, and statewide park-and-ride facilities aimed at reducing SOV driving and encouraging ridesharing, transit, and telecommuting.

[101] The Secretary's office Capital Program Summary – Line 2
http://www.mdot.maryland.gov/newMDOT/Planning/CTP/CTP_17_22/Documents/TSO.pdf

Electronic toll collection systems expedite the toll collection process, reduce delays at toll plazas, decrease emissions, and are available at all eight toll facilities across the state. GHG emissions are significantly reduced when tolls are collected electronically, due to reduced queuing and idling at toll collection plazas.

Enhancement Opportunities

Expansion of Maryland's TDM program offerings, geographic scope, and incentives would require additional funding and potential legislation regarding tax credits and incentives. Other opportunities, such as expanded coordination with services such as Uber and Lyft, to enhance access to transit and encourage ridesharing, are emerging possibilities to expand the scope of traditional TDM programs. MDOT will continue to add capacity, provide better transit access, and maintain park and ride lots, while providing information to the public to increase awareness about the possibilities of carpooling and taking transit.

Within USDOT's surface transportation reauthorization, the FAST Act, The Surface Transportation System Funding Alternatives grant program[102] funds projects to test the design, implementation and acceptance of user-based alternative revenue mechanisms. The program helps to address some of the concerns outlined in Beyond Traffic, the USDOT report issued in 2016 that examines the challenges facing America's transportation infrastructure over the next three decades, such as a rapidly growing population and increasing traffic. USDOT announced funding for eight projects in August 2016 that piloted a variety of options to raise revenue, including on-board vehicle technologies to charge drivers based on miles traveled and multi-state or regional approaches to road user charges. The projects address common challenges involved with implementing user-based fees such as public acceptance, privacy protection, equity and geographic diversity.

MDOT has been monitoring the progress of these studies, future grant funding opportunities, and other emerging road pricing technologies to learn innovative methods of funding the transportation system here in Maryland. Each state that received funding has conducted research regarding novel ways to collect road user fees, such as built-in electronic systems and pay-at-pump systems. Minnesota, for instance, investigated MaaS and examined trends (decline in private vehicle ownership, MaaS customers traveling less) and their potential effects on road use pricing. Research is ongoing, and MDOT will continue to examine the outcomes of this research.

Funding

MDOT sets aside nearly $26 million in the CTP over the next six years to support the TERM programs, covering 15 counties in Maryland designated as non-attainment through the Clean Air Act. These funds are leveraged by additional federal and local funds to deliver these programs to Marylanders.

The FY18-2023 CTP identifies $63.6 million in funding over the next six years to implement the next generation electronic tolling system that would represent the technology platform enabling a conversion to AET across the entire system. This next generation tolling system will significantly enhance the capacity for handling video tolling and citations. As of the 2018-2023 CTP, engineering is underway with collection system hardware and software procurement and installation starting in FY18. To provide a cost savings to Maryland citizens and move closer to AET, the State announced the elimination of the $7.50 E-ZPass Maryland transponder fee for all new customers in May 2018.

Funding has not yet been identified for the emerging and innovative strategies for expanding the TDM program and overseeing the regulatory facilitation of the PAYD strategy.

Challenges

[102] http://www.fhwa.dot.gov/pressroom/fhwa1648.cfm

TDM offsets vehicle congestion by offering incentives for Marylanders to use public transit, carpool, walk or bicycle instead of driving alone. Other ways that roadway demand can be reduced is the promotion of telecommuting and flexible work hours to reduce or shift trips to times when roadway capacity is less constrained. Expansion of employers offering these incentives and employees using them are associated with several business and personal cost and convenience considerations. Ensuring that information is available to employers and employees regarding program details is key to enhancing participation.

A key challenge to broader implementation and participation of TDM programs is the provision of ample and free employee parking. These decisions are traditionally led by the developer and property owners and informed by local zoning and development regulations. The State, through TOD development or other technical assistance programs can take a lead by example role as it relates to parking. Additionally, incentives can be considered to encourage alternative commuting rather than driving. MDOT is also facing a challenge of low usage of park and ride lots. Average occupancy rate of MDOT SHA statewide park-and-ride lots was at 51 percent capacity in CY16, down from 53 percent in CY15.

The significant expansion of transportation network companies operating in Maryland over the past couple years has changed the dynamic of ridesharing, guaranteed ride home, transit use, and participation in TDM programs. There are many uncertainties regarding the extent that transportation network companies are competing with traditional transportation providers. Shared-use mobility, and the proliferation of travel information apps and services, presents both a challenge and opportunity for TDM programs and for local transit services. MDOT continues to monitor ongoing FHWA and AASHTO studies and research on innovative financing options as a mechanism to potentially replace the Federal gas tax.

There is limited MDOT control and impact in the implementation of the PAYD program, which is already being offered by some private insurance providers. The role and efficacy of MDOT in regulating or facilitating the program to make it more widespread may require providing incentives and discounts.

Estimated Emission Reductions, Costs, and Cost Effectiveness

The following table shows estimated GHG emission reduction potential of the pricing strategies and estimated costs for implementation:

Table 4.3-10. Pricing Initiatives Estimated Emission Reductions and Costs.

Strategy	GHG Emission Reduction ($mmtCO_2e$)	Estimated Costs ($M)
Funded "On-the-books" Strategies		
TDM (Commuter Choice MD, Commuter connections ongoing and expanding programs)	0.142	$30
Pricing Initiatives (conversion to All Electronic Tolling)	0.018	$49
Emerging and Innovative Strategies (unfunded)		
Expanded TDM strategies (dynamic)	0.314	$15 to $30
Pay-As-You-Drive (PAYD) Insurance	0.062	Nominal §
Total Pricing Initiatives	**0.536**	**$94 to $109**

§ Nominal costs are program implementation, regulatory facilitation, and support costs for implementing emission reduction strategies, where MDOT has limited control.

4.3.9 Bicycle and Pedestrian Initiatives

Lead Agency: MDOT

Program Description

Bicycle and pedestrian initiatives aim for the continued non-motorized, active transportation system expansion through programs in the CTP such as Bikeshare, Bikeways, retrofit programs, and federal grants as summarized in the 2018-2023 CTP in addition to locally funded projects within the MWCOG and BRTB 2017-2022 TIPs. In addition, the State continues to work together to advance bike and pedestrian friendly designs and policies to promote safety and respect of all transportation system users.

Program Objectives

This program is part of a comprehensive effort to reduce GHG and other tailpipe emissions from passenger vehicles by providing active transportation alternatives to vehicle use. Building connected and safe infrastructure to support additional bicycle and pedestrian travel in urban areas also increases access to and use of public transit and supports the State's goal of increasing transit ridership.

Implementation Milestones

The 2040 Maryland Bike and Pedestrian Master Plan update was completed January 2019 whose draft goals include expanding travel choices and improve multimodal connectivity and advance biking and walking as economic development strategy.

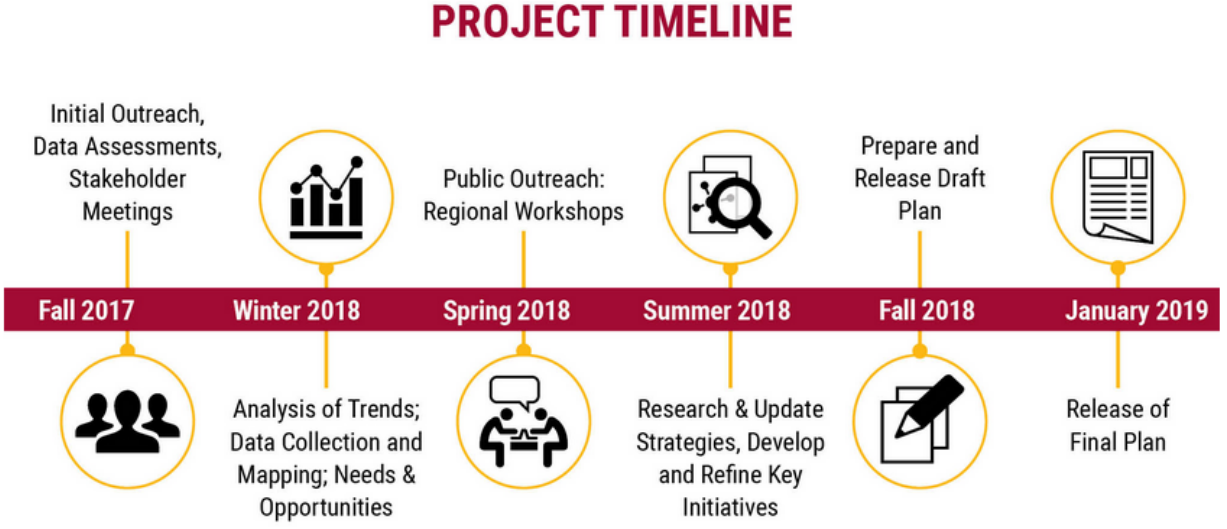

Figure 4.3-8. Bike/Pedestrian Plan Update Timeline.

The following implementation elements are consistent with the Bicycle and Pedestrian Master Plan:

- Bike sharing programs will continue being expanded in many Maryland communities, with financial and technical assistance from MDOT. Successful programs are operating in Montgomery and Howard counties as well as in the City of College Park.
- All 83 state managed MARC train stations have bike parking. Bike parking has been expanded and improved, including covered parking, where needed. Bikeshare stations have been added at 7 MDOT MTA rail stations. All MDOT MTA buses contain bike racks.
- Consider Bike Accommodations for all applicable Roadway Projects – 73 roadway capacity or bridge upgrade projects in the Consolidated Transportation Program include accommodations for bicycles and pedestrians. In FY17, some 93.9 directional miles of roadways have been improved for bicycle access.
- Seven bike network projects were funded in FY19 under the Maryland Bikeways Program. Approximately 91 bikeways projects that received funding through the Bikeways Program are complete. Additional projects will be solicited through annual grant cycles.
- MDOT SHA completed 12 sidewalk projects totaling 6.5 miles of both newly constructed and reconstructed sidewalks through the Sidewalk Construction for Pedestrian Access Program. Other funding programs that enhance bicycle and pedestrian safety and access as part of roadway expansion or maintenance projects, or as standalone improvements include the Sidewalk Reconstruction for Pedestrian Access Program, Urban Reconstruction Program, and Bicycle Retrofit Program.
- MDOT SHA's bicycle committee continues to improve bicycle guidance and policies for MDOT SHA roadways and the State continues to install bicycle improvements when feasible within a project's scope.
- MDOT staff continues to support the Maryland Bicycle and Pedestrian Advisory Committee (MBPAC), which was created by statute to advise all State agencies on matters pertaining to bicycling and walking. MBPAC has an active agenda that has recently focused on health and education.

Enhancement Opportunities

Impacts of an expanded bicycle and pedestrian system development initiative were estimated in the form of an accelerated development of bicycle and pedestrian facility infrastructure by 150 percent of existing bicycle and pedestrian infrastructure provision target. Future linear miles of pedestrian and bicycle facilities were estimated based on targets provided in the 2018 MDOT Attainment Report (2018 AR).

Along with the system-wide development of the bicycle and pedestrian infrastructure, MDOT is leading several major initiatives in the coming years including implementation of the bicycle and pedestrian priority area (BPPA) program, supporting localities in designating areas and developing plans leading toward implementation of network improvements in these areas. To date, BPPA Plans have been developed for Tilghman Island and Prince George's Plaza Metro, with plans in development for Silver Spring, Bethesda, and the Rockville Town Center area.

MDOT works closely with area MPOs to support their efforts on bicycle and pedestrian transportation. Several planning efforts are underway in Maryland jurisdictions and in Maryland's MPOs. MDOT SHA has completed Phase 1 of planning for a Bike Spine Network to connect major activity centers and guide the planning and construction of bicycle facilities. In Phase 2, MDOT SHA will work with the office of tourism to aggregate designated bicycle routes and points of interest to develop regional specific electronic and print maps to encourage bicycling in the state.

Funding

MDOT solicits and awards grants annually for bike and pedestrian improvements. The GHG-beneficial funding for bicycle and pedestrian projects totals $175.4 million in the FY18 – FY23 CTP. This MDOT estimate includes 103 funded roadway expansion projects that include pedestrian and bicycle elements, in addition to the Bikeways Program and the Transportation Enhancements program, which focus on bicycle and pedestrian projects. MDOT

manages several ongoing programs that provide funding for pedestrian and bicycle improvements, including: ADA Retrofit Program, Sidewalk Retrofit Program, Bicycle Retrofit Program, Urban Reconstruction Program, and management of the FHWA Transportation Alternatives (TA) Set-Aside funds. In September 2018, MDOT announced $17.2 million in grants for 43 projects to support improvements for bike and pedestrian connectivity across the state. It includes $1.9 million in State funds from the Maryland Bikeways Program, as well as $1.3 million in federal funding from the Recreational Trails Program, and $14 million in federal funding from the Transportation Alternatives Program.

Any expansion to the existing programs needs identification of new sources of funding or revenue to pay for infrastructure construction and maintenance. These new and creative sources may need to be prioritized (relative to other needs, such as system preservation) and invested into bicycle and pedestrian programs and projects based on emission reduction cost-effectiveness.

Challenges

Strong local partnerships are the key to improving bicycle and pedestrian infrastructure. While MDOT seeks design solutions to better accommodate cyclists and pedestrians on state roadways and transit, many of the most critical infrastructure and maintenance issues remain under local control. Local entities are also more acutely aware of the challenges and opportunities that their bicycle and pedestrian infrastructure presents and can use tools and benchmarks that are available at a national level. MDOT programs and technical assistance have been geared toward helping ensure that local jurisdictions have the tools necessary to strategically improve the network.

In the Federal Fiscal Year 2018 National Highway Safety Plan, MDOT documented our goal to reduce the number of non-motorized fatalities, plus serious injuries, on all roads in Maryland from 685 (2004–2008 average) to 433 or lower by December 31, 2020. To make measurable progress on these goals, State and local agencies meet on a regular basis to ensure progress on the identified action items. Beyond that, local jurisdictions have even established their own goals regarding roadway safety for all users: Montgomery County is the first county in Maryland to establish a “Vision Zero” set of guidelines.

Funding and availability of sustainable sources of revenue continues to be a concern to fund expansion and upkeep of bicycle and pedestrian infrastructure. The expanded bike/ped system development strategy may need a new source of funding for implementation.

Estimated Emission Reductions, Costs, and Cost Effectiveness

The following table shows estimated GHG emission reduction potential of the two bicycle and pedestrian strategies and estimated costs for implementation:

Table 4.3-11. Bicycle and Pedestrian Strategies Estimated Emission Reductions and Costs.

Strategy	GHG Emission Reduction ($mmtCO_2e$)	Estimated Costs ($M)
Funded “On-the-books” Strategies		
Bicycle and Pedestrian Strategies (program continuation and expansion through 2030)	0.004	$205
Emerging and Innovative Strategies (unfunded)		
Expanded bike/pedestrian system development	0.081	$103
Total Bicycle and Pedestrian Strategies	**0.085**	**$308**

4.3.10 Forestry and Sequestration

DNR's Natural and Working Lands 2030 Plan Overview

Maryland's GGRA was reauthorized in 2016 to expand its goal; it now requires the state to reduce its GHG emissions 40 percent from 2006 levels by 2030. The actions of DNR will continue to be an important part of the state's plan to reduce carbon emissions. DNR has reassessed its programs to evaluate performance and take advantage of the latest in scientific understanding around how forests and wetlands impact GHG budgets. This has included partnerships with the University of Maryland and the National Aeronautics and Space Administration (NASA) and the U.S. Climate Alliance's Natural and Working Lands group.

Variability in Projections

The forest management sequestration impacts in the *2019 GGRA Draft Plan* shows what DNR's management programs could achieve in terms of carbon sequestered in our forests by 2030 if fully funded, the forestry industry in Maryland remains healthy, and landowner interest in the programs is high through 2030. Lower funding levels, unfavorable conditions in Maryland's forestry industry, or a lack of willing landowners will result in lower sequestration, commensurate with estimates included in the Reference Case or Policy Scenario 1.

This is due to the fact that the interest of landowners can impact implementation levels in a given year. Landowner willingness can vary depending on markets for wood products, land prices, and the availability of incentives. To account for this variability DNR made low, medium, and high projections for 2020-2030 for the following programs- Managing Forests to Capture Carbon; Planting Forests in Maryland; Increasing Urban Trees to Capture Carbon and; Avoided Emissions Due to Forest Conservation. The projections reflected in the tables under each DNR program represent the expected outcomes of the programs given current programmatic resources and closely corresponds to the mid-level projection modeled in the Pathways GHG scenario model and the Regional Economic Model, Inc. (REMI).

Methodological changes in the 2030 Plan

Programs

DNR will continue to track all the programs included in the prior GGRA Plans. Additional carbon benefit for Creating and Protecting Wetlands and emission of methane from wetlands makes the net GHG impact of these actions uncertain. While DNR did not see a GHG benefit associated with Biomass for Energy Production, Geological Opportunities to Store Carbon, or Creating Ecosystems Markets from 2006-2019, work is underway so that these programs may factor in the 2020-2030 period. Maryland is actively working to promote biomass to energy in the state as an important part of our forestry industry and anticipates new installations prior to 2030, if feasible. Maryland is also actively working to advance markets for the forestry industry, but the future benefits are difficult to calculate at this time. When there is more clarity around these programs, DNR will calculate their carbon benefit and count it toward our GHG reduction goals.

The carbon benefits of a new program, Avoided Emissions Due to Forest Conservation, are based on an analysis done by the World Resource Institute (WRI) as part of the U.S. Climate Alliance's Natural and Working Lands working group. The WRI analysis compares historic rates of forest loss from 1986-2000 and the carbon sequestration potential that would be saved if this loss was avoided. DNR is working to refine this projection for a time period more relevant to Maryland policy and to incorporate land-use change projections made by the Chesapeake Bay Program. DNR projects a low estimate of 500 avoided acres of forest conversion, or 0.1 MMtCO2e per year, 800 acres of avoided forest conversion, 0.15 MMtCO2e per year as a mid-estimate, and 1,300

avoided acres of conversion, equating to 0.237 MMtCO2e per year as a high estimate, with the latter being the results of the calculation done by WRI.

Table 4.3-12. Summary of DNR GGRA Plan Projections.

Summary of DNR GGRA Plan Projections	Avg. Annual 2020-2030 Low	Av.g Annual 2020-2030 Medium	Avg. Annual 2020-2030 High	Avg. Annual 2020-2030 DNR Target		2030 Low	2030 Medium	2030 High	2030 DNR Target
Forest Management, public lands	1,500	2,000	3,000	1,600	Acres per year	0.020	0.020	0.021	0.020
Forest Management, private lands	35,000	50,000	60,000	38,000	Acres per year	0.86	1.04	1.16	0.92
Planting Forests	2,000	3,000	4,000	2,550	Acres per year	0.28	0.32	0.36	0.30
Urban Tree Canopy	150,000	350,000	500,000	265,000	Trees planted per year	0.003	0.004	0.005	0.0035
Avoided Forest Conversion	500	800	1,300	800	Acres per year	0.10	0.15	0.24	0.15
Total ($MMtCO_2e$ per year)						1.26	1.53	1.78	1.39

4.3.10.1 Managing Forests to Capture Carbon

Lead Agency: DNR

Program Description

Managing more forests to capture carbon will promote sustainable forestry management practices in existing forests on both public and private lands. Enrolling unmanaged forests into management regimes enhances forest productivity, which increases rates of carbon sequestration in forest biomass and the amount of carbon stored in harvested durable wood products. This translates to economic benefits and increased availability of renewable biomass for energy production. This increased forestry management in Maryland is estimated to result in a 1.80 $MMtCO_2e$ cumulative 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 ensures 100 percent of state forest lands will be third-party certified as sustainably managed. This program is performing as designed with all goals for 2020 either met or exceeded.

2030 Plan

We project that DNR will provide forest management services on between 1,500 and 3,000 acres per year on state lands and between 35,000 and 60,000 acres per year on private forest lands. This equates to the net carbon sink of forests in Maryland being increased by 0.88 $MMtCO_2e$ per year by 2030 in the low scenario and 1.18 $MMtCO_2e$ per year by 2030 in the high scenario, with our expected scenario being 0.94 $MMtCO_2e$ per year in 2030.

An additional consideration with forest management is that the period for the assumed carbon benefit for the management action is 20 years. Meaning, that once the management action takes place on the forest, we calculate the amount of carbon the forest will sequester relative to an unmanaged forest over a 20 year period. Accordingly, actions taken on forest land 20 years in the past begin to "drop out," (i.e. no longer contribute a carbon benefit) starting in 2026 with land where management actions took place 20 years ago in 2006. This would not preclude crediting subsequent actions taken, such as harvest for biomass-to-energy or additional management. If more acres are managed post 2026 than occurred 20 years prior, the sink will continue to grow. Otherwise, the sink will

decrease. While the carbon estimates presented here are reasonable estimates, we reserve the right to update them as updated or improved estimates become available.

Implementation Milestones

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 and Forest Sustainability Certification standards.
- DNR is developing similar sustainable forest management practices on state park and wildlife land.
- The Maryland Forest Service is currently working with DNR's Wildlife and Heritage Service on several projects, such as developing Forest Stewardship Plans on several Wildlife Management Areas.
- DNR has accelerated pace of silvicultural activity:
    - Savage River State Forest will increase the number of timber sales from 14 to 20. The Maryland Forest Service is continuing to work to decrease the backlog of timber sales.
    - State Forest Annual Work Plans include a planned 2,611 acres of timber harvests for FY18 that will be naturally regenerated.

Private Lands:

- Since 2006 we have implemented:
    - 247,769 acres of stewardship plans
    - 151,739 acres of sediment control
    - 98,378 acres of forest stand improvements (e.g., tree planting, timber stand improvements, wildlife habitat)
    - Total of 497,886 acres of forest management plans on private lands

Technical Assistance Provided:

- 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
    - Working on the next round of projects
    - Backyard Buffer Program
    - Environmental Quality Incentive Program (EQIP)
    - Conservation Reserve Enhancement Program (CREP)
    - Income Tax Modification (TAXMOD)
    - Expanded eligibility of forestry practices in 2014
    - Forest Conservation and Management Program
    - Woodland Assessment Program
- Completed the development and application of the University of Maryland remote sensing capability for forest carbon assessment.
- Launch of National Aeronautics and Space Administration, United States Department of Agriculture (USDA) and United States Department of Energy 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.
- Forest Management Study
    - DNR identified a forest management site that utilizes three forest management plans: Low Management (100 percent hardwoods), Moderate Management (50-70 percent pines: 30-50 percent oaks), and High Management (100 percent pine). DNR's Resource Assessment Service has and continues to evaluate the below ground carbon sequestration on these management plots to

complement the determination of carbon sequestration in the above-ground forest. Expected project completion: 2030.

- DNR is working with federal partners at the U.S. Forest Service to procure funds for a forestry product market analysis for Maryland

Table 4.3-13. Forest Management Programs.

Calendar Year	Stewardship Plan[1]	Sediment Control[1]	State Forest Regeneration[2]	Timber Stand Improvement[1]	Wildlife Habitat[1]	Total Acres
2006	13,834.1	9,113.1	2,417.0	3,092.9	2,172.6	30,629.7
2007	14,135.0	11,204.8	1,731.0	5,925.6	3,331.4	36,327.8
2008	26,787.3	11,692.2	1,823.5	5,611.2	4,146.4	50,060.7
2009	17,936.9	11,044.4	2,234.1	3,789.2	3,212.8	38,217.4
2010	14,921.2	9,539.8	2,158.2	3,178.0	2,070.6	31,867.8
2011	22,012.1	11,585.8	1,891.8	4,496.0	3,302.1	43,287.8
2012	19,486.4	12,177.6	1,723.6	3,910.0	2,705.8	40,003.4
2013	18,945.0	12,235.9	1,524.9	5,054.9	1,062.5	38,823.1
2014	16,580.0	13,100.6	1,249.2	3,072.9	434.0	34,436.6
2015	23,111.6	13,973.8	1,803.7	5,373.8	279.0	44,541.9
2016	35,224.3	18,022.1	1,866.6	3,802.1	696.2	59,611.3
2017	24,795.1	18,048.6	2,504.7	3,506.3	1,223.4	50,078.0
2018	18,000.0	11,000.0	1,500.0	4,500.0	2,800.0	37,800.0
2019	18,000.0	11,000.0	1,500.0	4,500.0	2,800.0	37,800.0
2020	18,000.0	11,000.0	1,500.0	4,500.0	2,800.0	37,800.0
Total	301,769.0	184,738.7	27,428.3	64,312.8	33,036.8	611,285.5
Average Annual	20,117.9	12,315.9	1,828.6	4,287.5	2,202.5	40,752.4
15 Year Target Goal	270,000.0	165,000.0	22,500.0	67,500.0	42,000.0	567,000.0
Percent of Goal Obtained	112%	112%	122%	95%	79%	108%
Estimated 2030 Target Annual Goal	20,000.0	12,000.0	1,600.0	4,000.0	2,000.0	39,600.0

(Red indicates projections)

From the Maryland Forest Service PMAS report where a calendar year is defined as Quarters 3 & 4 of the preceding year, and Quarters 1 & 2 of the current Fiscal Year. For example, the number for 2006 represents the reported values from PMAS for Q3 & Q4 of 2006 and Q1 & Q2 of 2007.

State Forest harvest acres are only tracked by FY. Number reported from the annual State Forest Harvest Report and harvest data from WMAs and demonstration forests for the same fiscal year.

Enhancement Opportunities

Current programming appears to be meeting targeted goals.

Funding

The Woodland Incentive Fund is the progenitor of much of the activity on private lands. This fund receives revenues from a number of sources, including revenues collected by DNR for assistance in implementation of an approved practice, money distributed from the Chesapeake and Atlantic Coastal Bays Trust Fund under § 8-2A-04 of § 5-307; and subject to approval by the secretary and the Board of Public Works, a portion of the revenues derived from the forestry practices on designated lands owned and managed by DNR. Another important source is the portion received from property tax on the transfer of forest lands (up to $200,000 per year). The property tax transfer allocation for the Woodland Incentive Fund is very variable from year to year ($9,500 in FY17, $94,500 in FY18 and $205,700 in FY19), and identifying a way to make the funding allocation more reliable would aid in more consistently providing cost-share to landowners for forest management activities. Removing barriers to accessing federal funds could also help forest landowners, particularly smaller landowners. DNR is actively working with MDA and the USDA on removing those barriers.

Challenges

Available and consistent funding.

4.3.10.2 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 cumulatively reduce GHG emissions in the State by 1.79 $MMtCO_2e$ by 2020. This program is performing as designed.

2030 Plan

We expect to plant between 2,000 and 4,000 acres of forest per year from 2020-2030, with the expected average estimate being 2,550 acres per year over that period. This equates to 25,500 acres planted by 2030. The state will also still be benefiting from the annual growth and carbon sequestration of the approximately 45,000 acres planted from 2006-2020. In total, the GHG benefit will range from 0.28 $MMtCO_2e$ per year to 0.36 $MMtCO_2e$ per year of additional GHG sink, with the expected estimate being 0.3 $MMtCO_2e$ per year.

Implementation Milestones

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
  - Forest Conservation Act (FCA) Implementation
- Financial Assistance – Rural Lands: State and Federal Cost Sharing
  - Woodland Incentive Program (Maryland 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)

Table 4.3-14. Acres of Forest Planted in Maryland.

	Year	Afforestation[1][2]	Reforestation[1][3]	Riparian Buffers[4]	Private Natural Regeneration[5]	Total Acres
	2006	845.7	3,318.0	388.2	1,400.0	5,951.9
	2007	343.4	1,990.2	242.8	1,400.0	3,976.4
	2008	404.9	1,598.2	191.2	1,400.0	3,594.3
	2009	531.1	1,497.4	162.6	1,400.0	3,591.1
	2010	596.0	417.4	545.6	1,400.0	2,959.0
	2011	1,223.6	633.9	503.1	1,400.0	3,760.6
	2012	433.7	615.3	320.1	1,400.0	2,769.1
	2013	198.1	593.6	237.0	1,400.0	2,428.6
	2014	409.8	559.2	287.3	1,400.0	2,656.2
	2015	294.1	633.1	213.7	1,400.0	2,540.9
	2016	180.0	638.9	263.0	1,400.0	2,481.9
	2017	97.6	434.0	127.4	1,400.0	2,059.0
	2018	100.0	400.0	100.0	1,400.0	2,000.0
	2019	100.0	400.0	100.0	1,400.0	2,000.0
	2020	100.0	400.0	100.0	1,400.0	2,000.0
	Total	5,857.8	14,129.0	3,782.0	21,000.0	44,768.8
	Average Annual	390.5	772.2	252.1	1,400.0	2,984.6
	15 Year Target Goal	6,000.0	10,500.0	6,000.0	21,000.0	43,500.0
	Percent of Goal Obtained	98%	135%	63%	100%	103%
	Estimated 2030 Target Annual Goal	350.0	600.0	200.0	1,400.0	2,550.0
	(Red Indicates Projections)					
(1).	From the Maryland Forest Service PMAS report where a calendar year is defined as Quarters 3 & 4 of the preceding year, and Quarters 1 & 2 of the current Fiscal Year. For example, the number for 2006 represents the reported values from PMAS for Q3 & Q4 o					
(2).	PMAS field CREP/HEL Afforestation plus the Other Afforestation Acres.					
(3).	PMAS field Reforestation Acres.					

(4).	Acres reported by the Maryland Forest Service Riparian Forest Buffer Restoration Program. http://dnr.maryland.gov/forests/Pages/programapps/rfbrestoration.aspx
(5).	Estimated area of privately owned forest regenerated annually following timber harvest. Assumes 20 percent of Sediment and Erosion Control permitted acres reported by counties are actually harvested and regenerated. Historically, the average is 1,400 acre/year

Enhancement Opportunities

Provide dedicated staff to identify landowners interested in participating in programs like "Lawn to Woodland" and "Marylanders Plant Trees".

Funding

See below.

Challenges

Identifying willing landowners to participate in tree planting programs, particularly given the current economic conditions.

4.3.10.3 Creating and Protecting Wetlands and Waterway Borders to Capture Carbon

Lead Agency: DNR

Program Description

In addition to forests, wetlands are known to be very efficient at sequestering carbon. DNR is planting forested stream buffers and pursuing the creation, protection and restoration of wetlands to promote carbon sequestration through several means including the Natural Filters Program, which restores wetlands and buffers on state and public lands to meet water quality goals and is provided through the Chesapeake and Atlantic Coastal Bays Trust Fund. The objectives of the Coastal Wetlands Initiative include restoring natural tidal marsh hydrology to coastal wetlands through ditch plugging practices, the development of a terrestrial carbon sequestration protocol and the Sea Level Affecting Marshes Model (SLAMM). The following are accomplishments toward wetland and waterways goals made in 2017:

The Natural Filters Program restored 149.4 acres of wetlands on state and public lands and planted 56.17 acres of streamside forest buffers on state and public lands in 2017, working toward the state's Phase II Watershed Implementation Plan (WIP) goals. Funded through the Chesapeake and Atlantic Coastal Bays Trust Fund, these projects are designed to accelerate Bay restoration by focusing limited financial resources on the most efficient, cost-effective, non-point source pollution control projects, which include wetland and buffer restoration projects.

Through a partnership between DNR, The Nature Conservancy (TNC), U.S. Fish and Wildlife Service, Natural Resources Conservation Service, and National Oceanic and Atmospheric Administration, DNR was able to restore 2,174 acres over a five year grant agreement between TNC and DNR (Chesapeake and Coastal Bays Trust Fund). The Pocomoke project is a joint restoration effort by federal, state, and private partners to rehabilitate the hydrology of the floodplain by creating breaches in the spoil levees to allow increased movement of water between the channel and the floodplain. This would improve water quality, increase storage capacity in the floodplain, and enhance resiliency to climate vulnerability. The wetlands restored were mostly forested riparian wetlands, with some emergent wetlands restored in agricultural fields in the watershed.

DNR's Maryland Innovative Technology Fund (MITF) has invested in solutions that have the co-benefit of mitigating GHG emissions. Manta Biofuel, a MITF grant recipient, has a system to grow, harvest and convert algae to biofuel. This algal biofuel can be a substitute for fossil fuels, or mixed with fossil fuels and will emit less pollutants compared to fossil fuels. Dr. Russell Hill at the University of Maryland Center for Environmental Science Institute of Marine and Environmental Technology (UMCES IMET) has worked with the company to develop their system. Another example is HyTek Bio, which is using an algae scrubber system to reduce GHG and nitrogen oxide emissions from the Back River Wastewater Treatment Plant. Dr. Feng Chen at UMCES IMET is partnering with HyTek Bio in the development of this technology.

In addition, DNR is including another best practice for terrestrial carbon sequestration through its Shoreline Conservation Service projects to install Living Shorelines. These are additional coastal wetland restoration practices that function to sequester carbon.

Implementation Milestones

On the ground wetland and waterway restoration projects:

Natural Filters Program: As of 2017, 1,635 acres of wetlands have been restored and 924 acres of streamside buffers planted. The Natural Filters Program has exceeded the established goals for public land restoration.

The Chesapeake and Atlantic Coastal Bays Trust Fund has, to date, funded the restoration of 1,879 acres of wetlands and 1,184 acres of riparian buffers. These totals include restoration gains from the Natural Filters Program, as documented above, and projects that have occurred on private lands. From this point onward, implementation tracking will be expanded to include both public and private land restoration projects that are funded through the Trust Fund to more accurately reflect potential carbon sequestration gains.

Coastal Wetlands Initiative Program: To date, 505.6 acres of coastal wetlands have been restored by plugging existing drainage ditches to restore these drained wetlands.

Living Shorelines through the Shoreline Conservation Service: To date, 12.21 acres of Living Shoreline have been implemented since 2006.

Studies and Protocols

A Tidal and Seagrass protocol has been developed in partnership with Restore America's Estuaries and the Verified Carbon Standard Program. The protocol provides a default value of 1.46 MG Carbon sequestered/hectare/year for tidal wetland restoration projects if more detailed and precise accounting methodologies are not applied.

The Sea Level Affecting Marsh Model has been completed for Maryland coastlines and is being actively used for a variety of wetland management practices including:

- Factoring into DNR's land acquisition efforts to target areas that may provide a future wetland benefit through inland marsh migration resulting from sea level rise.
- Developing new easement opportunities for landowners that own land within these wetland adaptation area transition zones.
- Identifying the value of current and future wetlands for protecting communities and infrastructure from coastal flooding and shoreline erosion through DNR's Coastal Resiliency Initiative.

Future work will address using the SLAMM model to determine the potential loss of tidal wetlands, and the potential gain to provide input to the *2019 GGRA Draft Plan* in understanding the effect of sea level rise on carbon storage pools in current and future wetlands.

Enhancement Opportunities

The new protocol for Tidal and Seagrass restoration opens up opportunities to account for the GHG benefits of carbon sequestration through Submerged Aquatic Vegetation restoration and re-establishment.

Restore America's Estuaries and the Verified Carbon Standards program will be pursuing additional carbon sequestration accounting protocols for tidal wetland conservation. This protocol will provide justification for projects that prevent the degradation of tidal wetlands. Living Shorelines projects will prove to yield greater benefit through this new protocol as a result of the protection these buffers provide to tidal wetlands landward from the shoreline restoration project.

Funding

Trust Fund: In 2007, the Maryland General Assembly created the Chesapeake and Atlantic Coastal Bays Trust Fund (Trust Fund) to provide the financial assistance necessary to advance Chesapeake Bay restoration. A portion of this funding is targeted to Local Solicitation and Natural Filters that includes best management practices for reducing nutrient pollution to waterways that includes forested buffers, reforestation, wetland restoration, stream and floodplain restoration, stormwater retrofits, and other bioremediation projects. In FY18, $29.72 million was allocated for Local Solicitation and Natural Filters ($6 million of which is Natural Filters).

Resiliency through Restoration Initiative: Over the past 10 years, Maryland has experienced seven weather-related events warranting Presidential Disaster declarations, including five coastal flood events totaling approximately $103 million in economic damage. Recognizing that coastal habitats help buffer communities from these climate-related impacts, DNR's Chesapeake and Coastal Service (CCS) launched a new *Resiliency through Restoration Initiative*. This Initiative, funded by Governor Hogan through the State Capital Budget, provides technical and financial assistance to restore, enhance and create coastal habitat with the goal of protecting Maryland communities and public resources from extreme weather and climate-related events. The Initiative has led to the design of 16 living shoreline, coastal, and inland restoration projects around Maryland.

Coastal Wetlands Initiative (CWI): There are no dedicated funds currently allotted to CWI. Funding is typically acquired through a competitive grant process, which in the past have used state transportation and other federal funding sources.

Shoreline Conservation Services: This program is funded through the Shore Erosion Control Revolving Loan.

DNR/MDOT SHA Memorandum of Understanding: DNR has partnered with MDOT SHA in an effort to lead by example in restoring the Chesapeake Bay and local waters. State Parks have initially been targeted to provide opportunities for MDOT SHA to implement restoration projects required by their Federal Stormwater Permit (MS4) and their nutrient and sediment reduction goals required under the Bay Total Maximum Daily Load (TMDL). A Memorandum of Understanding was signed in 2013 to initiate this program and is currently being updated to provide additional guidance. This MOU will increase the rate of restoration projects on state and public lands.

Challenges

While wetland restoration, in both inland, freshwater and tidal environments, are practices that significantly contribute to terrestrial carbon sequestration rates throughout the State, the highly variable rate of methane

emissions has a marked effect on net GHG benefits. Research at state, regional, national and global scales continues to evolve and narrow in on more precise methods to evaluate the GHG benefits of wetland restoration.

Measures of success for the various Coastal Wetland Initiative projects are currently being monitored. In some cases, ditch plugging has been very effective in establishing sheet flow across the marsh and allowing sediment to naturally fill the plugged ditches. In other areas, the ditch plugging has resulted in excessive water pooling, creating a drowned marsh effect. Ongoing monitoring of these projects will improve the design, best practices and success of future efforts.

Removing barriers to accessing federal funds could also incentivize landowners to participate in restoration projects. DNR is actively working with MDA and the USDA on removing those barriers.

4.3.10.4 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 employ wood heating and cooling and would benefit from such a program. For example, schools, hospitals, and municipalities, could utilize local fuel markets as a key component of their tree management programs and all surrounding residents would also benefit by having access to a wood fuel market.

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

Implementation Milestones

- DNR is actively working with partners including the MEA and the Maryland Department of Commerce (COMMERCE) to facilitate installation of wood energy systems

- Due to lack of program participation, MEA discontinued offering grant opportunities supporting wood energy at commercial and institutional settings. This grant program could be reinstated if adequate demand is demonstrated.

Enhancement Opportunities

An analysis of “woodsheds” where the available wood resource is quantified would help to raise confidence in the ability of an area to support industrial scale biomass to energy and in the feasibility of industrial scale biomass-to-energy. Additional educational outreach on the feasibility of biomass to energy to academic institutions and the business community would likely help to establish this program. On the economic development side, a Strategic Economic Adjustment plan will help prepare Maryland’s industry for the future. The U.S. Department of Commerce Economic Development Administration just awarded a grant to the Western Maryland Resource Conservation and Development Council, who is partnering with DNR and Commerce to develop the plan. Once finalized, the plan will serve as a roadmap for capitalizing on new opportunities in the forest industry including biomass for energy production.

Funding

See 'Challenges' section.

Challenges

Awareness of wood energy technology is the primary barrier to this program, in particular adequately informing the managers of commercial and institutional spaces of the opportunities to save money while improving environmental outcomes that are offered by the simple switching to wood fuels. Establishing some demonstration projects in Maryland would greatly assist with DNR's ability to showcase available technology.

Actions that still need to be implemented include:

1. Developing a policy supporting thermal energy
2. Recognizing wood as a renewable energy source, on par with solar, geothermal and wind

4.3.10.5 Conservation of Agricultural Land for GHG Benefits

Lead Agency: MDA

Program Description

Land conservation offers an important mechanism for mitigating and adapting to climate change. Healthy and vigorous forests and pasture lands not only provide direct benefits in GHG reduction but keeping them intact also helps to avoid or diminish GHG emissions associated with development.

MDA seeks to safeguard Maryland's network of natural areas, agricultural lands, and coastal zones through its established conservation programs and practices. MDA continues to pursue policies and programs that curb the conversion of agricultural lands and encourage the conservation of natural resources, working with its partners at DNR and MDP in these efforts and to promote the preservation and restoration of forested, grassed, and wetland areas on agricultural lands. Two MDA programs key to these efforts are the Maryland Agricultural Land Preservation Foundation (MALPF) and the USDA's Conservation Reserve Enhancement Program (CREP).

MALPF, which purchases permanent preservation easements, was established in 1977 and is one of the 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, the protection of agricultural land reduces random urban development, safeguards wildlife habitat, and enhances the ecology of the Chesapeake Bay and its tributaries.

Maryland has participated in CREP since 1997 to target high-priority conservation concerns by offering rental payments for 10-15-year set-aside contracts and other incentives to agricultural producers to protect environmentally sensitive lands, improve wildlife habitat, and reduce nutrient and sediment loss. 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.

Program Objectives

The State of Maryland's 2020 goal is to permanently protect 962,000 acres of farmland, woodland, and open space land from commercial, residential, and industrial development by purchasing permanent easements through MALPF, local government land preservation programs, local Transfer of Development Rights (TDRs), and other similar initiatives.

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.

Implementation Milestones

MALPF:

- As of June 30, 2018, 2,302 farms have been protected and land has been preserved in each of Maryland's 23 counties.
- MALPF's purchases represent a cumulative public investment of $729 million and increase total acres preserved in the program to 312,667.
- Current acreage totals bring MALPF's contribution alone to 33 percent of the 2020 goal.
- With a total of 640,128 acres protected with easements of all types, the State has achieved 67 percent of its 2020 target.

CREP:

- CREP enrollments have generally been declining.
  - Enrollments peaked at 74,500 acres in 2008.
  - Enrollments averaged 60,000 acres in the intervening years, but as of June 2018, dropped to 49,400 acres. It should be noted, however, that enrollments change throughout the year and the numbers can be higher or lower on any given date.
- The success of earlier years is unlikely to be repeated, and the achievement of almost 75 percent of the overall acreage goals in 2008 also represents a peak for the program.
- Despite the declines in enrollments, there are some reasons for optimism:
  - DNR's Easement Program has targeted CREP acres for permanent protection and now has 11,453 acres of former CREP-enrolled land under permanent conservation easement.
  - Even after contracts expire, many of the funded practices remain on the land and continue to provide the intended environmental benefits.

Enhancement Opportunities

Passage of legislation by the 2018 General Assembly will enable MALPF to participate in the U.S. Department of Defense's Readiness and Environmental Protection Integration Program (REPI) and enter into agreements with the Navy and other partners to share acquisition costs of easements to preserve agricultural land uses and natural habitat near military installations and ranges.

Funding

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.

The monies in CREP vary with authorized funding and participation levels. The USDA funds CREP rental payments and a percentage of cost-shares and incentives through its Farm Service Agency. The Maryland Agricultural Water Quality Cost-Share Program (MACS) offers grants, which are largely financed by State bond funds, to provide up to 87.5 percent of the costs to install eligible best management practices. State signing incentive payments are funded through grants from the Chesapeake and Atlantic Coastal Bays Trust Fund.

Challenges

Although MALPF saw an increase in allocated funds in FY17 and FY18, the applications for participation in MALPF exceed available funding every year. Starting in 2009, the General Assembly diverted monies from the program and partially replaced them with bond funds. Because of these decreases, the program combined its acquisition years over five cycles in order to have enough funding in each cycle to make at least one offer in each participating county. With the full funding of the program in the current fiscal year, MALPF will move back to an annual cycle of easement acquisitions for the first time in a decade.

Even though commodity prices have dropped substantially, CREP participation has not rebounded as expected. An aging farm population and turn-over in ownership, together with concerns about the ongoing demands of maintenance standards, suggest that farm operators are less willing to enter into lengthy contracts typical of CREP.

Relevant Information

Since both MALPF and CREP address working agricultural lands, their future sequestration potential will be captured under the Healthy Soils Program as part of the *2019 GGRA Draft Plan* to avoid possible double counting of GHG reduction estimates.

4.3.10.6 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 evaluate their urban tree canopy goals, and plant trees to meet those goals.

The goal of this program is to plant 12.5 million trees by 2020 in urban areas through the Forest Conservation Act, Marylanders Plant Trees, Tree-Mendous Maryland, and 5-103 State Highway Reforestation Act planting programs.

- Financial Assistance – Urban Lands: Public/Private Partnerships
  - Tree-Mendous/Arbor Day
    - 4,800 trees (48 acres) planted in 2016
- Marylanders Plant Trees/Private Nurseries
  - Reimbursed coupons for 3,998 trees (39.9 acres) in 2016
- Lawn to Woodland (e.g. National Arbor Day Foundation, etc.)
  - Kicked off in spring 2014 with 4.3 acres planted.
  - 100.73 acres on 84 sites planted in spring 2015
  - 60.33 acres on 55 sites planted in spring 2016
- Maryland Urban & Community Forestry Committee Grants
  - Small Community UTC Grants

2030 Plan

We estimate that on average, between 150,000 to 500,000 urban trees will be planted in Maryland per year from 2020-2030. This will equate to 1.5 to 5 million total trees planted over that period. Staff estimate that the average

of the past three years is reasonable to expect for a projected annual average during the 2020-2030 period; the average being 265,000 trees planted per year. The low estimate of GHG benefit is 0.0023 $MMtCO_2e$ per year, high is 0.0046 $MMtCO_2e$ per year, with the expectation of 0.0035 $MMtCO_2e$ per year of additional carbon sink in 2030.

Implementation Milestones

To date, 5,734,006 trees have been planted from 2006 to 2017 (total for this program and Planting Forests in Maryland).

Table 4.3-15. Urban Tree Planting (number of trees).

Year	Forest Conservation Act (FCA)(1)	Reforestation 5-103(1)	Tree-Mendous & Marylanders Plant Trees Programs	Total Trees
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
2015	142,875	6,251	8,435	157,561
2016	341,640	2,705	8,798	353,143
2017	265,050	8,388	12,545	285,983
2018	0	0	0	0
2019	0	0	0	0
2020	0	0	0	0
Total	3,918,195.0	543,259.0	192,393	4,653,847
Average Annual	261,213.0	36,217.3	12,826.2	310,256.5
15 Year Target Goal	N/A	N/A	N/A	N/A
Percent of Goal Obtained	N/A	N/A	N/A	N/A
Average of Last 3 Years (Rounded)	249,900.0	5,800.0	9,900.0	265,600.0
(1).	Assumes 450 trees			

	planted/acre.			

Enhancement Opportunities

The DNR Forest Service (MD Forest Service) developed two new tree planting assistance programs that reach landowners within the urban/suburban areas of Maryland. The new programs target the 1.1 million acres of turf statewide. Each targets different lot size and different available planting space.

- The "Lawn to Woodland" program, a partnership with the Arbor Day Foundation, targets the small lot with 1-5 acres of plantable space or turf. The Foundation does outreach while MD Forest Service handles the tree planting at no cost to the lot owner. In the spring of 2014, a pilot was done with 14 acres planted on 12 lots. In spring of 2015, 100 acres were planted on 84 sites and in the spring of 2016, 60 acres were planted on 55 sites. All total 174.3 acres were planted on 151 sites. This program is on hold until funding is found.
- The other program, "Marylanders Plant Trees," is a $25 coupon reimbursement program targeting individuals wishing to plant a tree. It enables very small lot owners to purchase a tree valued at $50 or more and reduce the cost $25. There are 85 participating nurseries across the state. From the program's inception in FY09 to FY18, 45,545 coupons have been reimbursed.

Funding

The "Lawn to Woodland" and the "Marylanders Plant Trees" programs are both funded through forest mitigation funds received as a result of highway construction projects complying with Reforestation Law (NRA 5-103). This makes the funding variable from year to year, and for the past several years the "Lawn to Woodland" program was on hold due to limited available funds. Identifying an alternative funding source when mitigation funds are limited or not available would allow for the programs to be consistently offered to the public.

Challenges

Year to year variability in program availability and funding levels creates a challenge in building program awareness in the public.

4.3.10.7 Geological Opportunities to Store Carbon

Lead Agency: DNR

Program Description

Geological carbon sequestration differs from other discussed sequestration methods because it captures carbon at the source, transports it to a 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 opportunities. More than 10 gigatonnes of storage capacity has been identified within the terrestrial portion of Maryland (103 years of storage capacity at current CO_2 estimated production rate of 97 million metric tons per year). An unquantified, amount of storage is located offshore of Maryland and is estimated to be much larger in magnitude.

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.

Program Objectives

The potential emission reductions from the Geological Opportunities to Store Carbon program have been aggregated with the estimated emission reductions from the Terrestrial Sequestration bundle (Forestry and Wetlands).

Implementation Milestones

DNR's Resource Assessment Service (RAS) and Maryland Geological Survey have completed or is currently working on the following implementation milestones.

- Total organic carbon content in Maryland black shales (e.g., Marcellus) is being evaluated as a precursor for determining the viability of these as storage units for CO_2. This data is incorporated into regional and national databases for various integration projects. This project is completed.
- The potential for offshore carbon sequestration is being evaluated in partnership with Harvard University, Battelle, US Department of Energy, Rutgers University, University of Texas, and the surrounding Mid-Atlantic States. Focus areas of this study include geologic characterization, capacity evaluations, injectability, and risk analyses. This project will provide foundation knowledge and an assessment of potential for carbon sequestration offshore in the Baltimore Canyon Trough. Projected completion date is June 2019.
- The potential of saline aquifers located under the Coastal Plain in Maryland as a target for carbon sequestration is being evaluated in cooperation with multiple state geological surveys. There is currently no funding for this research and saline aquifers remain a potential option, but unvalidated sink for CO_2.
- Baseline data has been collected to provide the foundation for conducting risk analyses for potential development of stray gas migration into potable aquifers.
- Research is ongoing to assess the CO_2 chemical adsorption capacity of power plant combustion by-products and organic shales and clays in the closest geologic formations.
- Research is ongoing to assess the CO_2 structural and chemical storage within failed rift basins. The Gettysburg-Culpepper basin is being documented in depth due to its exposure and a comparison is being made with the Taylorsville basin. Projected completion date is December 2019.

Other RAS program notes include:

- Site testing (carbon capture, transport, and storage) continues in Michigan and Ohio (Regional partners to Maryland in CO_2 sequestration projects) and has been completed in Kentucky. These programs are being evaluated at a national level and the results continue to be favorable at this time.
- Depleted gas fields present the most immediate option for permanent storage of CO_2 in Western Maryland.
    - RAS is currently assessing the potential of utilizing black shales (e.g., Marcellus) as permanent sequestration locations as a logical reutilization of natural gas infrastructure.
    - A methane emissions study of the Deer Park Anticline by the Western Maryland Regional GIS Center has ruled out using this Anticline for structural storage of CO_2 due to observed methane leaks primarily from the old Mountain Lake Park Gas Field. It could still have potential for chemical adsorption of CO_2.

Enhancement Opportunities

The Taylorsville Formation is closest to the majority of Maryland's coal and gas fired power plants. An investigation focused on the CO_2 chemical adsorption capacity of this formation could best serve the Maryland electric power industry as a repository for carbon capture. RAS is leveraging funds from Battelle to analyze the exposed Gettysburg-Culpeper Basin as a proxy for the Taylorsville Basin. This study begun in 2016.

Funding

Most of the funding for Geological Carbon Sequestration is coming from the U.S. Department of Energy, organized and administered through Battelle. Twenty thousand dollars per year is provided through the state's Environmental Trust Fund.

Challenges

The cost of capturing CO_2 using current technologies involves a parasistic loss in the range of 20 to 25 percent at the generation site. This loss continues to decrease as the technology matures. Carbon capture will become increasingly viable economically as this particular characteristic continues to decline. New research is being conducted in this area more broadly and it is expected aggregate costs will decrease, especially in conjunction with other policy tools like the 45Q tax credits being offered by the federal government. Research as contributed to a reduction in these on-site costs, but transportation economics may present some challeneges in the near-term.

4.3.10.8 The Maryland Healthy Soils Program

Lead Agency: MDA

Program Description

In addition to reducing nutrient and sediment flows into the Chesapeake Bay and its tributaries, many of the agronomic and conservation practices used by Maryland's farmers have the potential to make a significant contribution to the State's climate change goals by sequestering carbon and other GHGs. The 2017 Healthy Soils Act charged MDA with the development of a healthy soils program to improve the health, yield, and profitability of Maryland's soils and promote the further adoption of conservation practices that foster soil health while increasing sequestration capacity. In support of this initiative, MDA has collaborated with stakeholders from the Healthy Soils Consortium to complete a comprehensive scientific literature review to identify those practices that are most effective in improving soil health and building soil carbon stocks, and create a menu of Maryland-specific practices. MDA intends to use this information to determine the metrics and tools for quantifying soil carbon and provide incentives to encourage the additional implementation of climate friendly soil practices. Existing programs are also being examined to find ways to capitalize on co-benefits for both water quality and carbon sequestration.

Relevant Information

As noted elsewhere, MDA will be including the initiatives dealing with the conservation of agricultural lands and the addition of a carbon component to Maryland's nutrient trading market under the Healthy Soils Program in the new *2019 GGRA Draft Plan*.

4.3.11 Ecosystems Markets

4.3.11.1 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 to explore the establishment of ecosystem markets, create a tracking mechanism and develop protocols to assess/quantify GHG benefits of individual markets. However, no quantification target has been assigned.

Implementation Milestones

- DNR has completed a study to economically value a suite of ecosystem services for select habitats along an urban to rural gradient.
- Ecosystem services from forests, wetlands, cropland, and pasture land have been spatially quantified across Maryland. Spatial models for coastal ecosystem services have been completed and are available on Maryland GreenPrint (www.geodata.md.gov/greenprint/).
- The Nontidal Wetlands Mitigation Banking bill passed in 2016 removes barriers to mitigation banking in Maryland, with the goal of reducing the cost for meeting mitigation requirements in an ecologically beneficial way.
- Under Forest Conservation Act (FCA) banking, several counties in Maryland allow off-site mitigation for forest loss through purchasing credits in a forest bank. Over 2,000 acres of forest loss have been mitigated in this way over the past 15 years.

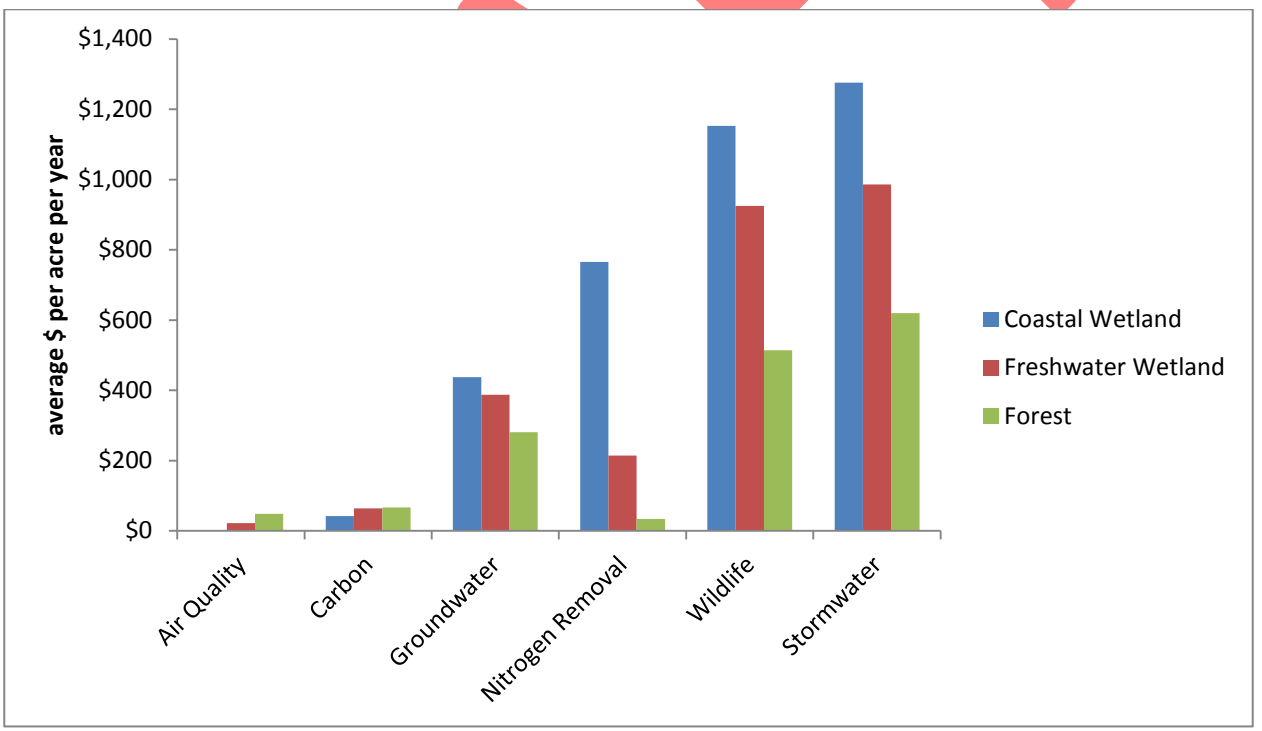

Figure 4.3-9. Ecosystem Service Non-Market Value in Maryland.

Enhancement Opportunities

Banking for forests and wetlands could prioritize habitat types that have high potential for carbon sequestration, like forested wetlands or deciduous forests.

Challenges

Without a cap and trade program on the national level, the voluntary carbon market in the United States has largely failed. Working within the boundaries of currently functioning ecosystem marketplaces for wetlands, forests and habitat presents limited opportunities for generating net carbon reductions. RGGI does allow for carbon emissions offsets to be generated through forest planting or management activities, but at this time there have not been any offsets generated in this way because they are not currently cost competitive with emission allowances on the RGGI market. Greater investment in conservation and restoration of natural lands, and projects that promote co-benefits, will create a positive trend in ecosystem services provided, including the sequestration of carbon.

4.3.11.2 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 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 maintain their limits by acquiring credits or offsets generated from reductions elsewhere.

Program Objectives

MDA expects to add carbon credits and enhanced nutrient credits to the Maryland Water Quality Trading Program. Carbon and enhanced nutrient credits would be "stacked" onto existing nitrogen, phosphorus, 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 cross-sector trades between nonpoint sources, such as agricultural operations and permitted point sources, including for the first time, entities operating under Municipal Separate Storm Sewer System (MS4) permits, would not only improve water quality and provide supplemental agricultural income, but also create new opportunities for GHG reductions by reducing fertilizer, pesticide/herbicide, and energy use, restoring wetlands and wildlife habitat, and promoting the preservation of agricultural and forested lands. MDA's goal for 2020 is to achieve participation by 10 percent of farms and landowners in providing nutrient, sediment, and carbon credits to an active environmental market in Maryland.

Implementation Milestones

- Unlike many states that use their trading programs to furnish compliance credits for existing wastewater facilities, Maryland relies on the Bay Restoration Fund (BRF) to provide monies to upgrade major wastewater treatment plants, and as a consequence, its trading program was designed from inception to supply offsets to accommodate new growth and development.

- Accounting for Growth (now known as "Aligning for Growth") policies and regulations still have not been finalized, leaving the program without a potentially significant driver for trading. The proposal to allow Phase I MS4 jurisdictions to meet a portion of their impervious area restoration requirement through the purchase of credits promises to offer a much needed alternative. Existing MS4 permits must be modified to allow nutrient trading, but subsequent permits will allow this compliance approach. Phase II MS4 permits and general permits for industrial stormwater also allow traded credits to be applied to restoration requirements. More detailed information can be found on MDE's trading website.

- In 2015, the Maryland Agricultural Nutrient Trading Advisory Committee was disbanded and a new Water Quality Trading Advisory Committee was convened in 2016 to provide direction to the overall trading program and oversee any further development of the trading infrastructure. The initial tasks of the new committee have been to review and refine a comprehensive trading manual and assist with the development of trading regulations.

- Although a public/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, that effort was discontinued in 2012 with the worldwide collapse in carbon credit prices. The Healthy Soils Consortium, which was convened in August 2016, undertook the tasks of the previous carbon advisory group to inventory best management practice and create a carbon and GHG practice menu. MDA intends to use the menu to determine the metrics and tools that will be used to measure carbon sequestration.

- An online, 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.

- MDA completed development of a web-based, inter-active, site-specific assessment tool to determine offset needs for development projects, as well as substantial enhancements to trading program's online registry and marketplace components to make them functional for all types of trades and use by all sectors.

- MDA's regulations for the generation, verification, and certification of agricultural nutrient and sediment credits became effective as of Aug. 29, 2016; MDE's regulations for the Maryland Water Quality Trading Program became effective as of July 16, 2018.

- Since the timing of a fully functioning marketplace remains uncertain, it is doubtful that 5-10 percent of Maryland's farms will be generating nutrient, sediment, and/or carbon credits in an active environmental market by 2020. The groundwork has been laid, however, and trading should become a more attractive and competitive option in future years.

Enhancement Opportunities

If work on Aligning for Growth policies and guidance should resume, the Water Quality Trading Advisory Committee is available as a resource to help in their development.

Funding

Trading program policy and infrastructure development was funded by USDA/Natural Resources Conservation Service Conservation Innovation Grants and the EPA Clean Water Act, Section 319(h), and Chesapeake Bay Implementation, Section 117, Grants. The last remaining grant ended during FY17, and support is currently coming from state General Funds.

Challenges

Major concerns center around the following issues:

- Appropriate metrics to estimate or measure carbon sequestration
- Viability of a voluntary program and participation levels
- Verification and certification protocols and the assurance that credits are real and reliable
- Public reporting procedures and accessibility and their role in fostering transparency and trust

- Compliance, liability, and enforcement provisions and exposure to legal action

Relevant Information

The potential economic impact of an active environmental market has not been evaluated. Such a market, however, would provide new employment opportunities for individuals and organizations offering services to support an emerging environmental restoration economy. Besides the benefits of creating and retaining jobs and generating supplemental income in the agricultural community, the assessment and verification of credits, the need for annual inspections, the design and installation of structures and systems and the acquisition, management, and re-sale of credits are expected to become sources of revenue for consultants, technical advisors, engineers, contractors, aggregators, brokers, and environmental bankers.

Because of the relationship of this initiative to the implementation of carbon sequestration efforts in Maryland, it will be included in the future under the *2019 GGRA Draft Plan* as part of the Healthy Soils Program.

4.3.12 Building and Trade Codes in Maryland

Lead Agency: Department of Labor

Program Description

Given the long lifetime of buildings, state and local building codes play an integral role in providing long-term GHG emissions reductions. The statewide building code in Maryland is adopted by the Building Codes Administration within the Maryland Department of Labor. The statewide building code is called the Maryland Building Performance Standards (MBPS). MBPS includes International Building Code (IBC), International Residential Code (IRC), International Energy Conservation Code (IECC) and International Green Construction Code (IgCC), all published by the International Codes Council (ICC). MBPS is updated every three years (except for IgCC). Within 18 months of publication of a new edition of these codes by ICC, the Building Codes Administration is required by law to adopt these latest edition of codes into the MBPS (except for IgCC). Subsequently, the local jurisdictions shall adopt and implement the MBPS within 12 months of State adoption. Local jurisdictions may amend the MBPS to meet the specific conditions and needs of their jurisdiction – with a few exceptions. For example, automatic fire sprinkler system (IRC), the energy code (IECC) and the accessibility code (Maryland Accessibility Code) cannot be weakened. IgCC is a voluntary option for local jurisdictions to adopt.

The Building Codes Administration also adopts the Model Performance Code, a collection of separate building codes, which regulates the construction of state buildings (owned, used or leased) and industrialized (modular) buildings. Modular buildings are constructed off-site in manufacturing plants, transported into Maryland and installed at job sites. The Model Performance Code includes not only the same ICC published codes as in the MBPS, but also other codes from the ICC family of codes such as International Mechanical Code & International Plumbing Code, as well as the National Fire Protection Association's (NFPA) National Electrical Code.

The Building Codes Administration also adopts the International Existing Building Code under Maryland Building Rehabilitation Code Regulations.

Maryland is at the forefront of building and energy code adoption in the United States.

Program Objectives

- Ensure that industrialized (modular) buildings are designed and constructed to meet Maryland's Model Performance Code.
- Adopt statewide building codes and work with local governments, design professionals, and building code enforcement officers, including plan reviewers and construction inspectors, to ensure reasonable protection to the public against hazards to life, health and property; to establish the policies and procedures associated with the operation of a database, which contains the MBPS, the local amendments, and other related information.
- Provide training on newly adopted building codes to local code officials and stakeholders.

Implementation Milestones

- Review new editions of mandatory building codes, including IBC, IRC and IECC, for adoption.
- Review other discretionary building codes during each code adoption cycle and update them as needed.
- Review building plans of industrialized (modular) buildings and conduct inspections of manufacturing facilities to ensure that construction of modular buildings meets requirements of Model Performance Code.
- Provide interpretation of Maryland Accessibility Code (MAC) and process Waiver Applications of Maryland Accessibility Code by following established procedures defined in the MAC.
- Conduct meetings of Maryland Building Rehabilitation Code Advisory Council for matters related to renovation/alteration of existing buildings.

Recommendations for Future Actions and Reporting:

- Allow the Building Codes Administration flexibility to consider building code action items due to changes in building technology.
- Provide education to local building code officials on amendments to IECC to allow flexibility in meeting energy efficiency requirements in residential dwelling construction. This was completed during the 2018 code adoption cycle through department regulations.
- Improve and expand training of state adopted building code for employees of local jurisdictions statewide.

Enhancement Opportunities

- Work with counties and other executive branch bodies that have control of different building codes, such as Maryland State Fire Marshal Office and Maryland Department of Labor, Division of Occupational and Professional Licensing, to better align the codes across all jurisdictions in Maryland.
- July 1, 2018, the Building Codes Administration was transferred from DHCD to Department of Labor Division of Labor and Industry (DLI). Within DLI, several related building design/construction related licensed professionals and trades are regulated. Additionally, the International Mechanical Code and International Plumbing Code are also adopted by other units within the Department of Labor. Since the Department of Labor is responsible for the majority of building related codes and licensing of persons engaged in design/construction, new opportunities are being realized for streamlining regulations related to building construction in the State of Maryland.

Funding

The Building Codes Administration has two primary funding sources, including general fund and funds received under the Industrialized Building Program. Manufacturers of the industrialized/modular buildings and their Approved Testing Facilities (ATF) are required to renew their Maryland registrations/approvals annually. The manufacturers of industrialized/modular building also purchase insignia, which are required to be attached to each modular building unit that is installed in the State. These Manufacturers are required to reimburse the State for travel expenses related to unannounced inspections by employees of the Building Codes Administration.

The Building Codes Administration also receives $13,000 in annual revenue from the federal Department of Housing and Urban Development (HUD) for serving as the State Administrative Agency (SAA) of the Manufactured Homes Program.

Challenges

Because Maryland is legislatively mandated to adopt the latest codes published before most other states do, cost effective solutions that meet new codes are not always readily available in the marketplace. This can increase the cost of building construction in Maryland until more states adopt the new codes and products are widely produced and become available at competitive prices.

Since Maryland statute allows local jurisdictions to amend state adopted building codes with few exceptions, home builders, manufacturers of modular buildings, building designers and general contractors are not always aware of all current requirements of building codes in effect in each jurisdiction.

Maryland law requires local jurisdictions to provide information on their amendments and adoption of building codes to Building Codes Administration. This information should be maintained in the database that Building Codes Administration is responsible for maintaining and updates. However, most local jurisdictions have not fulfilled this obligation.

4.3.13 Sustainable Materials Management

Lead Agency: MDE

Program Description

On June 27, 2017, Governor Hogan signed Executive Order 01.01.2017.13, Waste Reduction and Resource Recovery Plan for Maryland. The order adopts a first-ever sustainable materials management (SMM) policy for Maryland that aims to minimize the environmental impacts of the materials' use throughout the entire lifecycle. The policy emphasizes environmentally and economically sustainable methods to capture and reinvest resources into our economy, including everything from metals and plastics to energy, nutrients, and soil. It initiates a stakeholder consultation process to establish ambitious but achievable goals and to ensure tracking of complete materials management data. It also empowers new partnerships across State and local agencies, the agricultural, energy, and transportation sectors, environmental organizations, and recycling innovators.

New Program Initiatives

Specifically, the order contains the following initiatives:

- A stakeholder consultation process to improve MDE's methodology for tracking waste generation, source reduction, and recycling, including recommendations to better account for business recycling activities and new voluntary statewide goals for continuous improvement in SMM;
- A technical assistance partnership between the Departments of Commerce and the Environment will help establish new recycling businesses in Maryland;
- A partnership between the Departments of Agriculture and the Environment will provide research and demonstration of innovative nutrient recovery technologies in order to facilitate adoption of these technologies;
- A partnership between the MEA and MDE will research and promote adoption of energy recovery technologies such as anaerobic digestion;

- A partnership between the Departments of Transportation and the Environment will provide guidance to increase the reuse of dredged materials, including by State agencies; and
- Outreach partnerships will increase awareness of the benefits of and opportunities for waste diversion.

Future Challenges

The new order replaces Executive Order 01.01.2015.01 Executive Order for Maryland. The new approach recognizes that SMM efforts require collaboration, and the specifics of the initiatives conducted under the order will be shaped by stakeholder input. As MDE initiates the new partnerships and consultation processes included in the order, it will work to better quantify the GHG emissions benefits and jobs impacts of the initiatives for inclusion in the final GGRA Plan.

4.3.14 Maryland's Innovative Initiatives

4.3.14.1 Voluntary Stationary Source Reductions

Lead Agency: MDE

Program Description

The GGRA of 2016 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 Jan. 1, 2012, and secure a formal "credit."

Implementation Milestones

This is a voluntary program.

4.3.14.2 Buy Local for GHG Benefits

Lead Agency: MDA

Program Description

The public's growing awareness of the benefits of fresh, healthful food and its increasing interest in the sources of that food have sparked unprecedented consumer preference for locally-grown and locally-made agricultural products. Maryland's agricultural producers and processors provide a traceable and reliable supply of local foods, and MDA's "Buy Local" campaign continues to be highly successful in promoting local farms as preferred sources of food to all Marylanders. The "Buy Local" campaign offers assistance, too, for producers in marketing directly to not only consumers, but also supermarket, food service, institutional, and other wholesale buyers. MDA created the website "Maryland's Best" (www.marylandsbest.net) as an online resource for finding locally grown products. In addition, consumers can go the http://mda.maryland.gov/maryland_products/pages/farmers_market_dir.aspx for a complete directory of the State's farmers markets.

MDA's promotion of sustainable production and consumption of local agricultural goods helps to displace the production and consumption of products transported from other states and countries. In addition to the energy savings and GHG reductions resulting from decreased transportation emissions, greater demand for local products

preserves the agricultural landscape, supports agro-biodiversity, and encourages beneficial environmental practices.

Program Objectives

MDA works with farmers, local governments, restaurants, food distributors and retailers, value-added producers, public and private institutions, and trade associations to maintain and expand its popular "Buy Local" program. MDA's 2020 goals are to establish a state farmers market association, raise the number of farmers markets by 20 percent, and increase direct sales (buyer/grower) by 20 percent.

Implementation Milestones

MDA appears to have already fulfilled its goals under this initiative.

- The Maryland Farmers Market Association (MDFMA) (www.marylandfma.org) was established in 2012.
- As of 2017, there were 139 MDA-recognized farmers markets across the State, with at least one in every Maryland county and Baltimore City.
    - This number represents 90 percent 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.
    - Using data from a survey of farmers markets compiled by MDA and MDFMA in 2017, farmers markets generated sales of $65 million and more than 2.3 million consumers visited the markets during the year.
- MDA does not track direct sales figures, but if annualized participant numbers at the buyer/grower expo (now renamed Maryland's Best Expo) held each winter since 2002 are used as a proxy, the event has grown well over 100 percent during the subsequent years.
- MDA participates in USDA's Farmers Market Nutrition Program (FMNP), which provides checks for the purchase of fresh produce to low-income senior residents and participants in the federal Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).
    - Approximately 400 Maryland farmers join in this effort annually and all 139 farmers markets participate in FMNP.
    - About a third of the markets also participate in USDA's Supplemental Nutrition Assistance Program (SNAP), formerly known as food stamps, to help expand access for low-income Marylanders to fresh local foods.
- Launched in 2013, Maryland Market Money is a state-wide effort to increase the purchasing power of food-insecure households that spend federal nutrition benefits at participating farmers markets by providing additional dollars for these customers to spend on fresh, healthful food.
- In 2014, the Maryland Department of Human Resources joined with MDFMA to support a federal program for the installation of 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 to pilot the Farmers Market Finder, a mobile website (http://farmersmarketfinder.ub.1.co/) that lists all farmers markets in the State with vendors who accept FMNP checks.
    - The site also educates participants about the use of their checks, informs them of what foods are eligible for purchase, and provides links to videos and photos of farmers active in FMNP.
    - Participants can opt to receive mobile text messages every month from the site to remind them to use their FMNP checks before they expire.
    - In addition, the site has recipes for fresh produce dishes and provides farmers market shopping tips.
- In 2016, MDA joined with the Farmer Veteran Coalition (FVC) and MidAtlantic Farm Credit to launch the "Maryland's Best Homegrown By Heroes" program. This program supports Maryland veterans who have

returned home to the farm by providing unique signage to identify and promote products grown by local veterans at farmers markets and local groceries, as well as assistance through other business services.

Enhancement Opportunities

As is demonstrated by the numerous enhancements already made, MDA is always open to opportunities to improve the experience of all users of the "Buy Local" and allied programs.

Funding

The "Buy Local" initiative receives ongoing support from a number of sources, including grants from USDA, matching funds from MDA and the Maryland Department of Health, and state General Funds. The costs of some events are offset by sponsorships and registration fees.

Challenges

The primary challenge for the "Buy Local" program is maintenance of its success.

Relevant Information

The 2017 sales figure for farmers markets and the extraordinary growth shown by the buyer/grower program suggest that original estimates of job creation, net economic output, and wages appear to be understated.

As was noted above, the defined goals of the "Buy Local" program have been achieved and farmers markets appear to have reached their saturation point. While MDA will continue to support "Buy Local" efforts, contributions to GHG reductions are minimal and the initiative will no longer be tracked under the *2019 GGRA Draft Plan*.

4.3.14.3 Pay-As-You-Drive® Insurance in Maryland

Lead Agency: MIA

Program Description

Use-based automobile insurance is generally designed to align the amount of premium paid with actual vehicle usage. The distance an automobile is driven, the speed 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. Under use-based plans, the consumer generally uses a telematics device to provide information about the actual mileage and other driving behaviors to the insurance carrier. The carrier can use that information to adjust the price of coverage based on the degree of risk posed by the insured's actual driving behaviors.

As of spring 2019, at least 27 insurance companies offer a use-based insurance program for their private passenger insureds and at least 16 offer these programs to their commercial insureds. This is a voluntary program. In addition, four vendors offer a product that insurers may purchase (rather than developing their own program) to make available to their customers. An insurer that uses a vendor-created program must file the program with the Maryland Insurance Administration (MIA) prior to implementation. As a result, the MIA anticipates a continued increase in the availability of use-based automobile insurance. Consumers receive discounts off of their insurance premiums for participating in most use-based programs. However, nationally, the market is moving towards the use of discounts for safe drivers and surcharges for less safe drivers as measured by telematics devices.

Program Objectives

The MIA continues to work with insurers to increase the number of companies offering these programs.

Implementation Milestones

Obstacles/Considerations

While there are no statutory or regulatory prohibitions to use-based automobile insurance, any such program must operate within the confines of Maryland law. That being said, the following is a list of the obstacles/considerations that should be taken into account when reviewing these programs:

1. Use-based automobile insurance only produces financial rewards for individuals who drive short distances. Individuals lacking access to public transportation or alternatives to driving, such as those who live in rural areas or those who commute to work, will not be inclined to sign up for this type of program as it will not result in any cost savings to them.

2. Consumers may be concerned about the privacy issues surrounding programs such as this that utilize devices that monitor how, when and where they drive in order to justify the discounts provided.

3. Individuals who sign up for use-based automobile insurance are most likely persons who drive a limited number of miles, and as such, the actual reduction in GHG may not add up to the volume projected.

4. The increased costs and expenses for insurers to develop alternative rating plans and the devices used to track and transmit this data may limit its availability and affordability.

5. The (in)ability to collect additional premiums from insureds who exceed the mileage limits, or to legally disclaim coverage if the insured vehicle is involved in an accident after it is discovered that the amount of mileage insurance purchased has been exceeded.

6. The (in)ability to properly rate policies when more than one vehicle or driver are on the policy. Since different drivers present different risk factors, it is important for the insurer to know how many miles each insured person is driving each insured vehicle and this may be almost impossible to determine.

7. Depending on the type of telematics device and whether it sends information to an insurer via wireless phone networks, the ability to remotely execute malicious code could interfere with the data and data transmission.

4.3.14.4 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

Implementation Milestones

This is a voluntary initiative.

4.3.15 Land Use Programs

Lead Agency: MDP

The two programs designed to minimize GHG emissions from future land development are 4.3.15.1 Reducing Emissions through Smarter Growth and Land Use/Location Efficiency and 4.3.15.2 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 sprawl development and contribute to a reduction in Maryland's GHG emissions. Smart growth is characterized by compact land use, with neighborhood schools, compatible transit options, 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.

Implementation Milestones

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 and U.S. Census information. MDP assists local planning departments and commissions as they prepare their comprehensive plans for orderly and compact growth of their communities. 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 these areas. MDP also develops online tools, such as the Transit Station Area Profile Tool (TSAPT), created in partnership with MDOT, to facilitate local and business access to data and information needed to succeed with TOD activities.

In July 2019, MDP completed a state development plan, entitled A Better Maryland. The plan improves the coordination and effectiveness of State agency programs and enhances the accessibility and utilization of state information for local communities to promote redevelopment and to plan for compact new growth, while also integrating renewable energy opportunities into their communities and planning the compatible siting of renewable energy generation facilities to serve the region. A Better Maryland focuses on how state agencies can improve collaboration with local governments, which is where the ultimate decisions take place in land use planning, providing them the resources and information they need to facilitate decision-making in support of local objectives.

Smart Growth Subcabinet:

- Makes recommendations to the Governor regarding changes in State law, regulations, and procedures needed to create, enhance, support, and revitalize Sustainable Communities across Maryland.
- Facilitates interagency coordination to ensure successful statewide community reinvestment and compact development initiatives through implementation of the recommendations from the Maryland Sustainable Commission's Reinvest Maryland 2.0 report and the strategies associated with the new state development plan, A Better Maryland.
- An interactive Reinvest Maryland 2.0 website, maintained by MDP, illustrates how jurisdictions can promote compact development using smart growth tools offered by Subcabinet agencies and demonstrates how others have used these tools to revitalize their communities.

Maryland Sustainable Growth Commission:

- Identifies regional growth and development issues for the Governor's Smart Growth Subcabinet and advises on the local impacts of state policies and laws.
- Recommends ways to collaborate on planning between State agencies and local governments and coordinate growth and development among jurisdictions.
- Reviews statewide efforts to implement the State growth plan and the State plans for transportation and housing.
- Facilitates the review of State programs and development of tools and recommendations through its Reinvest Maryland 2.0 effort to assist Maryland's counties, towns, and communities to accelerate infill, redevelopment and revitalization.

Sustainable Communities Act of 2010:

- Established the "Sustainable Communities" designation in order to strengthen reinvestment and revitalization
- Simplified the framework for designated revitalization target areas in the Community Legacy and Neighborhood BusinessWorks programs
- Requires MDOT 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 4.3-10.).

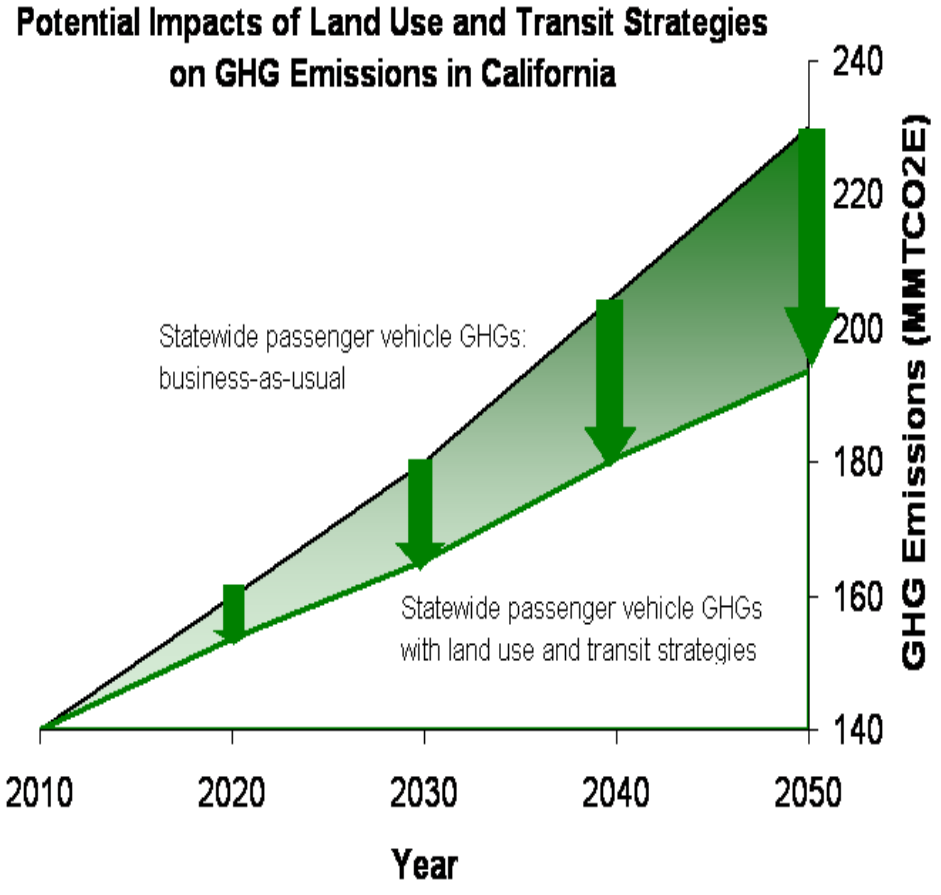

Figure 4.3-10. Potential Impacts of Land Use and Transit Strategies on GHG Emissions in California. The possible impacts of land use and transportation policies have been well documented. A 2008 U.C. Berkley study reviewed over 20 modeling studies from California (including the State's four largest MPOs), 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.[103]

4.3.15.1 Reducing Emissions through Smart Growth and Land Use/Location Efficiency

Lead Agency: MDP

Program Description

This program reduces Marylanders' dependence on motor vehicle travel, especially single occupant vehicles, by providing planning assistance to local governments, improving state-local and internal State agency communication and coordination, and developing incentives for development projects. Together, these efforts support 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 (e.g., 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.

[103] 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

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

4.3.15.2 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. Local jurisdictions can modify PFAs over time. A map of the Priority Funding Areas in Maryland is available on MDP's website at: https://mdpgis.mdp.state.md.us/PFA/publicinfotemplate/index.html. 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.

4.3.16 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 lifestyle 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 effort insures that scientifically based factual information is made available through public education and outreach efforts and reaches all segments of the public.

Implementation Milestones

This is a voluntary program.

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

4.3.17 Federal Measures

Lead Agency: MDE

The GGRA of 2016 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, USDA,

etc. that are not specifically discussed in this chapter. Many of the rules and initiatives below are being challenged by states and industry in the U.S. Courts.

Affordable Clean Energy Rule and The Clean Power Plan

The Affordable Clean Energy Rule (ACE)

In August 2018, EPA proposed the ACE Rule to replace the Clean Power Plan (CPP) in reducing GHG emissions throughout the country. In reviewing the burdens of environmental legislation EPA determined the CPP to be too burdensome on industry. Instead, the EPA claims the ACE Rule will empower states, promote energy independence, and facilitate economic growth and job creation.

EPA proposed the ACE Rule under section 111(d) of the Clean Air Act, only addressing standards for existing sources. The framework allows states to develop plans that establish standards of performance for their states' existing sources. Once the plan is submitted, EPA will determine the "best system of emissions reductions" (BSER) based on the states established performance standards. Under the ACE Rule, EPA also proposes to redefine BSER as being limited to emission reduction measures that can be applied to or at an individual stationary source instead of an action outside the facility.

The Clean Power Plan (CPP)

The federal CPP addressed 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.

Temporary Abeyance of the CPP

In 2016, both the D.C. Circuit Court of Appeals and the U.S. Supreme Court placed an abeyance or stay on the CPP. The D.C. Circuit Court of Appeals abeyance was temporary and had to be requested by the petitioners for renewal every 60 days. The abeyance is still in place by both courts; however, the D.C. Circuit Court of Appeals is predicted to not grant another stay moving forward. With the proposed CPP replacement, the ACE Rule, released in August 2018, the outcome of the court proceedings and abeyances, is unknown at this time.

Other EPA Regulatory Initiatives

Stationary Sources

The New Source Review (NSR) program requires industrial facilities to install updated pollution control equipment when they are newly built or when a change is completed that increases the facility's emissions significantly. There are three types of NSR programs. First, the Prevention of Significant Deterioration program applies to major new sources or major modifications to a source within an attainment area, and requires the source install the best available control technology. Second, the Nonattainment NSR program applies to major new sources or major modifications to a source within a nonattainment area, and requires the source install the lowest achievable emission rate system. Third, the Minor NSR program applies to minor new sources or minor modifications to major or minor sources within both an attainment or nonattainment area, and requires the source meet any emission control measures required by the state.

Along with the proposal of the ACE Rule in 2018, the EPA proposed a change to the NSR program. The change to the NSR program would allow sources to exceed annual emissions, as long as their hourly emission rates are not exceeded. The new exemption, allows electric generating units (EGUs) to extend their life and increase their use of fossil fuels, leading to increased release of CO_2 and other pollutants. EPA's regulatory impact assessment projected substantial increases in sulfur dioxide (SO_2) and nitrogen oxide under the ACE Rule compared to the CPP.

Transportation/Mobile Sources

The EPA proposed the *SAFE Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks*. The proposed SAFE Vehicles Rule, would replace the existing federal 2021-2025 light-duty vehicle GHG emission standards that matched the California standards. The proposed SAFE Vehicles Rule would roll back these existing federal light-duty vehicle emissions standards for model years 2021-2025. The proposed Rule also curtails the authority for states to adopt California's standards by limiting states in adopting more stringent rules than the federal government.

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 7 percent of expected annual diesel consumption and decreasing oil imports by $41.5 billion.

Heavy-Duty Trucks

The EPA and the Department of Transportation's National Highway Traffic Safety Administration jointly finalized standards for medium- and heavy-duty vehicles that would improve fuel efficiency and cut carbon pollution. the vehicle and engine performance standards would cover model years 2018-2027 for certain trailers and model years 2021-2027 for semi-trucks, large pickup trucks, vans, and all types and sizes of buses and work trucks. The final standards are expected to lower CO_2 emissions by approximately 1.1 billion metric tons, save vehicle owners fuel costs of about $170 billion, and reduce oil consumption by up to two billion barrels over the lifetime of the vehicles sold under the program.

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

Short-Lived Climate Pollutants

SNAP was established under Section 612 of the Clean Air Act to identify and evaluate substitutes for ozone-depleting substances. The program looks at overall risks to human health and the environment of existing and new substitutes, publishes lists and promotes the use of acceptable substances, and provides the public with information. Based on a partial vacatur and remand to EPA of EPA's rule 20, the EPA plans not apply the HFC listings from the 2015 Rule 20, pending a rulemaking.

4.4 Recommended New Programs

4.4.1 Maryland Clean and Renewable Energy Standard (CARES) Act of 2020

Lead Agency: MDE/MEA

Program Description

Comprehensive Climate Action

A major component of the *2019 GGRA Draft Plan* is to reduce GHG emissions from electricity generation is the proposed Clean and Renewable Energy Standard (CARES), which requires that an increasingly large share of Maryland's electricity be generated by zero- and low-carbon resources.

MDE and other state agencies are currently developing a full CARES proposal. The *2019 GGRA Draft Plan* includes an illustrative example of how the program would work.

Why CARES?

- *100 percent Clean Electricity*
  - CARES would build off the existing RPS, and require that 100 percent of Maryland's electricity come from clean sources by 2040, which is among the most ambitious state goals in the nation.

- *Technology-Neutral*
  - CARES would adopt a technology-neutral approach to achieving 100 percent clean electricity at the lowest cost. By incorporating all available and emerging zero- and low-carbon sources in Maryland, CARES would foster greater competition among available renewable and clean energy resources, which would reduce costs for ratepayers. The broad set of eligible technologies would include:
    - Additional Maryland solar beyond the requirements of the RPS carve out
    - New efficient Combined Heat and Power (CHP), cogeneration systems in Maryland
    - Hydropower in Maryland
    - Nuclear power in Maryland
    - Natural gas power with carbon capture and storage (CCS) technology in Maryland

- *Homegrown Energy and Jobs*
  - CARES would rely on electricity generators in Maryland to make progress beyond the existing goals, ensuring that Marylanders benefit from the direct job creation resulting from investments in clean and renewable resources.

4.4.2 The Transportation Climate Initiative (TCI) Cap and Invest

Lead Agency: MDE/MDOT/MEA

Program Description

TCI is a regional effort of Maryland and 11 other Northeast and mid-Atlantic states and Washington, D.C. 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 VMT, and help build the clean energy economy across the region.

Cooperation continues between Maryland with other mid-Atlantic and Northeastern states to develop a regional cap-and-invest program for transportation fuels that will drive investment in clean transportation infrastructure and encourage widespread use of EVs powered by increasingly clean electricity.

More information on this program can be found at:

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

Implementation Milestones

TCI is a multi-state collaborative and voluntary initiative.

4.4.3 In-State Methane Minimization

Lead Agency: MDE

Program Description

Methane Emissions from New Sources in the Oil and Gas Industry

Maryland, through MDE, and thirteen other states filed a motion to intervene in a lawsuit against EPA's actions to halt regulation of leaks of GHG emissions and other harmful air pollutants from new sources in the oil and gas industry. EPA asked that this lawsuit be held by the court due to EPA's related action on the proposed rulemaking discussed below.

MDE submitted written comments opposing EPA's proposed rule on amendments to the methane new source performance standards for the oil and natural gas sector. EPA proposed to reduce the monitoring frequency of fugitive emissions at compressor stations and to extend the allotted time for owners and/or operators of compressor stations to repair fugitive emission components. Additionally, EPA sought comment on extending the time period for owners and/or operators of well sites or compressor stations to conduct an initial monitoring survey and reoccurring leak inspections. MDE strongly opposed these proposed amendments. The EPA has not yet finalized this proposal.

Methane Emissions from Existing Sources in the Oil and Gas Industry

Maryland and 14 other states filed a lawsuit against the EPA for failing to perform a legal duty to control emissions of methane from existing oil and gas operations. Specifically, the suit charges that the EPA has violated the CAA by 'unreasonably delaying' its mandatory obligation under the Act to control methane emissions from these operations.

Methane Emissions from New and Existing Landfills

A coalition of eight states, including Maryland, filed a lawsuit against the EPA over its failure to implement and

enforce a critical landfill methane regulation. The regulation would reduce landfill emissions of volatile organic compounds, hazardous air pollutants, CO_2, and methane. It went into effect on October 28, 2016, but the EPA has not implemented or enforced it. EPA proposed a new rule on this topic that would delay the compliance date for states to file a plan.

4.4.4 RGGI Expansion

Lead Agency: MDE

Program Description

In 2017 RGGI completed a Program Review, and strengthened RGGI to continue steady, deeper reductions of GHG emissions by 2030.

With the success of the initiative, and as a national leader in the effort to combat climate change, Maryland and the other participating RGGI states are actively working to engage new participants in the program. The first-in-the-nation carbon cap-and-invest program for power plants has been strengthened by implementing the participating states' plan to secure an additional 30 percent reduction in power plant emissions by 2030, and expanding the program to new participating states in the region to reduce pollution from power plants supplying electricity into Maryland. In July 2019, New Jersey finalized regulations allowing it to rejoin RGGI in January 2020. Other states including Virginia and Pennsylvania have taken important steps that could lead to future participation.

4.4.5 Hydrofluorocarbons (HFCs)

Lead Agency: MDE

Program Description

Under a federal Clean Air Act program designed to identify and evaluate alternatives to stratospheric ozone-depleting substances, HFCs have been one of the most common alternatives. However, HFCs are extremely potent GHGs. One pound of certain HFCs is potentially as potent as 1,400 pounds of CO_2. After efforts have stalled at the federal level, states have begun their own phase out initiatives. Maryland is developing regulations similar to regulations and laws enacted in California, Washington, and Vermont, which would phase out the use of certain HFCs in multiple end uses, such as foam products and in refrigeration equipment in retail establishments, such as supermarkets. The phase out of HFCs will encourage the use of substances with lower GHG emissions. Products with alternatives to HFCs are already available. Other states in the United States Climate Alliance are expected to take similar steps.

MDE is working to adopt these regulations by the Fall of 2020. More information on the rule adoption process may be found on MDE's web site.

Emission reductions from this effort are not included in the *2019 GGRA Draft Plan*. Maryland and other states in the United States Climate Alliance are developing emission reduction quantification tools and MDE expects to include emission reductions in the final plan. The reductions from this measure are expected to be significant and provide several million metric tons of CO_2e reduction by 2030.

4.5 Voluntary and Non-Traditional Programs

4.5.1 The United States Climate Alliance

Lead Agency: MDE

The U.S. Climate Alliance (the "Alliance") is a bipartisan group of states and territories committed to meeting their obligations under the Paris Climate Agreement, while continuing to grow their economies. Currently, there are 25 participating states and territories, and the Alliance is eager to grow larger as more states begin to prioritize climate action. The Alliance formed in 2017 in response to President Trump announcing his intention to withdraw from the Paris Agreement. The states in the Alliance represent 40 percent of the U.S. population, and account for nearly $9 trillion in combined economic activity.

2018 marked the first full year of accomplishment for the Alliance, as the group established a structure and added an executive director. On June 1, 2018, the U.S. Climate Alliance celebrated their one-year anniversary by announcing a wave of initiatives to accelerate and increase climate action across the Alliance states. The states worked together at the end of 2017 and in early 2018, to establish priorities that would return economic benefits while reducing the impacts of climate change. Despite federal efforts to repeal many federal climate and GHG policies, the Alliance states are projected to achieve a combined 18-25 percent reduction in GHG emissions below 2005 levels by 2025. This is thanks to the hard work of each of the participating states, the U.S. Climate Alliance staff, and technical support from nonprofits.

Current U.S. Climate Alliance initiatives include:

- Reducing emissions of short-lived climate pollutants
- Mobilizing financing for climate projects (green banking initiative)
- Modernizing the electric grid
- Increasing deployment of solar projects (solar soft costs initiative)
- Coordinating state adoption of energy efficiency standards
- Natural and working lands
- Increasing state resilience to climate impacts
- Decreasing carbon emissions from the transportation sector

Maryland's Role

In January 2018, Governor Hogan proudly committed Maryland to participation in the U.S. Climate Alliance. When the President announced his intention to withdraw from the Paris Climate Agreement, Governor Hogan disagreed with the decision. It is important that there is aggressive, but balanced action in states, communities, and businesses and the need for multi-state collaboration and international leadership on climate change grows stronger every day.

Over the course of 2018 and 2019, Maryland has worked with the U.S. Climate Alliance states to share insights, experiences, and strategies in order to meet and excel beyond the requirements of the Paris Climate Agreement. Maryland has encouraged all participating states to adopt clean air standards and GHG goals as strong and aggressive as Maryland's. Through collaborative efforts, the U.S. Climate Alliance states are demonstrating leadership in addressing climate change and inspiring climate action throughout the United States.

Since joining the Alliance, Maryland has been a leader and active participant, contributing our experience, knowledge, and cutting-edge research. Many participating states have looked to Maryland to learn from our collaborative and ground-breaking work on the Healthy Soils Initiative, the Climate Leadership Academy, the MCCC, RGGI, and TCI. The U.S. Climate Alliance has played an integral role in helping Maryland launch a regulatory initiative to phase out HFCs and also work to strengthen our forest and agricultural carbon sequestration programs.

Alliance Initiatives

The Alliance and participating states know there are significant actions needed to reduce GHG emissions. For this reason, the participating Governors have committed to accelerating climate action that is based on collaborative and consistent efforts across the U.S. Climate Alliance states. Together the states developed initiatives for 2018 and have continued to work on those initiatives in 2019: reducing short-lived climate pollutants, mobilizing financing for climate projects (green banking initiative), modernizing the electric grid, increasing deployment of solar projects (solar soft costs initiative), coordinating state adoption of energy efficiency standards, increasing state resilience to climate impacts, increasing carbon sequestration on natural and working lands, decreasing carbon emissions from the transportation sector. Work groups on these priorities have met regularly to discuss roadmaps, develop model rules, and provide technical support to one another.

Maryland continues to encourage all participating states to adopt cleaner air standards and GHG goals as strong and aggressive as Maryland's. In addition, Maryland has found the Alliance's coordination helpful and encouraging as we advance actions and partnerships in our own state.

Reducing Super Pollutants

Short-lived climate pollutants (SLCPs) such as black carbon, methane, tropospheric atmospheric ozone, and HFCs, act as powerful GHGs. U.S. Climate Alliance states are stepping up with state-level rules and programs to backstop against federal efforts to unwind reasonable regulations that reduce methane from oil and gas and landfills, HFCs, and black carbon from woodstoves and other sources. The Alliance states challenged all national and subnational jurisdictions to work to reduce SLCPs at the Global Climate Action Summit in September of 2018. This year the Alliance's main SLCP focus was reducing HFC emissions.

In Maryland, we accepted the SLCP Challenge and are working to reduce black carbon, methane, tropospheric atmospheric ozone, and HFCs. Maryland has had a head start in addressing many of the SLCP initiatives, thanks to our accelerated climate action already in place. Maryland is using its knowledge and experience to help other states reduce their SLCP emissions, while also learning how we can further reduce SLCP emissions in Maryland.

Black Carbon

States are working to reduce black carbon emissions through local and state efforts to improve air quality and cut diesel pollution. Maryland has taken significant efforts to reduce black carbon through our work to meet the 40 percent GHG emissions reductions by 2030 in the GGRA of 2016 and our anti-idling campaign for diesel trucks. Maryland's Volkswagen mitigation plan will also reduce black carbon emissions and help protect public health. Maryland is sharing our accomplishments with the other Alliance states, to ensure states are doing the most they can to reduce black carbon emissions.

Methane

To address methane, states are actively working to determine better techniques to capture and utilize methane from natural gas. To reduce methane pollution in the atmosphere, Maryland collaborated with the participating states to learn how states are cutting methane in the oil and gas transmission sector, as well as how to reduce methane release on farms. Maryland is currently working with stakeholders to reduce methane emissions from compressor stations and landfills, with future plans to address methane from wastewater treatment plants. These three categories represent the largest sources of in-state methane emissions. Maryland is looking forward to sharing our experiences as the Alliance expands their work to reduce methane emissions.

Tropospheric Atmospheric Ozone

With the many SLCP initiatives, the Alliance did not make significant strides to develop a plan to reduce tropospheric atmospheric ozone. Maryland looks forward to being a model as the Alliance begins to reduce tropospheric atmospheric ozone in the future. In 2015, Maryland developed a requirement that provided important immediate nitrogen oxide reductions. The 2015 requirements alone have achieved approximately 10 tons of additional nitrogen oxide reductions on hot, peak energy demand days. Maryland also continues to pursue opportunities to reduce nitrogen oxide in up-wind states through the Ozone Transport Commission and petitions to EPA.

In May 2019, Maryland petitioned the Ozone Transport Commission (OTC) under Section 184c of the Clean Air Act (CAA) to make recommendations for additional nitrogen oxide emission control requirements on several coal-fired energy generating units (EGU) in Pennsylvania. The coal-fired EGUs significantly contribute to ozone formation in Maryland and other downwind states. The results of air dispersion modeling indicate that the coal-fired EGUs in Pennsylvania with existing control equipment are not being operated in an optimal manner during the summer ozone season causing significant nitrogen oxide impacts in Maryland. This analysis is very similar to the 126 petition analysis that indicated that significant pollution reductions would occur with optimization of EGUs. Our experience in reducing nitrogen oxide will be valuable to the other participating Alliance states.

Hydrofluorocarbons (HFCs)

HFCs are used as refrigerants and in air conditioning, foams, aerosols, and other applications. Maryland joined the first group of Alliance states to announce they would pursue HFC phase-out rules in 2019. Alliance states are working together to develop consistent rules that would follow the 2015 and 2016 EPA Significant New Alternatives Policy (SNAP) rules concerning HFCs. California, Washington, and Vermont have enacted HFC regulations and laws. Maryland is working with other Alliance states to develop similar rules. MDE has drafted regulations and is currently starting the regulatory process to phase out HFCs.

Mobilizing Financing for Climate Projects (green banking initiative)

The Alliance states are collaborating on an initiative to expand clean energy finance opportunities and create new Green Banks that can be supported by centralized capacity and resources. Alliance states are collaborating on potential new avenues to establish Green banks. States are actively engaging with the Alliance for Green Capital, as well as consultants, foundations and educational nonprofits to advance and scale new green bank models. States are further exploring opportunities to leverage existing internal infrastructure to expand and scale green bank financing nationally.

Power Sector Investment and Modernization

In September 2017, the U.S. Climate Alliance established a Power Sector Working Group to develop new tools and resources that benefit the electric grid and help meet renewable energy and emission reduction goals. U.S. Climate Alliance States are actively collaborating on grid modernization strategies, including non-wires alternatives, and will work together to synthesize lessons learned from non-wires procurement approaches around the United States.

U.S. Climate Alliance States are further collaborating to create an implementation “playbook” to help regulators and utilities implement non-wires approaches and best practices. States are working with the Rocky Mountain Institute to develop the non-wires alternatives playbook and support broad dissemination and implementation of the findings and resources.

Increasing Deployment of Solar Projects (Solar Soft Costs Initiative)

U.S. Climate Alliance states are acting to accelerate solar adoption and soften the impact of the federal solar tariff by collaborating on characterizing and lowering solar soft costs. States worked together to develop a national solar-ready community guidebook to support solar deployment and reduce costs. The guidebook synthesizes existing solar market best practices and lessons learned, provides sample policy and program frameworks, and identifies additional key state, federal, and private resources. The guidebook was released in December 2018, and is aimed at elevating crucial strategies and tools for state and local governments to reduce the non-hardware costs of solar development.

Energy Efficiency

Various Alliance states are collaborating to advance energy efficiency standards for consumer products and appliances to save Americans billions in energy costs and cut GHG emissions. This new initiative is still developing. Maryland is excited to begin collaborating with participating states on new energy efficiency rules. By creating consistent rules, the participating states hope to ease the transition for industry and residents and help provide leadership across the nation.

Natural and Working Lands

The U.S. Climate Alliance states are pursuing a wide range of actions and measures that support land conservation, improve ecosystem health, and sequester carbon. Alliance states have programs in place to support the rural economies, wildlife habitat, and water infrastructure that depend on healthy forests, which provide water resources to cities, towns, and farms. The Natural and Working Lands initiative of the U.S. Climate Alliance is identifying best practices for land conservation, management and restoration to develop a carbon storage policy framework for implementation. At the Global Climate Action Summit, the U.S. Climate Alliance challenged all national and subnational jurisdictions to reduce GHG emissions and protect and enhance carbon sequestration across all natural and working lands.

NGO Partnerships

Through the support of the Doris Duke Charitable Foundation (DDCF), the participating states worked with leading non-governmental organization (NGO) partners American Forests (AF), TNC, World Resources Institute (WRI), American Farmland Trust (AFT), the Coalition on Agricultural Greenhouse Gases (C-AGG), and Trust for Public Land (TPL) to pursue shared goals. Maryland and other states benefited from the technical expertise to support comprehensive action on natural and working lands for climate goals. The first product of the innovative partnership with leading NGOs was a series of Opportunity Assessments to support natural and working lands climate mitigation in Alliance states. The Opportunity Assessments identified the carbon sequestration and emissions reduction potential of land and coastal conservation, restoration, and management practices for land types.

National Learning Lab: Natural and Working Lands

American Forests hosted a Learning Lab in Washington, D.C. staffed by more than 50 leading experts – from government, academia, nonprofits, landowners and industry - in the field of land-based carbon mitigation. Alliance states were able to build on their Opportunity Assessments to create detailed, state-specific strategies that activate the best opportunities for carbon sequestration on natural and working lands. Maryland actively participated, sharing our experience with the Healthy Soils Program. Since the Learning Lab, Maryland has assisted many states as the move forward with programs similar to our State's Healthy Soils Program.

Climate Resilience

Improving the resilience of our communities, infrastructure, and natural resources has long been a priority in the U.S. Climate Alliance states. The participating states are now taking steps to better understand the human, physical and economic impacts of severe weather and climate change on their communities, especially those most vulnerable, to help plan and respond to a changing climate. This analysis will ensure the participating states are investing in mitigation and adaptation actions that deliver benefits that far exceed the costs of inaction.

All of the Alliance states have conducted state impact assessments, and the vast majority has a climate resilience plan in place or under development. Maryland has shared with the other states our CoastSmart Communities Program, which assists coastal communities to address short- and long-term coastal hazards, such as coastal flooding, storm surge, and sea level rise by connecting local planners to essential resources, information, tools and trainings. In addition, states are following our Maryland Climate Leadership Academy, to learn from the successes of the program. Coordinated action with the other Alliance states builds on Maryland's leadership in helping to protect our residents from climate impacts.

Clean Transportation

Alliance states continue to lead the nation in reducing passenger vehicle emissions by implementing policies and programs that advance the deployment of ZEVs. Maryland is participating in the Clean Transportation work-group as they work to reduce the carbon footprint of the transportation sector. The Alliance states know that by shifting towards ZEVs, and working to reduce vehicle miles travelled, we can dramatically reduce our carbon pollution, create jobs, and protect the health of our communities.

Maryland, along with other participating Alliance states, is a member of the ZEV program, which is working to increase ZEV sales and distribution, as well as increase our charging infrastructure. While a member of the U.S. Climate Alliance, Maryland has worked to educate others on the work of TCI, and encouraged others to participate. Being a member of the U.S. Climate Alliance is another opportunity for Maryland to continue the conversation of cleaning-up our transportation system. Individually, all Alliance states invested as much as they could from the Volkswagen settlement funds in charging infrastructure. This effort will grow electrified corridors across the country. In addition, the Alliance states opposed recent efforts by the EPA and NHTSA to weaken the nation's clean car standards.

Conclusion

Maryland appreciates the opportunities for collaboration and assistance in the U.S. Climate Alliance. Member states are working together to meet GHG reduction goals outlined in the Paris Climate Agreement. Maryland is proud to be a part of the Alliance and to be a leader in reducing GHG emissions nationwide.

MDE expects that many of the USCA efforts will evolve quickly and there may be significant additional reductions by 2030 linked to Maryland's participation in the Alliance. Most of the potential GHG emission reductions from potential USCA initiatives have not been included in the *2019 GGRA Draft Plan*.

4.5.2 Zero Emission Vehicle (ZEV) MOU Partnership

Lead Agency: MDE

On June 20, 2018, nine Northeast and West Coast states, including Maryland, reaffirmed their strong commitment to a clean, low-carbon transportation sector with the release of a new Multi-State ZEV Action Plan for 2018-2021 to support the successful implementation of the states' ZEV programs.

The Action Plan, which builds on the successes and lessons learned from implementation of an earlier 2014 ZEV Action Plan, presents 80 market-enabling recommendations for states, automakers, dealers, utilities, charging and fueling companies and other key partners to rapidly accelerate mainstream consumer adoption of ZEVs, including plug-in hybrid, battery electric and hydrogen fuel cell vehicles.

Release of the new Action Plan follows the 2017 expiration of the "travel" provision in the participating states' ZEV regulations, which allowed automakers to get compliance credit in Oregon and Northeast ZEV states for fully EVs placed in California, and to use that credit to meet their ZEV obligations. Automakers are now required to deliver fully EVs to meet specific sales goals in Oregon and the Northeast ZEV states for the first time.

Background

The updated ZEV Action Plan is the work of the Multi-State ZEV Task Force, which was formed in 2013 under a Memorandum of Understanding (MOU) signed by the governors of California and seven other states that have adopted California's ZEV program – Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island and Vermont. New Jersey became the ninth ZEV state to join the coalition when they signed the MOU in May 2018. Together, the nine ZEV MOU states represent nearly 30 percent of the new car sales market in the United States.

The transportation sector is now the largest single source of GHG emissions across the nation. Light duty vehicles alone contribute almost 25 percent of total emissions. Transportation electrification is essential to deliver the deep reductions in emissions that are needed to meet state climate goals. The state ZEV programs, which require automakers to deliver increasing numbers of ZEVs between now and 2025, are a key strategy in state climate plans.

To support successful implementation of the ZEV programs, the MOU states committed to the collaborative development and implementation of the first 2014 Multi-State ZEV Action Plan.

A New Market Phase

The ZEV market is entering a new phase of development. In the four years since the release of the first ZEV Action Plan, the cumulative number of ZEV sales in the United States has grown from 200,000 cars to more than 750,000 cars today. During that same time in Maryland, sales of plug-in EVs have almost tripled. Market changes and technology developments have laid a strong foundation for rapid growth of the emerging EV market. Battery costs are continuing to decline and the electric range of lower-cost battery EVs is three times what it was in 2014. Consumers can now choose from more than 40 different plug-in and fuel cell models, and all the major automakers have announced plans to significantly expand EV offerings across multiple market segments in the next several years.

Key Action Plan Recommendations

While many of the recommendations in the 2014 Action Plan remain valid today, the new Action Plan represents a redoubling of state efforts to accelerate electrification of the light-duty vehicle market, and recognition of the important role that public-private partnerships involving the automakers, dealers, utilities and others play in the effort. Recommendations for states and other key partners in the updated Action Plan are focused on five priority areas:

- Raising consumer awareness and interest in EV technology;
- Building out a reliable and convenient residential, workplace and public charging/fueling infrastructure network;

- Continuing and improving access to consumer purchase and non-financial incentives;
- Expanding public and private sector fleet adoption; and
- Supporting dealership efforts to increase ZEV sales.

The full Multi-State ZEV Action Plan is accessible at: http://www.nescaum.org/documents/2018-zev-action-plan.pdf

Maryland has been a leader in working to implement the ZEV Action Plan recommendations in our State. For years Maryland has had various incentives, financial and other, for purchasing EVs. In 2018, Governor Hogan elected to not only extend the incentive for both EVs and infrastructure, but to significantly increase these incentives. Under the Clean Cars Act of 2017, Maryland offers a tax credit of up to $3,000 for electric and plug-in vehicles with a sale price up to $60,000. Governor Hogan increased the funding for this program from $1.8 million to $3million annually. In addition to vehicles, the Clean Cars Act allows both residential and commercial entities to receive a rebate of 40 percent of the purchase and installation of electric recharging equipment. Governor Hogan doubled the funding available for this program from $600,000 annually to $1.2 million. In addition to these programs, the State has many other incentives available such as, the Alternative Fuel Infrastructure Program and offering HOV access to plug-in vehicles. Through these efforts, Maryland now has over 1,500 public level 2 and 3 chargers throughout the state. In addition to these incentive based programs, the State has been active in promoting EVs by performing outreach to build consumer awareness. Some of these efforts include hosting workplace charging events and staffing informational booths at events across the state.

Additionally, the Clean Cars Act of 2019 increases the transfer amount from SEIF to TTF to $6 million and adds fuel cell vehicles to be eligible for the excise tax credit and adds them to EVIC.

- Effective July 1, 2019:
  - For FY20 the lesser of $6 million or the actual total amount of credits allowed against the excise tax shall be transferred from SEIF to the TTF
- Effective July 1, 2026:
  - The bill defines fuel cell vehicles
  - Adds fuel cell vehicles to the excise tax credit provision and amends the provision to red “the credit allowed may not exceed the lesser of the amount of excise tax paid for the purchase of the vehicle; or $3,000”
  - Adds fuel cell vehicles to EVIC’s purview and changes the name of EVIC to the Zero Emission Electric Vehicle Infrastructure Council
  - Adds a fuel cell EV manufacturer representative and a fuel cell EV equipment representative to the Council
  - Adds fuel cell considerations to the Council’s action plan

4.5.3 Leadership-By-Example – State of Maryland Initiatives

Lead Agency: DGS

Overview of Programs

The State of Maryland, through the DGS Office of Energy Performance and Conservation administers a comprehensive suite of lead-by-example programs that improve energy efficiency, reduce waste, integrate renewable energy, develop sustainable practices, and track the progress of these programs in all State operations and facilities.

These programs include:

- High Performance Buildings through the Maryland Green Building Council
- Maryland Green Purchasing Committee
- Generating Clean Horizons Utility-scale Renewable Energy Contracts
- Energy Performance Contracting
- State Energy Database
- Facility submetering
- Ongoing energy efficiency projects such as building retro-commissioning, lighting replacements, and efficient HVAC installations.

The objectives of these programs are to reduce energy consumption, lower utility bills, and reduce Maryland's impact on the environment.

Supporting laws and regulations:

- Executive Order 01.01.2001.02, "Sustaining Maryland's Future with Clean Power, Green Buildings, and Energy Efficiency"
- State Buildings Energy Efficiency and Conservation Act of 2006 (Senate Bill 267)
- Maryland Green Building Council (Senate Bill 332/ House Bill 94)
- EmPOWER Maryland Executive Directive
- High Performance Buildings Act of 2008 (Senate Bill 208)
- High Performance Buildings Act – Applicable to Community College Capital Projects (Senate Bill 234/House Bill 1044)
- Green Purchasing Committee established by the Green Maryland Act of 2010 (Senate Bill 693/House Bill 1164)
- Executive Order 01.01.2019.08

High Performance Buildings

The **Maryland Green Building Council** was created in 2007 to guide Maryland's High Performance Building Program. By statute, DGS staff and supports the Council. The Council is composed of private sector and State agency membership and makes recommendations about implementing the High Performance Building Program, assists the Governor and General Assembly on green building legislation and works to promote green building throughout the government and private sector.

All new or significantly renovated fully State funded buildings, K through 12 public schools and new community college buildings over 7,500 gross square feet must be constructed as High Performance Buildings. A High Performance Building is one that achieves a Silver rating or better under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system, a two Green Globes rating or better under the Green Building Initiative's Green Globes rating system, or which complies with the Maryland Green Building Council's supplement to the IgCC enacted in November 2014.

Maryland Green Building Council 2018 Annual Report Summary:

The 2018 Maryland Green Building Council Annual Report highlights the importance of increasing energy efficiency in State buildings. The Council set four goals in 2018 to help increase the energy efficiency in State buildings. The first goal is to concentrate on existing building education, which includes upgrading existing buildings for energy conservation. This first goal also focuses on how to improve the performance of existing buildings. The second goal is to conduct outreach, which entails correlating the Council's initiatives with the governor's agenda, as well as performing outreach and engaging with other state agencies. The third goal is energy

efficiency education, which incorporates developing recommendations to measure energy and water use in existing buildings so they can guide upgrades in future facilities. This will help in the assistance of establishing state energy reduction goals. The final goal of financial incentives will help promote the use of green building standards for the private sector, along with recommending financial incentives for the renovation of existing facilities.

The construction of the new science facility at Towson University and the Percy Julian Building renovation at Coppin State University are two projects that received all of their funding from the State to meet the requirements defined in the Maryland High Performance of Green Buildings program that have been initiated or completed during the past year. The new science facility at Towson includes: water-efficient landscaping, rain garden for storm water control, bicycle storage and changing rooms, and low impact materials. Although not required to do so, two facilities met the requirements defined in the Maryland High Performance Green Buildings program. These facilities are the University of Maryland Baltimore County Event Center and the University System of Maryland A. James Clark Bioengineering Building. In 2018, some notable projects in Maryland schools were initiated or completed sought or have achieved LEED Silver and Gold certifications including 94 new facilities and/or major additions for high schools, middle, and/or elementary schools.

Maryland Green Purchasing Committee

The Maryland Green Purchasing Committee is an interagency committee created by the Green Maryland Act of 2010 and tasked with providing the State with education and training promoting environmentally preferable purchasing. The Committee develops and implements statewide green purchasing policies, guidelines, programs, best practices, and regulations, which will provide benefits to the health and well-being of Maryland citizens and environment.

The Committee initially focused on the creation of guidelines for state purchasers that would advance the conservation of natural resources and energy in state agency operations. Specifications for the procurement of certain environmentally friendly goods and services have since been created in order to outline such requirements. Additionally, the Committee has delivered training and organized educational events to further promote Maryland's leadership in environmentally preferable purchasing.

In 2018, the Maryland Green Purchasing Committee was reinvigorated under new leadership.

Funding

Primary funding comes from RGGI's auction revenues and the American Recovery and Reinvestment Act.

Challenges

Budgeting for Environmentally Preferable Purchasing (EPP) may be a challenge for State agencies, since in some cases, an EPP product may cost more up front, while saving money by lasting longer or using fewer resources over its life.

The development of strict procurement rules or regulations is necessary in order to seek progressively elevated annual spend totals for environmentally preferable products and services in the state government. If a mandate ensured that State agencies procure a certain amount of "green friendly" items on a yearly basis with increased goals annually, the payback overtime would be astronomical. The challenge is convincing agencies to buy into the idea of purchasing items at a higher market value and removing cheaper items that are less environmentally friendly from their inventory.

Another major challenge that continues to be prevalent for the DGS procurement division is capturing each detailed "green or environmentally preferable" product or service that has been provided from a vendor through a

purchasing card (pcard) transaction. This challenge is reconcilable through various strategies and approaches that will be pursued through the committee's proactive and progressive efforts.

Relevant Information

Increasing energy efficiency in State government facilities, operations, and purchasing practices reduces the need for power generation from fossil fuel sources. In addition to reducing GHG emissions, this will create reductions in nitrogen dioxide, sulfur dioxide and mercury.

- Nitrogen dioxide emission reductions will help Maryland meet air quality standards for ground level ozone and fine particulate matter. The reductions will also significantly help Maryland reduce nitrogen pollution in the Chesapeake Bay.
- Sulfur dioxide emission reductions will help Maryland further reduce fine particulates and also help achieve the visibility improvements required to comply with federal regional haze requirements.
- Mercury, a toxic pollutant, is primarily released by air pollution sources but ultimately affects water quality. Mercury reductions will help improve water quality in Maryland.

Renewable Energy

DGS currently has Solar PV installations at four agency buildings, with a total capacity of 432 kW and generating approximately 520,000 kWh per year:

- Tawes State Office Building - 580 Taylor Avenue. Annapolis - 126 kW
- John R. Hargrove, Sr. DC & MS Center -700 E. Patapsco Ave. Baltimore - 106 kW
- Elkton DC & MS Center -170 E. Main St. Elkton - 74 kW
- Ellicott City DC & MS Center -3451 Courthouse Dr. Ellicott City - 126 kW

Other Maryland State agencies have Solar PV installations with a total capacity of 1.75 MW and generating approximately 2,943,360 kWh per year:

- Maryland Aviation Administration – Thurgood Marshall/BWI Airport 500 kW
- Maryland Transit Administration – 500 kW
- Maryland Port Administration (MDOT MPA) – 750 kW

Generating Clean Horizons

Through a DGS and USM managed initiative, the State purchases renewable power from two large wind installations and a solar installation, through 20-year Power Purchase Agreements (PPAs) that provide nearly 14 percent of the electricity that the State uses in government operations:

- Mount St. Mary's Solar – 13 MW installation, 12,968 MWh/year. Delivery began July 2012
- Roth Rock Wind – 10 MW installation, 30,605 MWh/year. Delivery began August in 2011
- Pinnacle - 55.2 MW installation, 173,542 MWh/year. Delivery began December 2011

DGS also works with State agencies in the development and implementation of additional renewable projects throughout the State.

Renewable Energy Credits (REC)

The sale of RECs incentivizes investment in renewable power generation. Through the Generating Clean Horizons PPAs, the State pays for renewable electricity generation into two parts: the electricity or electrical energy

produced by a renewable generator and the renewable "attributes" (RECs) of that generation. (These attributes account for the tons of GHG that were avoided by generating electricity from renewable resources instead of conventional fuels, such as coal, oil, or gas.) RECs may be sold separately at prevailing market prices.

In 2015, DGS elected to retire a portion of its legacy (2012) RECs in order to satisfy its 2014 obligation under the Maryland RPS:

- RECs Retired to Meet DGS 2014 RPS Obligation
  - Tier 1: 59,394
  - Solar: 2,089
  - Tier 2: 14,923

DGS retains any remaining RECs in an account for future use, such as sale at a discounted price to an eligible public sector entity.

Energy Performance Contracting

DGS works with State agencies to substantially reduce the energy consumption of Maryland's government operations. DGS manages 27 active energy performance contracts that will save approximately $322.8 million throughout the life of the contracts, $24.9 million annually, and GHG reductions of 104,249 tons of CO_2 annually.

For example, at Spring Grove Hospital Center, energy conservation measures under an EPC completed in January 2010, have provided confirmed avoided utility costs of more than $5.5 million, nearly $1.4 million in excess of the guarantee over that period.

State Energy Database

DGS operates and maintains the most comprehensive and complete state-wide utility tracking database in the country. DGS tracks the energy consumption, cost and carbon footprint (CO_2e) for all utility accounts paid in the State's name. The State Energy Database is a comprehensive large-scale utility management system that includes over 1 million invoices and over 22,000 State utility accounts. Commodities tracked include electricity, natural gas, water, sewer, steam, chilled water, and fuel oil. The State total utility expenditure was $212 million in FY18.

The database provides transparency, access, accountability, and trackability for 58 State entities. It is accessible to the public in a limited version, and with additional detail to over 300 registered users with login privileges.

The State Energy Database supports energy efficiency initiatives and Energy Performance Contracts, energy reduction reporting, deregulated energy procurement, energy planning, and utility bill analysis.
Facility Submetering

In FY 19 DGS embarked on an effort to install building level submeters at all State facilities that operate on a central plant. In late FY 19 DGS issued an RFP to pre-qualify submeter installation firms that will compete against each other for individual projects. DGS is currently working on a meter plan for the Annapolis Capital Complex.

Building level submeters will empower the State to track the energy use of individual buildings, which is currently not possible at approximately 80 percent of the State's buildings. Having energy use data available will allow DGS to identify buildings that are good candidates for efficiency measures. Building level submeters will also allow DGS to track the effectiveness of efficiency projects at individual buildings, and will alert maintenance staff to unusual changes in energy patterns.

Executive Order 01.01.2019.08

On June 25, 2019 Governor Hogan issued an executive order establishing a new energy savings goal for State government. DGS, in cooperation with MEA is to manage a "Maryland Leads by Example" energy savings initiative that will oversee reducing, by the year 2029, the energy use of State-owned buildings by 10 percent compared to a 2018 baseline.

The executive order outlines five specific tasks, one supporting role, and a partnership role to be performed by the DGS Energy Office. These tasks and DGS' plans to support them are as follows:

Task 1 - On an annual basis, DGS Office of Energy Performance and Conservation, utilizing the Comprehensive Utility Records Management Database (Utility Database), shall analyze the entire inventory of State-owned buildings in order to identify and prioritize the least energy efficient buildings in the State.
Energy Office Response – The Energy Office continues to improve and update the energy database in order to be as prepared as possible to address this task. DGS held internal discussions on the strategies we would engage to complete this task, given that most of the State's buildings are not yet individually metered. Our strategies to discover energy saving opportunities will include analyzing individual buildings when possible, and groups of buildings on a master-metered campus facility when building level meters are not present. The Energy Office will then develop Energy Use Indexes (EUI) for individual buildings or campuses, which measure energy use per square foot per year (MMBTU/SF/YEAR), and will then compare those EUIs to national averages to determine energy savings opportunities.

Task 2 - Every year, a minimum of 2 million square feet of the least efficient buildings will undergo a DGS energy audit to identify low cost measures with a five-year or less payback period. A copy of the energy audit shall be provided to each participating agency's Secretary or Director.
Energy Office Response – The Energy Office is prepared to employ DGS' existing engineering contracts to accomplish this task. The audits will be equivalent to ASHRAE level 1, and will identify major opportunities for improvements in energy efficiency.

Task 3 - DGS will measure post-installation energy use for one year following the installation of these measures, which will be normalized and compared to the buildings' pre-installation total energy use to determine energy savings.
Energy Office Response – The Energy Office will accomplish this task by using the energy database.

Task 4 - Progress toward the 10 percent savings goal, monitored through the Utility Database, will be reported to the Governor annually each fiscal year by DGS, with the support of MEA.
Energy Office Response – DGS and MEA are prepared to develop this report.

Task 5 - DGS, MEA, DBM, and DoIT shall collaborate on designing and implementing additional cost-effective and -efficient energy saving programs that may include any combination of technology adoption, management protocols, IT solutions and staff education and engagement.
Energy Office Response – DGS is prepared to initiate these discussions after the issuance of the EO.
The supporting role that the Energy Office will play includes partnering with agencies who are interested in engaging with the Energy Performance Contracting (EPC) program, and promoting the EPC program. The Energy Office will also advise all Maryland State agencies on strategies they may employ to save energy, and will lead DGS' efforts to make the 6.8 million square feet of DGS owned facilities more energy efficient.

The Executive Order states that "All units of State government shall, in support of their core missions, implement projects and initiatives to conserve energy and reduce consumption." In light of this, on September 12, 2019, in an effort to collaborate and coordinate on energy savings activities throughout State government, DGS initiated the first quarterly meeting of the Working Group on reducing Energy use in State Operations. The members of the Working Group include the 20 agencies that are the largest consumers of energy in the State. Invited agencies are:

1. [UMCP-USM] University of Maryland – College Park (UMCP)
2. [DPSC] Department of Public Safety & Correctional Services (DPSC)
3. [UMB-USM] University of Maryland – Baltimore (UMB)
4. [MDOT-MAA] Maryland Aviation Administration (MDOT-MAA)
5. [DGS] Department of General Services (DGS)
6. [UMBC-USM] University of Maryland – Baltimore County (UMBC)
7. [MDOT-MTA] Maryland Transit Administration (MDOT-MTA)
8. [DHMH] Maryland Department of Health (MDH)
9. [TU-USM] Towson University (TU)
10. [MSU] Morgan State University (MSU)
11. [SHA] State Highway Administration (MDOT-SHA)
12. [FSU-USM] Frostburg State University (FSU)
13. [SU-USM] Salisbury University (SU)
14. [STADAUTH] Maryland Stadium Authority (STADAUTH)
15. [MDTA] Maryland Transportation Authority (MDTA)
16. [DMIL] Military Department (DMIL)
17. [BSU-USM] Bowie State University (BSU)
18. [MDOT-MPA] Maryland Port Administration (MDOT-MPA)
19. [CSU-USM] Coppin State University (CSU)
20. [UMBI-USM] University of Maryland – Biotech Institute HQ (UMBI)

The DGS Office of Energy Performance and Conservation will take the lead role in motivating agencies, and monitoring progress towards meeting the ten percent savings goal.

4.5.4 Leadership-By-Example – State

Lead Agency: MDE/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
- Maryland RPS

Implementation Milestones

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, DBM, Maryland Green Building Council, and Maryland Green Purchasing Committee for administering them.
- Programmatic progress is tracked in annual reports that 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)

4.5.5 Leadership-By-Example – Federal

Lead Agency: MDE

Program Description

The Federal Green Challenge is a lead-by-example program for the federal government aimed at improving energy efficiency, reducing waste, and integrating renewable energy practices in all of its agencies' operations and facilities, as well as their purchasing practices.

Program Objectives

The program's objective is for federal facilities located in Maryland to use environmentally friendly techniques and methods to "lead by example." Such techniques include energy reduction in public buildings, facilities, and lands, improved efficiencies in fleet vehicles and fuels, water conservation, waste reduction, waste recycling, purchasing of products/services with lower life-cycle impacts, and greater use of renewable energy.

Implementation Milestones

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 2009 levels by 2020 and implement aggressive energy and water efficiency programs (Executive Order 13514, issued Oct. 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.

The Order was replaced in 2015 by Executive Order 13693: "Planning for Federal Sustainability in the Next Decade." This Executive Order had a similar plan to cut the federal government's GHG emissions by at least 40 percent over the next 10 years, demanding more renewable energy, more efficient water use and management, and improved vehicle fleet efficiency (fleet defined as at least 20 motor vehicles).

Executive Order 13834 was replaced in 2018 by President Trump's Executive Order 13834: "Regarding Efficient Federal Operations." This Executive Order states that federal agencies "shall meet statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment."

Enhancement Opportunities

This lead-by-example program can be enhanced by at the federal level by making specific goals for energy efficiency and water management.

Funding

The state has allotted $40,094,750 for the lead-by-example – federal program between 2010 and 2020.

Challenges

This program may eventually reach a point where further efficiency simply isn't possible, or does not require a whole initiative to attain. If it reaches that point, it will have attained its goal and either be shut down, or left to uphold static, non-changing standards.

4.5.6 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. The policies also aim to reduce the carbon footprint in 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.

Program Objectives

Lead-by-example programs for local government aims to improve energy efficiency, reduce waste, and integrate renewable energy practices in all local government operations and facilities, as well as their purchasing practices.

Implementation Milestones

These programs combine 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. Parts of these plans identify emissions that result from government operations. Using baseline data in the plans, the benefits are calculated for 25 percent and 50 percent reductions from the base year, respectively.

Enhancement Opportunities

These lead-by-example programs can be enhanced by increasing public awareness of local governments' efforts. Although Maryland achieves obvious emission reductions from the programs themselves, if the government is more vocal about its efforts, it adds credibility when it asks the general public and companies to reduce their emissions/energy usage.

Funding

The lead-by-example local government programs are allocated funds by counties. Baltimore County had a budget of $250,000 for energy conservation tax credits, but it was expanded to $750,000 for future years after it exceeded the initial budget. Frederick County used a federal grant from the US Department of Energy for $659,800. Harford County and Prince George's County had a budget of $250,000, which they have also exceeded. Howard County uses a tax credit program that provided 565 credits equal to over $2.5 million for renewable energy systems. Queen Anne's County is expected to save $350,000 on power due to a new lower rate, and also was awarded an EmPOWER fund of $15,000. Washington County received a similar $15,000 grant from the EmPOWER program. Talbot County received a grant from the American Recovery and Reinvestment Act, and also made $132,158 from the sale of surplus carbon and RECs. Wicomico County collects gases from their Newland Park Landfill, selling them for carbon credits ($183,000 worth in 2012). It also sells power from solar arrays, and Salisbury (a city within Wicomico) received an $80,000 grant from EmPOWER.

Challenges

This program may eventually reach a point where further efficiency simply is not possible, or does not require a whole initiative to attain. If it reaches that point, it will have attained its goal and either be shut down, or left to uphold static, non-changing standards.

4.5.7 Leadership-By-Example – Universities and Colleges

Lead Agency: MDE

Program Description

In Maryland, the presidents' of 23 colleges and universities, including all University System of Maryland (USM) institutions, Morgan State University, St. Mary's College of Maryland, four community colleges and four independent institutions, have signed the American College and University Presidents Climate Commitment (now called the Carbon 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 would be reduced or mitigated from a base year, with remaining emissions offset by purchasing carbon credits or other means.

University-Based Climate Efforts

Higher education institutions are actively engaged in addressing climate change. The State, through MDE, has reached out to public and private Maryland colleges and universities to aid in their efforts, recognize their accomplishments, and account for their actions in meeting the state's GGRA of 2016 goals. Several Maryland universities and colleges are represented on and play an active role on the various MCCC Working Groups. Higher education institutions have a key role in building awareness of the impacts from climate change and identifying actions that both individuals and organizations can implement. MDE's Air and Radiation Administration Director and senior staff have met with students as part of their curricula requirements at both Frostburg State University and University of Maryland, Baltimore County. These discussions were very informative and engaging for both the students and staff.

Benefit

Building awareness and understanding of the significance of climate change as well as State programs being implemented to satisfy the goals of the GGRA of 2016 among college students is important. These are the individuals that will manage and guide future efforts to mitigate GHG emissions as well as implement adaptation and response measures. Engaging with college students also aids them in their career development path as they consider job opportunities related to addressing climate change. Working with university and college administrators aids in ensuring coordination with these institutions to ensure their programs and priorities are consistent with the policy objectives of the GGRA of 2016.

Partners

Maryland higher education institutions represented on the MCCC or its Working Groups include; University of Maryland Center for Environmental Science, University of Maryland; College Park, University of Maryland; Baltimore County; Washington College; and Johns Hopkins University. MDE sent a letter to the presidents of all private and public sector colleges and universities in Maryland to further facilitate partnerships. USM is a charter signatory of the American College and University Presidents' Climate Commitment (now called the Carbon

Commitment). By its leadership and through the implementation of its Climate Action Plan, USM is taking actions to reduce its carbon footprint and achieving its goal of carbon neutrality for all types of emissions by 2050. The State looks forward to working with all Maryland universities and colleges in meeting their campus/system-wide goals related to climate change.

Conclusion

The universities and colleges that are active members of the MCCC and its Working Groups have provided valuable expertise to the Commission and aided in the Commission's work. Emission reductions from this effort have not been included in the *2019 GGRA Draft Plan*. Should the program evolve to the point of having additional quantitative estimates of GHG emission reductions for the 2030 to 2050 time frame, MDE plans to include these reductions in future updates to the plan. The GGRA allows for reductions from voluntary programs and partnerships to count towards the goals of the Act.

4.5.8 The Climate Champions Program

Lead Agency: MDE

Program Description

The Climate Champions program provides an opportunity for organizations to voluntarily commit to actions related to climate change and be recognized for their actions. These actions include, but are not limited to; mitigating the release of GHGs, building awareness on the issue, and adaptation and response measures. Participants document actions taken and outcomes. This documentation includes quantifiable or non-quantifiable metrics. Members are recognized for their participation in the program and successful actions are publicly recognized.

In 2018, MDE implemented the Maryland Climate Champion Challenge as part of the Maryland Green Registry. Participants identified a minimum of five actions that they implemented related to addressing climate change. Organizations entering the Challenge include businesses, state and local government agencies and universities. Participants were recognized at an event on June 28, 2018.

Benefit

Providing an opportunity for interested stakeholders to participate in a program where their actions are recognized helps build awareness of the issue. Oftentimes organizations taking voluntary actions do not have a forum or outlet to report their activities and build awareness among their own stakeholders about how they are addressing climate change. For businesses, the Climate Champion program is an opportunity to show employees and customers their commitment to the issue. Similarly, for government agencies the program is a way to demonstrate to citizens, "government taking action". For educational institutions such as colleges and universities, participating in the program is a way to build awareness among the faculty and student body. For all organizations that participate, having a voluntary program where participants are recognized creates a competitive atmosphere around a very notable cause where actions that are noteworthy are publicly recognized. This in turn results in a positive image for the participating organization. Having a voluntary program such as Climate Champions is a way for Maryland's citizens to see the commitments of a variety of stakeholders across the State.

The GGRA of 2016 allows for voluntary actions to be credited towards meeting the State's goals. The Climate Champions program allows MDE to capture those voluntary actions that may be credited, including recognizing those organizations implementing those actions. To satisfy the GGRA of 2016 goals related to the economic

benefits resulting from addressing climate change, the Climate Champions program is a way to capture and document those benefits.

Partners

MDE has engaged with government agencies, businesses and business associations, as well as universities and colleges. The agency will continue to work with these organizations as well as additional stakeholders to refine and build on the Maryland Green Registry's Climate Champion Challenge. Identification of and engagement with new stakeholders to participate in the Climate Champion program is a goal of MDE.

Conclusion

Maryland will continue to implement the Climate Champions program. With input from stakeholders, MDE will build upon previous efforts to ensure the Climate Champions program is transparent, implementable for participants and for MDE, the commitments by participants are meaningful and the recognition provided is notable.

Emission reductions from the Climate Champions program have not been included in the *2019 GGRA Draft Plan*. Should the program evolve to the point of having quantitative estimates of GHG emission reductions for the 2030 to 2050 time frame, MDE plans to include these reductions in future updates to the plan. The GGRA allows for reductions from voluntary programs and partnerships to count towards the goals of the Act.

4.5.9 Idle Free Maryland

Lead Agency: MDE

Program Description

Idle Free Maryland is a partnership between the State, the private sector and Maryland schools, which is designed to reduce unnecessary idling though outreach, education and voluntary action. For now, the initiative focuses on three types of idling activities:

- Motorists who idle their cars for a variety of reasons,
- Idling by truckers, and
- Idling around schools.

Idling emits about 11 million tons of CO_2, 55,000 tons of nitrogen oxides, and 400 tons of particulate matter in the U.S. each year. These pollutants contribute to climate change and can cause cancer, respiratory issues, reproductive effects, birth defects and other serious illnesses. Idling also impacts the health of Maryland streams, rivers, lakes, bays and coastal waters, increasing the levels of nitrogen in the Chesapeake Bay. Reducing vehicle idling is increasingly seen as a way to improve air quality and to help meet climate change goals.

The goal of the Idle Free program is to significantly reduce idling by building awareness of its impact on Maryland communities. The program establishes partnerships with motorists, communities, and the transportation industries with the intention of reducing emissions from unnecessary idling by decreasing the social tolerance of idling through fact-based education.

Resources have been created to help spread the word about idling's impact on health and the environment. The tools developed are aimed at educating motorists, schools, and transportation industries on ways to implement an idle-reduction plan. The campaign includes a toolkit of more than 30 products, including fact sheets, social media

materials, pledge sheets, signage, policies and other communications media. This includes resources developed specifically for implementation in schools. [https://mde.maryland.gov/idlefreeMD]

Benefits

If every driver who took the pledge to be idle free could reduce their idling by just five minutes a day, it would prevent 25 pounds of harmful air pollutants and 260 pounds of CO_2 from entering the atmosphere each year. Idle Free Maryland reductions will help the State meet its climate change goals by reducing GHG emissions. The initiative will also reduce emissions of other air pollutants and help the State better protect public health by continuing to make progress on ground-level ozone and fine particulate air pollution. If half of Maryland drivers would make that "five minutes a day" commitment, more than 50 million pounds of pollutants per year could be prevented from entering Maryland's air. Idle Free MD will not only improve the air quality in Maryland communities, but also reduce the negative impact of air pollution on streams, rivers, lakes, bays and the Chesapeake Bay.

Partners

MDE and its State partners, MDOT, MEA, and the Maryland State Department of Education, are working with several key partners to implement Idle Free Maryland. These include the Maryland Motor Truck Association. MDE is working with individual schools, many of which are Green Schools, to assist in implementing their own idle reduction strategies. Green Schools is a program administered by the Maryland Association for Environmental & Outdoor Education (MAEOE) so that schools and their communities can evaluate and improve their efforts in environmental sustainability. So far, over fifty five partner schools and five State Green Centers, which work with schools to achieve their educational and environmental goals, have signed on as partners. MDE has participated in Green School evaluations, made presentation to teacher conference, and had a booth at MAEOE's year-end Youth Summit where students could play games and get stickers while teachers could sign up their schools to become Idle Free partners. Opportunities for further engagement with communities, local governments, school systems and additional transportation industry sectors are continually being sought.

Conclusion

The tools and resources to launch Idle Free MD have been completed. Additional outreach and stakeholder engagement are planned to increase awareness of the program. MDE will continue to evaluate potential recognition and incentive programs to encourage involvement. There will also be increased emphasis on tracking the results from the Idle Free MD campaign and identifying avoided emissions due to the implementation of the program.

Projected emission reductions from the Idle Free MD initiative through 2030 have not been included in the *2019 GGRA Draft Plan*. MDE expects the GHG emission reduction from this effort to exceed 100,000 metric tons of CO_2e by 2030. As the program matures, MDE may include reductions in future updates to the plan.

4.5.10 The Port Partnership

Lead Agencies: MDE/MDOT

Program Description

In December 2015, MDE, MDOT, and MDOT MPA entered into a voluntary agreement (the Agreement) that commits the agencies to work cooperatively to identify, develop, and, when appropriate, implement voluntary projects that will reduce emissions and increase energy efficiency at the Port of Baltimore (Port). Since signing the

Agreement, a workgroup of representatives from the participating agencies has been meeting monthly to efficiently and effectively leverage resources and pool their knowledge to implement the Agreement's goals.

The partnership is primarily focused on reducing emissions at the Port to help the state meet air quality and climate change goals, but also acknowledges the role that the Port plays in driving economic growth and creating jobs. The Port is often referred to as one of the most important economic engines for the State of Maryland. The partnership recognizes this critical role for the State and works to have a clean and green Port for both environmental and economic reasons.

Benefits

As a result of this unique collaboration, Maryland has made great strides in implementing Port-related projects that have supported a number of emissions reduction grant-supported initiatives, such as projects funded by the Diesel Emission Reduction Act (DERA) Grants. DERA-funded projects have supported the replacement of drayage trucks, cargo handling equipment, and installation of idle reduction equipment on switcher locomotives. To date, over $18 million has been invested into diesel emission reduction activities at the Port. Agreement-supported projects to date will, over the lifetime of the equipment, reduce in excess of 2,500 tons of air pollutants, including nitrogen oxides, particulates, hydrocarbons and carbon monoxide. The emission reduction activities at the Port will also result in significant reductions in GHG emissions, primarily CO_2 and black carbon.

The Port-related emission reduction projects continue through 2019 and 2020. The partnership was successful in obtaining a $2.4 million grant, as part of the 2018 DERA process, which will be used to upgrade drayage trucks, cargo handling equipment, and marine engines. In addition to the 2018 DERA initiative, there are several Port projects that will be funded as part of the Volkswagen Mitigation Plan (see Section 4.5.11). Funding from the Volkswagen Mitigation Plan will be used to reduce diesel emissions from the legacy fleet, including drayage trucks and cargo handling equipment. All of the 2019/2020 projects will not only reduce key air pollutants, like nitrogen oxide and fine particulates but will continue to provide significant reductions of CO_2 and black carbon.

The Partnership also supports research opportunities. MDOT MPA sponsored Fellows from the Environmental Defense Fund's (EDF) Climate Corps Program in the summers of 2018 and 2019 on two different research projects. The first project involved studying the potential effectiveness of natural gas fuel cell technology to reduce emissions. This fuel cell study provided guidance for the workgroup as it seeks cost effective reduction projects. MDOT MPA is deploying a natural gas fuel cell to help with peak energy savings in one of its maintenance buildings as a result of this work. The second project looked at carbon sequestration at restored wetlands on dredged material and used Hart Miller Island as the case study (see additional information below).

The partnership plans to continue to implement new emission reduction programs every year between now and 2030.

Partners

In addition to the primary partners, MDE, MDOT, and MDOT MPA, the workgroup's projects and initiatives have benefited greatly with the active involvement of others, including the Environmental Defense Fund, MEA, the Maryland Clean Energy Center, the U.S. Maritime Administration, and private port businesses. The workgroup also continues to place a high priority on involving key stakeholders, especially those in underserved areas and has received direct input from residents of the Turner Station, Curtis Bay, and Brooklyn communities. As part of this partnership, for the past three years, MDOT MPA has sponsored graduate students from the Environmental Defense Fund's Climate Corps Program. Through this fellowship program, each student researched opportunities for technology deployment at Port facilities to reduce GHG emissions. This included, but was not limited to, the use of fuel cells and shore power.

Conclusion

The workgroup will build on its initial successes by continuing to pursue ways for the Port to grow sustainably. Specifically, the workgroup will focus on developing future innovative emission reduction and energy-saving projects and has already identified potential funding sources for these projects.

Over the past 17 years, the State, through MDOT MPA has worked diligently to identify and implement a variety of environmental programs, with a focus on climate initiatives for MDOT MPA and its tenants' operations, including the following items:

- Quantifying GHG and criteria air pollutant emissions from Port operations through land-side and water-side air emission inventories, which began in 2008 with the 2006 Comprehensive Baseline Inventory of Landside Air Emissions. Inventories help identify target areas for GHG reductions and track the progress of those programs.
- Promoting energy efficiency and grid resiliency through Port-wide energy audits and engaging with energy service companies (ESCOs) to design, build, and fund projects that save energy (thereby reducing GHGs), reduce energy costs, and decrease operations and maintenance costs at Port and tenant facilities.
- Securing over $18 million in federal and state funding to replace or retrofit older, less-efficient diesel engines in drayage trucks, cargo-handling equipment, harbor craft, and switcher locomotives. A highlight of the diesel emission reduction program is the Dray Truck Replacement Program, which provides funds to truck owners to help defray the cost of replacing older trucks with newer, more efficient models. Approximately 200 trucks have been replaced through this program. While primarily focused on reducing criteria pollutant emissions, the newer trucks are more efficient, resulting in reduced GHG emissions as well as fuel consumption.
- Reusing dredged materials for wetland and coastal habitat restoration projects. Along with providing habitat and water quality benefits, wetlands help store carbon and decrease storm surges, helping to enhance coastal resiliency in adjacent waterways.
- Instituting new technologies at Port terminals, such as optical character recognition cameras/software to track container movements at the terminal and instituting chassis pooling to reduce the number of truck moves, thereby, reducing trips, idling, and emissions.
- Partnering with community groups to promote environmental awareness and funding projects, such as the Schoolyard Greening Program, which replaces pavement at local schools with trees and planting to reduce stormwater runoff, provide greenspace, and promote carbon uptake.

GHG emission reductions from the Port Partnership have not been included in the *2019 GGRA Draft Plan*. The partnership's goal is to implement new emission reduction projects through 2030 and beyond. By 2030, this partnership could achieve an additional reduction in GHG emissions approaching the 500,000 metric tons of CO_2e level. The Port initiatives will not only help reduce emissions of CO_2, but it will also help reduce emission of black carbon, a very potent GHG. As this effort continues to grow, MDE plans to include GHG reductions in future plan updates.

Hart Miller Island Carbon Sequestration

Hart-Miller Island (HMI) is a State-owned former dredged material placement site located within the Chesapeake Bay near the mouth of Back River. The site was originally two separate islands, Hart Island and Miller Island, which were both eroding at a rapid pace. The Maryland Geologic Society predicted that Miller Island would be gone by 2008 and Hart Island by 2045. In 1970, Congress approved deepening of the Port of Baltimore navigation channels, and MDOT MPA began placing dredged material to join and restore Hart and Miller Islands. HMI now includes wetlands, forests, trails, and sand beaches managed by DNR. The restored south area opened to the public in 2016 for wildlife viewing and recreation.

Along with restoring nearshore habitat and creating a resource for recreational activities, HMI serves as a potential CO_2 sink. MDOT MPA is currently investigating the amount and rate of carbon sequestration in the site to assess if HMI could be a significant carbon capture and storage opportunity. Closure and restoration of former dredged material sites, such as HMI, may provide sustainable and long-term sequestration of carbon through vegetation growth and creation of wetlands and marshes.

4.5.11 The Volkswagen Mitigation Fund

Lead Agency: MDE

Program Description

On Sept. 18, 2015, the EPA and the California Air Resources Board (CARB) issued a Notice of Violation of the Clean Air Act to Volkswagen AG (VW), Audi AG and Volkswagen Group of America, Inc. alleging that model year 2009-2015 Volkswagen and Audi diesel cars equipped with 2.0 liter and 3.0 liter engines included software that circumvents EPA and CARB emissions standards for nitrogen oxide. Approximately 550,000 vehicles in the United States had "defeat devices" installed; approximately 16,000 were delivered to Maryland.

On October 25, 2016, the U.S. District Court for the Northern District of California approved a Partial Consent Decree between the U.S. Justice Department and VW regarding excess emissions of nitrogen oxide due to the installation of "defeat devices" on 2.0 liter diesel engines. The use of "defeat devices" has increased vehicle emissions of nitrogen oxide, resulting in adverse affects on air quality. The Consent Decree established an Environmental Mitigation Trust of $2.7 billion to fully remediate the excess nitrogen oxide emissions from the affected 2.0 and 3.0 liter vehicles. The State of Maryland is eligible to authorize spending $75.7 million from the VW Trust to use for specifically defined eligible mitigation projects. To guide the use of funds over the Trust's 10-year lifetime, Maryland has developed a Mitigation Plan that outlines the eligible projects Maryland will use to reduce excess nitrogen oxide emissions. More information on the Mitigation Plan can be found on MDE's web site.

Benefit

Strategies for reducing nitrogen oxide emissions will in most cases also result in reductions of GHG emissions. Many of the programs to be implemented under the VW Mitigation Plan will reduce both CO_2 emissions and emissions of black carbon. Black carbon is a potent short-lived climate pollutant. Applicants seeking funds from the VW Trust must submit a proposal to MDE that specifies, among other things, emission reductions from the planned project(s). The evaluation criteria for awarding funds includes benefits from reducing other pollutants such as CO_2. As projects receiving funds from the VW Trust are implemented, MDE will track avoided/reduced CO_2 emissions resulting from these projects. The evaluation criteria for proposed projects also includes identifying benefits to environmental justice and underserved communities. Addressing the needs of underserved communities is a priority for the MCCC.

Partners

MDE has conducted extensive outreach with citizens, advocacy groups, local & state government and the private sector with a focus on communities that bear a disproportionate share of the air pollution burden. Citizen and advocacy group engagement is a priority for Maryland. MDE has met with citizens at community meetings to discuss the opportunities for funding, as well as, to obtain input on project opportunities. MDE has also worked closely with MEA and MDOT and its business units such as the MD Port and Transit Administrations, as well as, the Baltimore Port Alliance to identify projects to implement at Port facilities and in communities near the Port of Baltimore.

Conclusion

The use of funds from the VW Trust to implement projects will provide air quality benefits, including reductions in GHG emissions, which contribute to meeting the policy goals in the GGRA of 2016. Projected emission reductions have not been included in the *2019 GGRA Draft Plan*. MDE will be tracking these important emission reductions and including them in the final GGRA Plan and in updates to the GGRA Plan.

4.5.12 The Metropolitan Washington Council of Governments' (MWCOG) Climate Energy and Environmental Policy Committee (CEEPC)

Lead Agency: MDE

Program Description

In November 2008, MWCOG's Board of Directors adopted the *National Capital Region Climate Change Report*, committing the region to meeting GHG emission reduction goals of 80 percent by 2050. COG brings area leaders together to address major regional issues in the District of Columbia, suburban Maryland, and Northern Virginia. COG's membership is comprised of 300 elected officials from 24 local governments, the Maryland and Virginia state legislatures, and U.S. Congress. MDE was a member of the Climate Change Steering Committee (CCSC) that developed the regional climate initiative.

COG's Climate, Energy and Environment Policy Committee (CEEPC) was created by the COG Board on April 8, 2009 through Resolution R18-09. The Committee serves as the board's principal policy adviser on climate change, energy, green building, alternative fuels, solid waste and recycling policy issues, and other environmental issues as the board may assign. CEEPC is responsible for managing the implementation of the *National Capital Region Climate Change Report*. This responsibility includes development of a regional climate change strategy to meet the regional GHG reduction goals adopted by the board.

CEEPC includes representatives from COG's member governments, state environmental, energy, and transportation agencies, state legislatures, the Air and Climate Public Advisory Committee (ACPAC), federal and regional agencies, electric and gas utilities, environmental organizations, business organizations, and members of the academic community. In addition to the local county and city government members of COG, MDE, MEA, and MDOT are members of CEEPC. Stakeholders from Maryland also regularly participate in CEEPC and regional actions, including the Maryland Clean Energy Center (MCEC).

Climate change activities in the region are guided in part by CEEPC's Regional Climate and Energy Action Plan, a tool first developed in 2009 to help the region achieve its regional GHG emission reduction goals. The plan puts forth recommended actions for local governments aimed at reducing the carbon impact of the built environment, energy, and transportation sectors, while increasing resiliency and improving education and outreach.

Regional efforts are also supported by COG's Built Environment and Energy Advisory Committee (BEEAC), regional working groups (EVs, tree canopy, agriculture, urban heat island), and the COG Solid Waste and Recycling Committee. Policies and actions are also closely coordinated with COG's Transportation Planning Board (TPB), Metropolitan Washington Air Quality Committee (MWAQC), and Chesapeake Bay and Water Resources Policy Committee, among other committees.

COG and its partners base their climate actions on pillars of economic development, innovation, and finance, while also focusing on issues such as resilience, equity, and competitiveness. COG supports action plan implementation, manages a voluntary data sharing agreement with electric and natural gas utilities, and regularly tracks and shares

progress on leading climate and energy indicators through a Regional Climate and Energy Progress Dashboard. COG, state agencies, local members, and other stakeholders routinely collaborate to identify and develop programs and projects to support key activities to reduce emissions and manage efforts to transition to cleaner low-emitting technologies and solutions.

Benefits

As a result of this strong framework for regional collaboration, COG, member governments, and regional stakeholders have made great strides in implementing programs to address climate change. Some of the more impactful programs have included Sustainable Maryland, Maryland Smart Energy Communities, U.S. Department of Energy programs, including the Better Buildings Residential network, the Rooftop Solar Challenge and Solar Market Pathways initiatives, combined heat and power and microgrid development partnerships, efficient outdoor lighting programs, the Fleets for the Future initiative and the Mid-Atlantic Property Assessed Clean Energy Financing Alliance.

COG's regional dashboard shows that regional climate initiatives through COG and its partners have resulted in significant outcomes across Charles, Frederick, Montgomery, and Prince George's counties, including:

- GHG emission reductions of 16 percent between 2005 – 2015.
- High performance buildings increased from just over 20 in 2005 to more than 500 as of 2016.
- Grid-connected renewables have grown from 275 systems with 2,900 kilowatts of capacity in 2009 to more than 28,000 systems with 272,000 kilowatts of capacity as of 2017.
- EV charging stations have increased from 47 stations in 2012 to 243 stations in 2018.
- As of 2016, there are more than 40,000 hybrid and EV owners.

Partners

The following organizations and agencies coordinate and collaborate climate program activities with COG: MDE, MEA, MDOT, Maryland Clean Energy Center (MCEC), and the University of Maryland Environmental Finance Center (UMD/EFC). Local government members of COG with representation on CEEPC include Prince George's, Montgomery, Charles, and Frederick Counties, and the cities of Takoma Park, Rockville, Frederick, Bowie, Greenbelt, College Park, Mt. Rainier, and Gaithersburg.

The Greater Washington Regional Clean Cities Coalition, the mid-Atlantic Combined Heat and Power Technical Assistance Program, the Maryland National Capital Park and Planning Commission (MNCPPC), the mid-Atlantic Purchasing Team (MAPT), and the Greater Washington Board of Trade also participate in and support regional climate activities. Other stakeholder partners include the Georgetown Climate Center and the National Capital Planning Commission (NCPC).

COG is also a member of the Northeast States for Coordinated Air Use Management (NESCAUM) NE Corridor EV Investment Strategy Steering Committee. COG has had great success in coordinating activities with other regional councils, particularly on solar market development, alternative fueled vehicles, and green cooperative purchasing through the National Association of Regional Councils (NARC). Capacity building and leadership development also occur through collaboration with the Mid-Atlantic Sustainability Network (MASN), the Urban Sustainability Directors Network, the Star Communities Program, the Rockefeller Brothers and Bloomberg climate programs, and the Institute for Sustainable Communities (ISC).

Conclusions

COG's regional climate program celebrated 10-years of success in November of 2018. Building on these early accomplishments, CEEPC will continue to focus regional action and leverage partner activities to foster the

transition to a clean low-carbon economy. High priority actions for the next 10 years will include a continued focus on widespread deployment of renewable energy, grid modernization and resilience, distributed generation, high performance buildings, energy financing initiatives, electric and alternative fuel vehicle initiatives, tree canopy protection and urban heat island mitigation, and smart cities/smart region initiatives.

Specific additional emission reductions from the COG Climate Action Plan through 2030 and beyond have not been included in the *2019 GGRA Draft Plan*. MDE will be working with COG to calculate and may include reductions in future updates to the plan.

4.6 Outreach Efforts to Build Public Awareness and Promote Voluntary Action

4.6.1 Education, Communication, and Outreach Working Group

Lead Agencies: MDE, DNR, DHMH

Program Description

The MCCC and the State have identified underserved communities as a priority for building awareness on issues related to climate change. To pursue this goal, the State, through MDE, DNR, and DHMH, has made an effort to ensure that residents living in underserved communities are aware of the impacts of climate change, the actions that can be taken to address those impacts, and the available programs that can help fund some of the actions.

MDE Efforts

As part of this initiative, MDE has presented at community meetings and met with individual representatives from the Turner Station, Curtis Bay, West Baltimore, eastern Baltimore County and northern Anne Arundel County communities as well as with air and public health advocacy groups that interact directly with underserved communities. These meetings have presented good opportunities for MDE to learn about residents' air quality concerns, provides overviews on the impacts of climate change, and establish relationships and processes for sharing information in the future.

Also, as part of this initiative, fact sheets developed by MCCC have been distributed to citizens and other stakeholders throughout Maryland, including in underserved communities. Additionally, as part of this initiative, MDE supports the MCCC's Education, Communications & Outreach (ECO) Working Group to coordinate and leverage the work in underserved communities being performed by the Commission on Environmental Justice and Sustainable Communities as well as the Children's Environmental Health & Protection Advisory Committee.

Benefits

All Maryland residents need to hear about the potential impacts of climate change and the actions that they can take to reduce their GHG emissions. MDE's initiative works to ensures that underserved communities are not left out of this important dialogue. The meetings with communities and individuals in underserved areas have enabled MDE to convey important information about climate change to these audiences. In the meetings, MDE has explained how GHG is emitted into the atmosphere, the severe weather events and sea level rise that these emissions cause, and in turn, the threats to human health and their quality of life that result.

Actions communities can take to reduce emissions and how they can protect themselves from the impacts of climate change are also explained. Perhaps most importantly, underserved communities are made aware of the programs that can help pay for some of the measures they can take, such as to help them make their homes more energy efficient. A further benefit is that MDE's understanding of why some of these programs are not as effective in underserved communities has been enhanced and attempts are being made to modify the programs to better

serve these communities. Working with citizens in these communities is an opportunity to build awareness of state policies and programs that focus on the impacts from climate change. It also enables MDE to raise awareness of MCCC's efforts. As agencies conduct outreach with citizens, the feedback received is invaluable in the consideration of new policies and programs to aid these communities.

Partners

MDE has met with citizens at community meetings and/or meetings with the leadership of various community associations and organizations active in underserved communities. These include, but are not limited to:

- Greater Baybrook Alliance
- Bon Secours Community Works
- Turner Station Conservation Teams
- North Point Peninsula Council
- St. Helena Community Association
- Safe Alternative Foundation for Education
- MD Environmental Health Network
- Greater Pasadena Council
- Dundalk Renaissance Corporation
- Community of Curtis Bay Association

MDE looks forward to continued engagement with these partners, as well as developing productive relationships with other communities and advocacy groups. Additional information on this MDE initiative can be found in Section 6.5.1.

DNR Efforts and DHMH Efforts

DNR and DHMH have both implemented extensive efforts to reach out and get input from communities overburdened with environmental issues. DNRs efforts have focused on adaptation and resiliency. DHMH's effort addressed the health implications associated with climate change. Both of these efforts is described in more detail in Sections 6.5.4 and 6.5.6.

Conclusion

Through these efforts, the State is hoping to better address the needs of communities that are overburdened with pollution problems. Many of the strategies described in this Chapter specifically address how underserved communities are addressed. Chapter 6 specifically addresses social equity issues.

4.6.2 Climate Ambassadors

Lead Agency: MDE

Program Description

The Climate Ambassador Pilot Program is an effort to educate key stakeholders on climate change, and the important actions Maryland is taking to address climate issues, in a way that allows these stakeholders to educate others on the same issues. In 2016, the ECO Working Group of the MCCC identified the need for a voluntary program that allows for education and training on the causes of climate change, its consequences, and actions that can be taken at the local level. The program will train Climate Ambassadors on climate science and how to inform others of climate change and the adaptation and mitigation measures the State is using to address the issue.

Programmatic Approach

The Climate Ambassador Program gauges the success of and interest in a climate education program, and incorporate improvements for future implementation. MDE, in partnership with Maryland Delaware Climate Change Education Assessment and Research center (MADE CLEAR), is implementing the initial Climate Ambassadors training program with Bon Secours Community Works in West Baltimore. The curriculum is designed to train stakeholder participants around locally specific climate change concerns, impacts, and action steps. A "train the trainer" approach is used so that individuals can train and educate others, particularly among their peers. This approach will encourage information sharing throughout communities and strengthen climate change action in Maryland. Individuals that become Climate Ambassadors are recognized for their participation.

The program endeavors to provide a deep knowledge base on climate change that reflects the interest of the community or organization receiving the training. The Climate Ambassador program can provide training on a variety of issues, including, but not limited to: changing climate patterns, health impacts, social and economic impacts, equity, policy implications, and job creation. Specific frameworks and lessons learned will be shared between the Climate Ambassadors. The ECO Working Group serves as a conduit for this information sharing.

The development and implementation of Climate Ambassador Programs are supported by various agencies, including MDE, Maryland Department of Health (MDH) and DNR, through their existing stakeholder engagement efforts. In addition, community organizations, non-profits, and environmental advocacy programs have shown interest in the training. MADE CLEAR has also played a key role in the Ambassador program.

Additionally, MDE has also engaged with the Executive Director of SAFE Alternative Foundation for Education to implement a Climate Ambassador Program for their students. MDE has conducted extensive outreach in underserved communities to identify opportunities to further implement the Climate Ambassador Program. MDH is also implementing a Community Ambassador program in Prince George's County tailored to middle and high school students.

4.6.3 Climate Champions

Lead Agency: MDE

Program Description

The Climate Champions program provides an opportunity for organizations to voluntarily commit to actions related to climate change and be recognized for their actions. These actions include, but are not limited to; mitigating the release of GHG, building awareness on the issue, and adaptation and response measures. Participants document actions taken and outcomes. This documentation includes quantifiable or non-quantifiable metrics. Members are recognized for their participation in the program and successful actions are publicly recognized.

In 2018, MDE implemented the Maryland Climate Champion Challenge as part of the Maryland Green Registry. Participants identified a minimum of five actions that they implemented related to addressing climate change. Organizations entering the Challenge include businesses, state and local government agencies and universities. Participants were recognized at an event on June 28, 2018.

Benefit

Providing an opportunity for interested stakeholders to participate in a program where their actions are recognized helps build awareness of the issue. Oftentimes organizations taking voluntary actions do not have a forum or

outlet to report their activities and build awareness among their own stakeholders about how they are addressing climate change. For businesses, the Climate Champion program is an opportunity to show to employees and customers their commitment to the issue. Similarly, for government agencies the program is a way to demonstrate to citizens, "government taking action". For educational institutions such as colleges and universities, participating in the program is a way to build awareness among the faculty and student body.

For all organizations that participate, having a voluntary program where participants are recognized creates a competitive atmosphere around a very notable cause where actions that are noteworthy are publicly recognized. This in turn results in a positive image for the participating organization. Having a voluntary program such as Climate Champions is a way for Maryland's citizens to see the commitments of a variety of stakeholders across the State.

The GGRA of 2016 allows for voluntary actions to be creditable towards meeting the state's goals. The Climate Champions program allows MDE to capture those voluntary actions that may be creditable, including recognizing those organizations implementing those actions. To satisfy the GGRA goals related to the economic benefits resulting from addressing climate change, the Climate Champions program is a way to capture and document those benefits.

Partners

MDE has engaged with government agencies, businesses and business associations, as well as universities and colleges. The State will continue to work with these organizations as well as additional stakeholders to refine and build on the Maryland Green Registry's Climate Champion Challenge. Identification of and engagement with new stakeholders to participate in the Climate Champion program is a goal.

Conclusion

MDE will continue to implement the Climate Champions program. With input from stakeholders, MDE will build upon previous efforts to ensure the Climate Champions program is transparent, implementable for participants and for MDE, the commitments by participants are meaningful and the recognition provided is notable.

4.7 Emerging Technologies

Various technologies are in development to mitigate the impacts of GHG emissions. This section summarizes the more prominent emerging technologies in this field. Further analysis of these and other emerging technologies will be included in the final GGRA Plan.

4.7.1 Zero Carbon Steel[104]

New technology has emerged where steel can be produced with little or no CO_2 emissions. Steel is an integral part of our society. The demand for it will only increase with our growing population. The production of steel leads to large amounts of GHGs being emitted. Steel production accounts for about 7 percent of the world's CO_2 emissions. The reason for these CO_2 emissions is the use of coal, especially in a blast furnace (used to produce iron in the steel process). Today's steel production is a very dirty and energy intensive process. Three companies in Sweden

[104] http://www.jernkontoret.se/en/vision-2050/carbon-dioxide-free-steel-production/
http://www.hybritdevelopment.com/hybrit-toward-fossil-free-steel
http://www.hybritdevelopment.com/why-hybrit
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http://carbon-pulse.com/17894/
https://carbonmarketwatch.org/wp/wp-content/uploads/2016/04/SSAB-HYBRIT-A-Swedish-prefeasibility-study-project-for-hydrogen-based-CO2-free-ironmaking.pdf

have recently developed a method known as-- HYBRIT (Hydrogen Breakthrough Ironmaking Technology). HYBRIT was created in the hopes of reducing CO_2 emissions from steel production. This method will attempt to de-carbonize steel operations over the next 20-25 years. HYBRIT will replace coal with hydrogen in the steel making process. In order for carbon-free steel to be manufactured, a few changes to the current production of steel needs to occur. First, instead of using a blast furnace, which uses coking coal, to make the steel, you will need an alternative technique. This process is known as the direct reduction method. Secondly, you will need to replace the coking coal with hydrogen. When using hydrogen the by-product will be water, which is a much cleaner fuel than coal, which releases CO_2. As technology changes, so too has the iron ore being used in this process. Presently, steel production uses iron ore pellets that produce less GHG emissions.

4.7.2 Direct Air Capture (DAC)[105]

A technology similar to BECCS or bio-energy with carbon capture and storage is DAC or direct air capture. This method - instead of capturing carbon released from power plants –literally takes CO_2 out of the sky. DAC pulls CO_2 from the atmosphere, purifies it and then sequesters it for further use. This allows for the capture of CO_2 at more diverse and distributed sources over BECC. The only major inputs of DAC are water and energy with the output being pure CO_2. This excess CO_2 can be sent to a greenhouse, enabling produce to grow. The leftover CO_2 can also be used to make synthetic fuels or heated to release a pure gas stream, which could be turned into diesel, gas, or jet fuel. This is accomplished by way of large silver tubes, which imitate trees. These artificial trees are able to pull CO_2 out of the atmosphere. These "trees" then mimic the process of photosynthesis that natural leaves accomplish. By using these negative emissions, jurisdictions may be able to restore the atmosphere similar to how forests sequester carbon. If the world had ten million artificial trees they could remove 3.6 billion tons of CO_2 a year. The limiting problem with this technology is the price; right now it costs $600 a ton. Firms are attempting to reduce this number to $100 a ton by 2025, making it more economically feasible. DAC technology is currently being utilized on an industrial scale in Europe. The Climeworks AG facility in Switzerland has become the first ever company to capture CO_2 at an industrial scale from the air and sell it directly to a buyer.

4.7.3 Energy Storage

Constant improvements to the technology of energy storage have created a lot of important implications for GHG reduction. As the use of clean and renewable energy sources, specifically solar and wind, have increased, 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 use fossil fuels and, therefore, produce GHG emissions. Allowing energy to be stored during off-peak hours could 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.

4.7.4 Smart Grid Technology

105 https://www.engadget.com/2018/09/11/robot-trees-co2-into-concrete-climate-change/?yptr=yahoo
http://www.sciencemag.org/news/2017/06/switzerland-giant-new-machine-sucking-carbon-directly-air
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https://www.nytimes.com/2018/02/28/climate/remove-co2-from-air.html
http://www.bbc.com/future/story/20121004-fake-trees-to-clean-the-skies

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 EV 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 EVs, 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.

4.7.5 Electric Vehicles (EVs)

Due to a large portion of GHG emissions coming from the transportation sector, replacing gasoline-fueled vehicles with EVs would have a significant GHG reduction benefit. EVs are vehicles that are powered by electricity that is usually stored in the vehicle in a battery. Larger-scale vehicles can be connected directly to generator plants, which is how electric trains and trolleys work. As EV technology improves, the range of the vehicles on a single charge goes up and purchase 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 EVs don't emit GHGs themselves, they move the source of pollution to the power plant generating the extra energy required to power the vehicles. EVs still have a net positive impact, but this could be expanded even more by generating the electricity they require with renewable sources. EVs charged using electricity generated by solar or wind power would be the most effective way of decreasing transportation emissions. Some EVs 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. EVs used in tandem with a smart grid that provides significant charging infrastructure for the vehicles would also greatly encourage their use.

4.7.6 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 about 1,000 gallons of water being used 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 produced, which reduces methane generation associated with certain wastewater treatment processes. 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 percent GHG reduction goal.

4.7.7 CO_2 Reduction Technology

Integrated Environmental Services, Inc. has developed CO_2 Reduction Technology, a process that breaks down CO_2 into graphite and oxygen. The graphite that it produced can then go on to be used in other industries, such as battery, hybrid EV, and solar panel production. This process of breaking down CO_2 was initially inefficient due to it emitting more CO_2 when producing the energy needed to undergo the process than was removed, but IES has developed a method where they pre-process the CO_2, which allows the molecular bond to require less energy to be broken. This results in the process eliminating more CO_2 than is produced. This technology can be used in power

plants to reduce their CO_2 emissions and allow them to produce graphite that can be used in other industrial processes.

4.7.8 Bio-Energy with Carbon Capture and Storage (BECCS)

Another emerging technology 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 CO_2 emissions. This process allows the generation of energy to become carbon negative by removing CO_2 from the atmosphere and releasing none. The methods of capturing carbon and storing it underground are expensive and there are a number of key technological gaps to be filled in. The compression and transport of CO_2 leaves a lot of room for potential leaks and spills that would release large amounts of CO_2 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 CO_2 in deep saline aquifers. Another option that is being considered is injecting the CO_2 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 CO_2 and stores it in a sandstone formation 7,000 feet underground.

4.7.9 Biochar

A technology similar to BECCS is biochar, a carbon-negative plant byproduct that resembles charcoal. Biochar is made via pyrolysis (heating material slowly 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 GHGs.

4.7.10 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 form normal concrete, which helps cut down on demand. Finally, it undergoes a unique process that requires the concrete to consume CO_2 as it cures. This results in the process being carbon negative since it reduces the amount of CO_2 in the atmosphere.

4.7.11 Algae Systems

Algae Systems has developed an advanced process that uses algae to produce carbon negative fuels. The system is overall extremely sustainable. It starts by taking untreated wastewater and giving it to algae, which uses CO_2 and sunlight to convert 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 consume more CO_2 than the end product biofuels emit.

4.7.12 Fuel Cell Vehicles

As an alternative to fossil fuel hybrids or EVs, 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 farther than battery powered EVs, with a current range of up to 406 miles on a tank of compressed hydrogen gas. Hydrogen fuel cells have gotten some controversy due to the fact that they require energy to electrolyze water to produce the hydrogen fuel. The process, therefore, releases CO_2 into the air when creating hydrogen gas, 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 CO_2 that is produced to prevent it from entering the atmosphere.

4.7.13 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 CO_2 removal approaches that would reduce the amount of CO_2 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/

4.7.14 Mass Timber

Mass timber refers to the construction method where large structural panels, posts, and beams glued under pressure or nailed together in layers, with the wood's grain stacked perpendicular for extra strength are used in place of other building materials. This method is relatively common for large building construction in Europe, and is emerging in North America, with several large mass timber buildings completed in Canada and recent completions of mass timber building in Portland, Oregon; Minneapolis, Minnesota; and New Haven, Connecticut; with many more in the planning phase. The international building code recommends a maximum of 18 stories if only using mass timber, but buildings incorporating mass timber can be built much higher. Using mass timber has significant carbon benefits and using it reduces the carbon footprint of the construction phase by up to 20 percent, with lifecycle benefits often much higher. It has also been shown to reduce the time of construction by up to 10 percent.

4.8 Short-Lived Climate Pollutants (SLCPs)

Short-lived climate pollutants (SLCPs) are air pollutants that have relatively short lifetime in the atmosphere and a warming influence on our climate. As opposed to CO_2, which has an atmospheric lifetime of about 100 years, SLCPs have an atmospheric lifetime of a few years to even a few days. The most common SLCPs are methane, black carbon, and HFCs.

- Methane is the second most emitted GHG in the U.S., accounting for about 10 percent of national GHG emissions. Emissions of methane also contribute to ground level ozone. About 60 percent of all methane emissions are anthropogenic and are expected to increase. The primary sources are from agriculture, waste treatment, and the oil and gas sectors. Capturing methane from these sources is cost effective, can improve

air quality, provide fuel for industry and vehicles and industry and displace other more carbon-intensive fossil fuels.

- Black Carbon is a component of fine particulate matter, which is the result of incomplete combustion of fossil fuels and biomass, particularly from older diesel engines and forest fires. Black carbon has been identified as a risk factor for premature death. It warms the atmosphere by absorbing solar radiation, influences cloud formation, and darkens the surface of snow and ice, which accelerates heat absorption and melting.

- HFCs are industrial chemicals primarily used for refrigeration and air conditioning. HFCs were created to replace extremely volatile CFCs and HCFCs that were originally used for the same purposes and were found to be ozone-depleting. After the Montreal Protocol phased out these chemicals, HFCs became prominent and while they aren't ozone depleting, they have a high global warming potential. Most HFCs emissions are from leaks in refrigeration and air-conditioning systems. HFC emissions are relatively low at present, but projections indicate that global emissions are increasing at a rate of 8-15 percent per year (https://www.ccacoalition.org/en/resources/hfc-initiative-factsheet). HFC use is expected to increase disproportionately in developing countries because of population growth, rapid urbanization, electrification and changing consumption patterns. Reducing HFCs could provide mitigation equivalent to 100 billion tons of CO_2 by 2050. Furthermore, improving the energy efficiency of room air conditioning equipment alone can provide further mitigation of up to 100 billion tons of CO_2 equivalent by 2050 (https://www.ccacoalition.org/en/resources/hfc-initiative-factsheet).

Table 4.8-1. Pollutant Lifetime (20-year and 100-year GWP).

Pollutant	Lifetime (years)	20 year GWP	100 year GWP
CO_2	100	1	1
CH_4	12	86	34[a]
Black Carbon	Days to weeks	3,200	900
HFCs	13	3,830	140-11,700

[a] To reflect the most current IPCC report, the 100-year GWP is updated from 21 (the value EPA currently uses) to 34

In order to show the short term climate significance of these pollutants, the data presented in the adjacent pie charts show Maryland GHG data with both a 100 year global warming potential and a 20 year global warming potential. SLCPs have a much smaller GWP over 100 years, so they may appear to have less of an impact; however their effect in the near-term (20 years) can be significant.

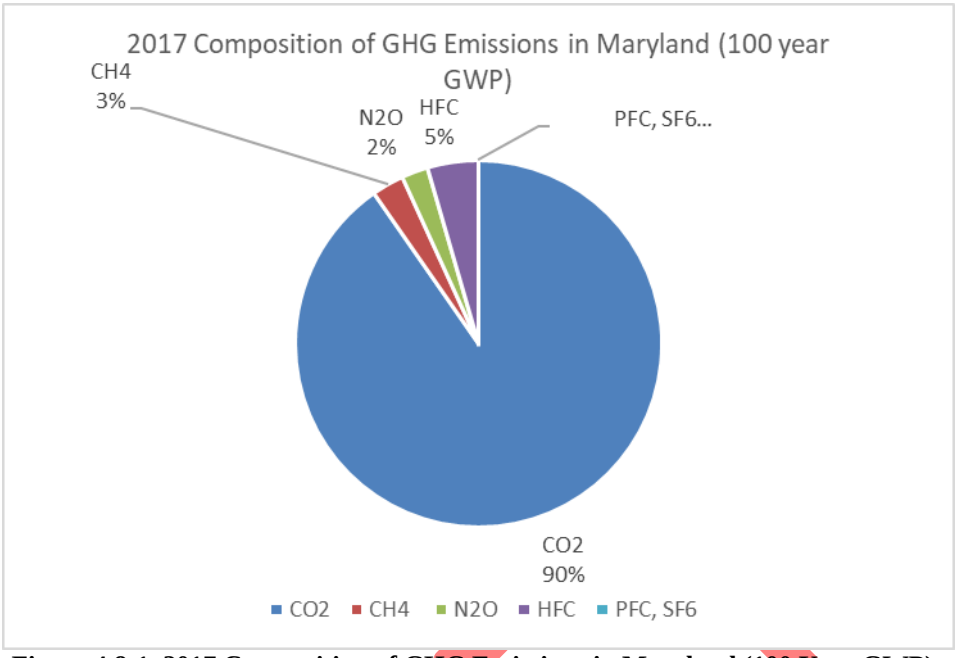


Figure 4.8-1. 2017 Composition of GHG Emissions in Maryland (100 Year GWP).

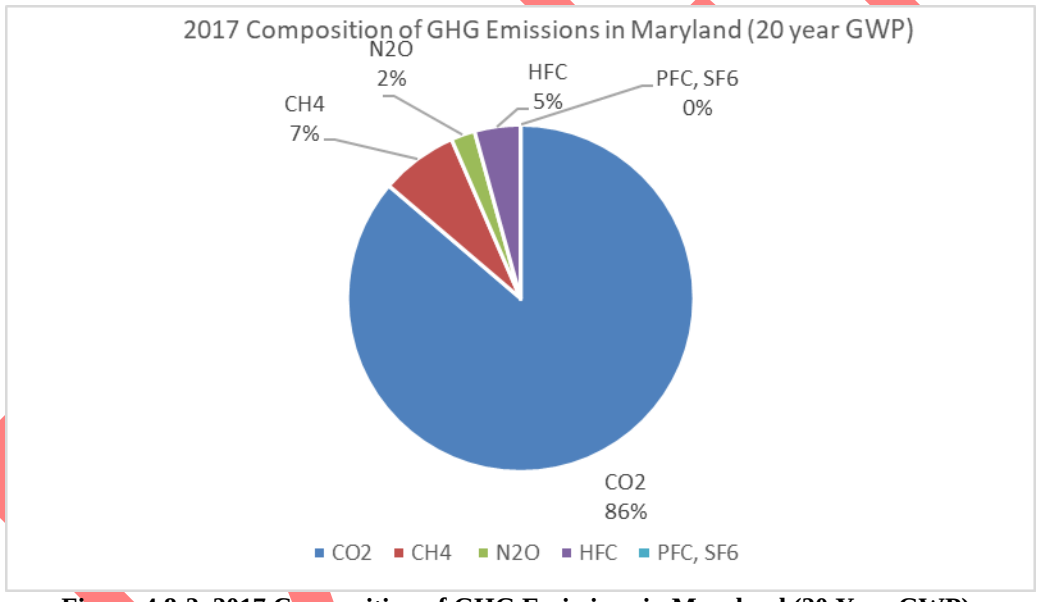


Figure 4.8-2. 2017 Composition of GHG Emissions in Maryland (20 Year GWP).

4.8.1 Why Are SLCPs Important?

Despite being short lived, SLCPs disproportionately contribute to climate change, based on how they add heat the atmosphere. Their warming potential can be tens, hundreds, or even thousands of times greater than that of CO_2. Reducing emissions of SLCPs would provide immediate benefit - far sooner than reductions in CO_2 - due to how little time they remain in the atmosphere. In addition to the environmental benefits of reducing SLCPs, there would also be a large public health impact.

Certain SLCPs are also associated with direct public health risk. Black carbon exposure can lead to cardiovascular and respiratory illnesses and ground-level ozone formed by methane is harmful to agriculture and public health. The UN Environment Program reported that an aggressive policy towards reducing SLCPs would avoid 2.4 million premature deaths worldwide by 2030 while also reducing global warming between now and 2040 by half a

degree. Wide-spread and immediate benefits from cost-effective and readily available reduction strategies could have measurable positive impacts on both public health and global climate impacts.

4.8.2 Uncertainty From Federal Regulations on SLCPs

Until recently, a growing and effective regulatory framework was in place to help reduce SLCP emissions in the U.S. It included regulations to reduce methane from oil and gas production, and landfills, and agreements were in place to phase out the use of HFCs, improve refrigerant management, and develop cleaner wood-burning stoves. Many of these rules have been rescinded or delayed, leading to significant uncertainty in the regulatory landscape. Given this uncertainty at the federal level, Maryland has elected to lead by example on mitigation. Maryland is working on an ambitious set of actions that have the potential to reduce SLCP emissions as part of the state's 40 percent by 2030 GHG reduction goal. There is growing support for reducing SLCPs in the state.

4.8.3 SLCP Emissions in Maryland

Short-lived climate pollutants make up only about 13 percent of GHG emissions in Maryland when measured over a 20-year period. In other states, like California, SLCP's contribute as much as 40 percent of total GHGs. Despite contributing such a small fraction of total GHG emissions, Maryland is still reviewing policies and implementing programs to reduce emissions of SLCPs.

Several uncertainties exist related to methane emissions due to the nature of certain emission sources. For emissions from enteric fermentation and manure management, the data relies on animal populations and other factors that can be unreliable. There are similar issues estimating contribution from landfills and forest fires.

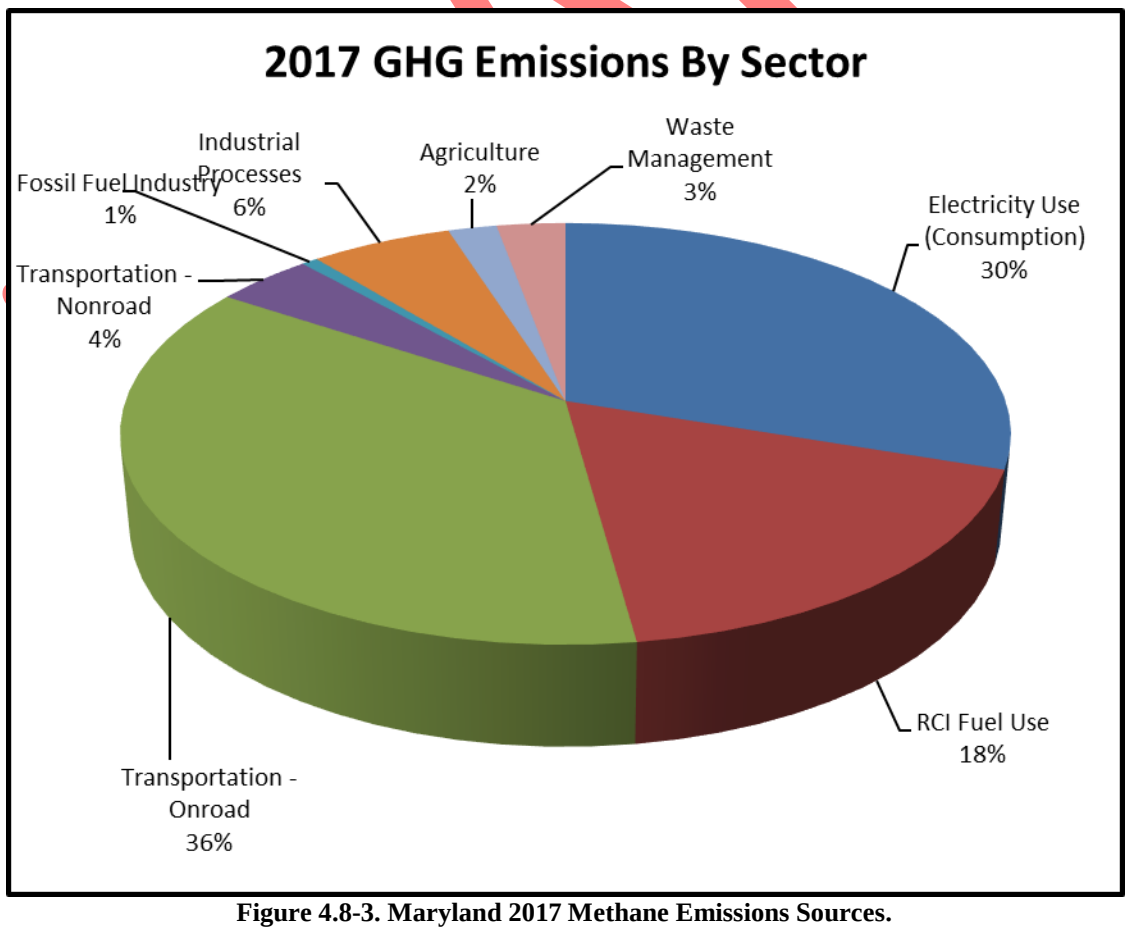


Figure 4.8-3. Maryland 2017 Methane Emissions Sources.

In 2011, the natural gas industry provided about 35 percent of the total methane emissions in Maryland, while the agricultural sector (enteric fermentation, manure management, and agricultural burning) emitted 24 percent and wastewater management contributed 20 percent. These 3 main sources are responsible for almost 80 percent of the total methane emissions in 2011, with landfills, RCI fuel use, and coal mining accounting for most of the remaining emissions. All sources show increases in 2020 BAU projections except for RCI fuel use, coal mining, manure management, and forest fires. Landfill emissions are projected to more than double by 2020, and on road transportation emissions are projected to increase dramatically as well.

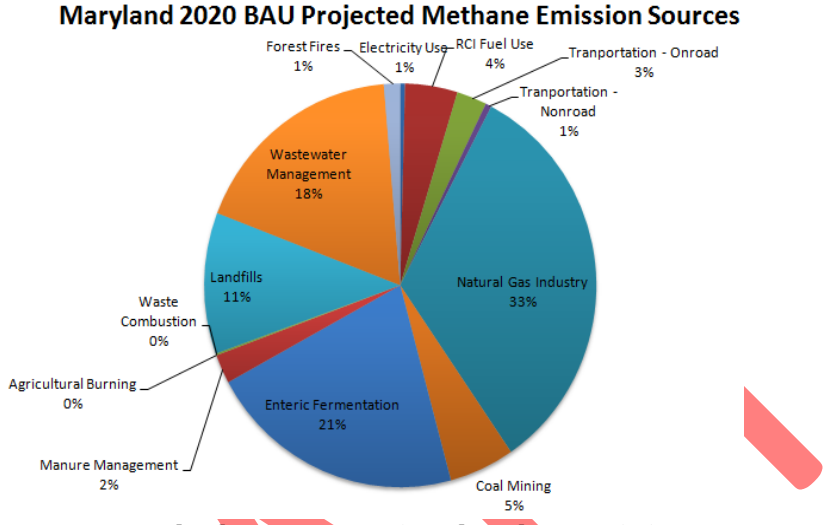


Figure 4.8-4. Maryland 2020 BAU Projected Methane Emission Sources.

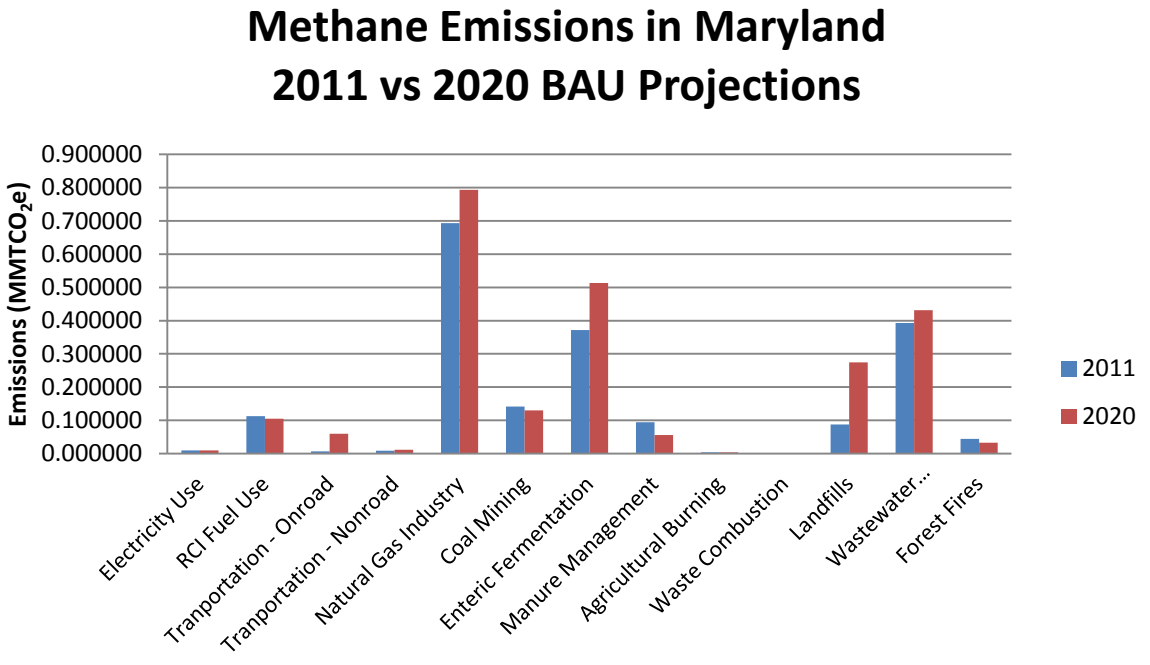


Figure 4.8-5. Methane Emissions in Maryland (2011 vs 2020 BAU Projections).

Methane reductions aimed at the natural gas and agriculture sectors and better management and utilization of organic waste in the waste stream can result in large reductions of methane emissions. Mitigation strategies would have a significant impact on regional SLCP concentrations. This can be accomplished by diverting the organic material and treating it as a potential resource for renewable fuels and composting. These actions will have a positive impact on Maryland's economy and will create jobs.

A significant effort is needed to evaluate methane emissions from the natural gas industry, the greatest source of methane emissions in Maryland. Renewable sources of process gas should be utilized as much as possible by using capturing it at sources such as landfills, wastewater treatment plants, food waste facilities, and agricultural operations. The oil and gas sector must reduce fugitive methane leaks, a large source of atmospheric methane. Energy demand projections indicate that that consumption of natural gas will increase by 2040, making these steps to control emissions especially important.

Maryland's HFC emissions are also expected to increase by 2020, with some projections indicating that HFC emissions could as much as triple by 2030. HFCs in Maryland are emitted as a result of being substituted for ozone depleting substances, or ODS. HFCs accounted for about 7 percent of Maryland's total GHG emissions in 2011 using a 20 year global warming potential. Emissions are projected to increase to around 8 percent of total emissions in 2020 and will significantly increase annually as seen in the figure below.

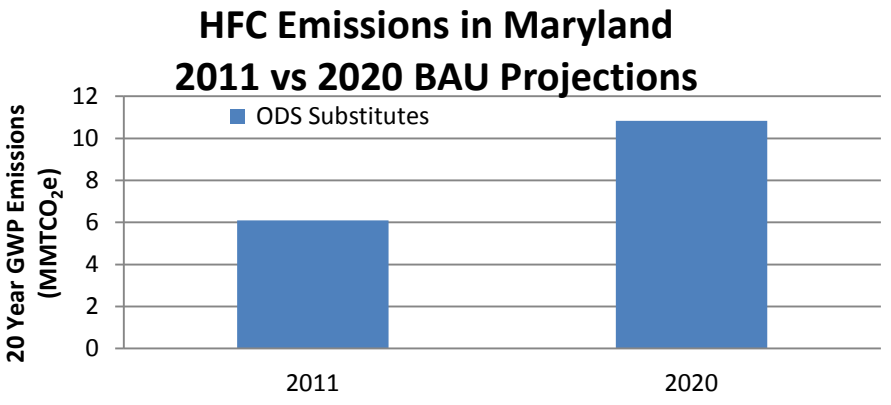


Figure 4.8-6. HFC Emissions in Maryland (2011 vs 2020 BAU Projections).

Alternatives to currently utilized HFCs are commercially available and have lower GWPs. HFCs can also be captured and destroyed from the emission sources with relative ease, especially from appliances that have reached the end of their use. HFCs can be phased out in favor of low GWP alternatives that have the same function, such as hydrocarbons for domestic refrigeration and NH_3 for industrial refrigeration.

There is limited data available for black carbon emissions in Maryland. This is an area that needs a greater focus.

4.8.4 What is Maryland Doing to Reduce SLCP Emissions?

Methane

Methane is emitted from a variety of sources related to Maryland's agriculture industry, the natural gas sector, and waste generation, disposal, and processing. Maryland has already taken steps to curb methane emissions, including requiring controls on landfills and providing incentives to capture and destroy methane emissions from landfills, and agricultural manure management operations. In addition, existing source reduction and landfill diversion targets in the State's waste management plan will further reduce (or eliminate) organic waste disposal in landfills and the resultant methane emissions.

In 2016, the MCCC issued its annual report a recommendation that Maryland should reduce methane emissions from municipal solid waste (MSW) landfills, natural gas infrastructure (e.g. compressor stations, and underground storage) and wastewater treatment plants. At the Dec. 12, 2016 Air Quality Control Advisory Council (AQCAC) meeting, MDE announced that the State will be using EPA's rules that address methane emissions at MSW landfills and gas compressor stations as a starting point for state regulations. MDE's Air and Radiation

Administration has since held several public meetings with various stakeholders concerning in-state methane emissions from the oil and natural gas industry, specifically the transmission and storage sector, and municipal solid waste landfills.

Priority has been placed on addressing fugitive methane emissions from the oil and natural gas sector. There are at least four natural gas compressor stations and one large liquid natural gas import and export facility currently operating in Maryland. EPA requires new facilities (built after September 2015) to monitor fugitive methane emissions with a quarterly to annual leak surveys and to repair them within a certain time-frame. On Oct. 15, 2018, EPA announced an amendment proposal to these rules (40 CFR Part 60, Subpart OOOOa) that would reduce the frequency of the leak surveys.

ARA plans to take a two-prong approach in reducing methane emissions from the oil and gas sector in the absence of finalized federal regulations. MDE is promulgating a regulation modeled after EPA proposed rules as well as other leading-states rules. Maryland's effort is aimed at reducing fugitive emissions from the natural gas transmission and storage sector, including liquid natural gas (LNG) processing facilities. In addition, MDE has proposed a non-regulatory, data-driven memorandum of agreement (MOA) with owners and operators of smaller natural gas emission sources. MDE is currently developing draft versions of both the COMAR regulation and the MOA. The proposed regulation would require leak detection and swift repair, as well as gas compressor maintenance and pneumatic device upgrades. The MOA will include several best management practices (BMP) that the oil and gas industry has deemed cost effective and beneficial as well as a fence-line monitoring requirement and possible inclusion of an emissions offset requirement.

Municipal Solid Waste Landfills

On July 14, 2016, EPA finalized rules to reduce landfill gas from MSW landfills (composed of 50 percent methane), but placed a 90-day stay on the rule on May 5, 2017. The stay was lifted, but EPA has not provided guidance on how states should proceed.

ARA began the MSW landfill stakeholder process in March 2017, but shifted the focus to gas compressor stations after rule was stayed. ARA plans to notify MSW landfill stakeholders of our intention to continue the stakeholder process. ARA would plan to take a two-prong approach in reducing methane emissions from MSW Landfills similar to that of the natural gas compression and storage sector.

Wastewater Treatment Plants

Capturing and utilizing methane from wastewater treatment plants is a burgeoning area of opportunity that Maryland has already begun exploring. Sixty-seven major wastewater treatment facilities in Maryland have been targeted to be upgraded with enhanced nutrient removal (ENR) technologies to reduce nutrients in wastewater effluent and reduce methane emissions. Over 40 plants have already been upgraded as of late 2015. Emissions reduction benefit from these upgrades is currently unknown.

Black carbon

Black carbon emissions are 90 percent lower than they were in the 1960s, and will be cut in half again by 2020. Maryland has several programs and regulations to reduce diesel particulate emissions, a major source of black carbon emissions:

- Maryland Diesel Vehicle Emissions Control Program
- Engine idling restrictions
- Diesel retrofits
- SmartWay upgrade kits (voluntary fleet fuel efficiency improvements)

EPA Rules

- 2007 Heavy Duty Highway Diesel Rule
- Clean Air Non-Road Diesel Engine & Fuel Rule
- Highway and Non-Road Diesel Rules (updated in April 2006)
- Clean Diesel Program for Locomotives and Marine Engines

Hydrofluorocarbons (HFCs)

Demonstrating the state's commitment to meeting GHG reduction goals, Maryland will be pursuing measures to phase out the use of HFCs in foam products, aerosol propellants, air conditioning and refrigeration. MDE will develop regulations similar to California's rule and other US Climate Alliance Sates that prohibits the use of certain HFCs in foam products, aerosol propellants, air conditioning and in new and retrofitted refrigeration equipment in retail establishments such as supermarkets. It also requires that potential emissions sources certify that they use compliant refrigerants. The phase out of HFCs will encourage the use of substances with lower GHG emissions that are already available in the state.

Maryland Department of the Environment

Chapter 5

Emissions Modeling and Economic Impacts

5.1 Emissions Modeling

5.1.1 Background

The Regional Economic Studies Institute (RESI) at Towson University was contracted to develop a macroeconomic assessment of Maryland's greenhouse gas (GHG) reduction policies by the Maryland Department of the Environment (MDE). The project is divided into two phases;

- The first phase (2017) included the development of a reference case of GHG emissions for Maryland consistent with existing energy policies in the LEAP model. This work was presented to the Mitigation Working Group of the Maryland Commission on Climate Change (MCCC) in February 2018.
- The second phase (2018-2019) includes an evaluation of deeper GHG reduction scenarios with additional and more aggressive measures.

This report provides documentation for the assumptions, methods, and results of both phases of the project.

5.1.2 Reference Case Results

This study developed a long-term projection of Maryland's GHG emissions based on existing policies that are in place to reduce emissions, as well as forecasted future economic activity and population in the state. The forecast based on existing policies provides a starting point for Phase 2 of the project, which considered additional and increased actions to achieve Maryland's established GHG emissions targets.

Based on Maryland's 2014 inventory, the most recently available data at the time of the study, the largest categories of GHG emissions are electricity generation, transportation, and direct energy combustion in buildings (see Figure 5.1-1). Electricity generation emissions are dominated by in-state coal generation as well as imports from the Pennsylvania Jersey Maryland Interconnection, LLC. Transportation emissions are largely attributed to passenger vehicles. Direct emissions from buildings are mostly from water heating and space heating end uses.

Figure 5.1-1. Maryland 2014 Gross GHG Emissions by Sector and Subsector (93.4 MMtCO2e)[106].

We project historical emissions into the future using the LEAP tool (Long-range Energy Alternatives Planning system)[107], which accounts for the natural rate of equipment and infrastructure roll-over, electricity sector operations and trends in energy use. This projection without any Maryland policy is used to develop a Baseline Scenario. To develop the Reference Scenario, existing Maryland policies are translated into their impacts on new equipment and infrastructure and then used to adjust future assumptions, resulting in the reference case forecast. For example, given the Maryland Renewable Portfolio Standard (RPS), we assume that the generation mix includes an increasing share of renewable generation until the existing RPS goal of 25 percent is reached in 2020. The most important existing policies considered in the development of the reference case include the RPS, EmPOWER efficiency, and zero emission vehicle (ZEV) memorandum of understanding (MOU). A complete list of policies in the Baseline and Reference Scenarios is provided in this report.

In Figure 5.1-2 we compare the Reference Scenario emissions trajectory to Maryland's climate goals. The current goals are set to reach GHG emissions levels 25 percent below 2006 levels by 2020, 40 percent by 2030 and 80 percent by 2050. The Reference Scenario reaches the 2020 goal and shows that additional GHG emission reductions are necessary to meet the 2030 and 2050 goals.

[106] Industry includes emissions from direct energy combustion; Industrial Process emissions include non-combustion categories such as cement and refrigerants. Emissions categorization into transportation and building subsectors are a result from E3 PATHWAYS modeling.
[107] More information on the LEAP software can be found at www.energycommunity.org

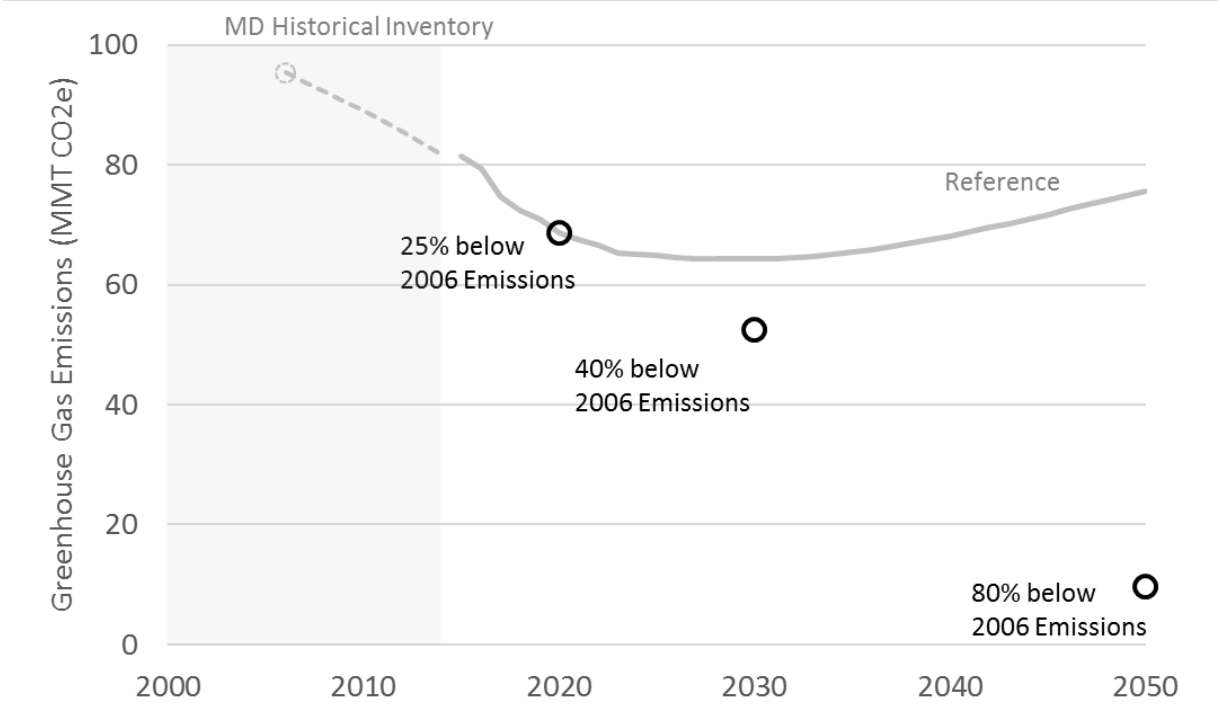


Figure 5.1-2. Maryland Net GHG Emissions Results for Reference Scenario, 2015-2050 compared to the adopted GHG targets[108].

Table 5.1-1 shows the GHG goals for each target year and the difference relative to the modeled Reference Scenario. GHG targets in Maryland are calculated primarily on a gross emissions basis, meaning that percentage reductions are calculated based on 2006 gross emissions (107.2 $MMtCO_2e$) and emissions sinks from land use are then subtracted (11.8 $MMtCO_2e$).

Table 5.1-1. Maryland Net GHG Targets Compared to Reference Scenario Net GHG Emission Results.

[$MMtCO_2e$]	2020	2030	2050
GHG Target	68.6	52.5	9.7
Reference Scenario	68.6	64.3	75.7
Difference	*0.0*	*11.7*	*66.0*

5.1.3 Policy Scenario Results

Figure 5.1-3 shows the results for all policy scenarios explored as a part of this analysis. Each policy scenario was designed with a specific philosophy in mind.

1. **Policy Scenario 1**: Continuation or extension of current programs
2. **Policy Scenario 2**: New programs and changing program frameworks and long-term measures to achieve the 2050 GHG target
3. **Policy Scenario 3**: Carbon pricing program in addition to complementary policy (specified by the MCCC)
4. **Policy Scenario 4**: Revised version of Policy Scenario 2

[108] GHG emissions are displayed as net GHG emissions after sinks. GHG goals are calculated as a percent below gross emissions (i.e. without land use sinks) and then emissions sinks are subtracted to calculate net emissions.

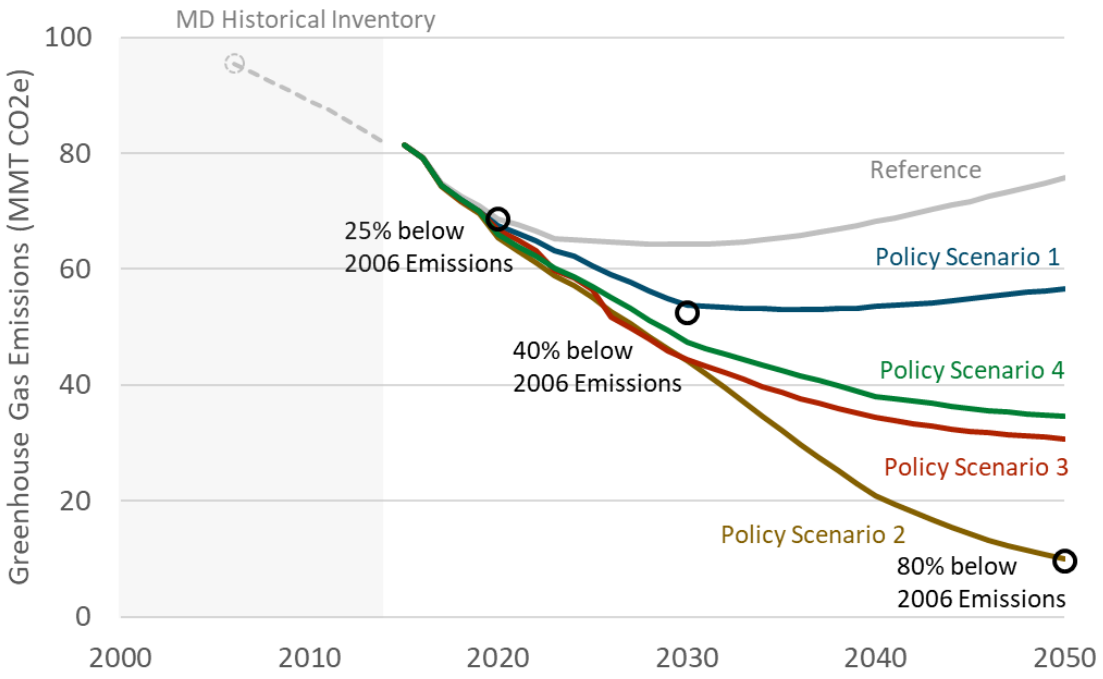


Figure 5.1-3. Maryland Net GHG Emissions Results for Policy Scenarios, 2015-2050 compared to the adopted GHG targets.

All Policy Scenarios meet the 2020 goal. Policy Scenario 1, which represents an extension of existing efforts, including building efficiency and the state's RPS get close but falls short of the 2030 goal. Policy Scenarios 2, 3, and 4 meet the 2030 goal. Policy Scenario 3's included carbon pricing mechanism has the most effect between 2020 and 2030, after which the reductions taper off and the scenario falls short of the 2050 goal. Policy Scenario 2 meets the 2050 GHG target by including targeted complementary policies and measures to reduce GHGs in all sectors of Maryland's economy. Policy Scenario 4 is a revised version of Policy Scenario 2 that constitutes Maryland's draft plan to achieve the 2030 GHG target. Policy Scenario 4 highlights the need for additional policy mechanisms to achieve the emission reductions necessary to meet the 2050 economy-wide GHG goal.

Table 5.1-2. Policy Scenario Net GHG Emission Results.

[$MMtCO_2e$]	2020	2030	2040	2050
Policy Scenario 1	67.5	53.9	53.5	56.6
Policy Scenario 2	65.4	44.1	21.0	9.9
Policy Scenario 3	66.7	44.4	34.5	30.7
Policy Scenario 4	66.2	48.1	38.7	35.2
GHG Goals	68.6	52.5	31.1	9.7

RESI also ran several sensitivities on Policy Scenario 4 to test the impact on emissions of federal action and consumer adoption. The three sensitivities were defined as follows:

1. **Low Adoption**: Evaluates the impact of only achieving half of the projected sales of new electric vehicles (EVs) and efficient household appliances
2. **Low CAFE**: Evaluates the impact of removing the improvements in federal Corporate Average Fuel Economy standards from 2021-2026
3. **Low Adoption and Low CAFE**: Evaluates the combined impact of lower consumer adoption and lower fuel economy standards for light-duty vehicles.

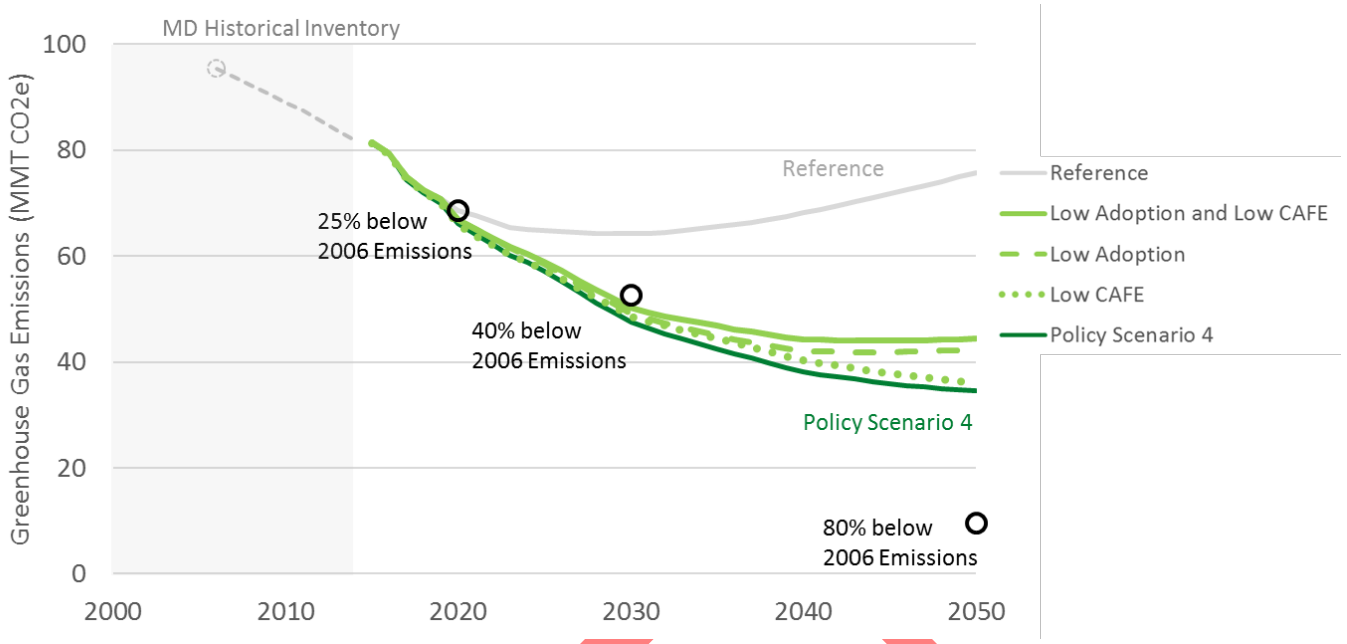


Figure 5.1-4. Maryland Net GHG Emissions for Sensitivities on Policy Scenario 4, 2015-2050.

Figure 5.1-4 highlights the fact that even with more conservative assumptions on consumer adoption of devices and federal action on fuel economy standards, the measures and actions in Policy Scenario 4 are sufficient to meet Maryland's 2030 GHG target. By 2050, however, the lower levels of consumer adoption creates a significant emissions gap as the state tries to reach its 2050 GHG goal.

5.1.4 Further Explanation

Please refer to Appendix F for a more detailed explanation of the PATHWAYS scenario modeling in the *2019 Greenhouse Gas Emissions Reduction Act (GGRA) Draft Plan*.

5.2 Economic Impacts

5.2.1 Background

RESI of Towson University was tasked by MDE to provide a coherent set of analyses to inform the development of its proposed plan to reduce statewide GHG emissions by 40 percent from 2006 levels by 2030, to satisfy MDE's obligations under the GGRA of 2016. RESI contracted with Energy and Environmental Economics, LLC (E3) to model changes in emissions arising from various policy bundles under consideration. The results of the emissions modeling, conducted using the Pathways model, are discussed in Section 5.1 of this report, while the current section contains the results of the economic modeling, which the Project Team completed using REMI PI+ (REMI).[109]

The REMI model is a high-end dynamic modeling tool used by various federal and state government agencies in economic policy analysis. The REMI model is calibrated to the specific demographic features of Maryland as a whole and five regions of the state:

- **Central Maryland**: Baltimore City and Harford, Baltimore, Carroll, Anne Arundel, and Howard counties
- **Southern Maryland**: St. Mary's, Charles, and Calvert counties
- **Capital Maryland**: Frederick, Montgomery, and Prince George's counties
- **Western Maryland**: Garrett, Allegany, and Washington counties

[109] All analyses were conducted using REMI Version 2.2.

- **Eastern Shore**: Cecil, Kent, Queen Anne's, Talbot, Caroline, Dorchester, Wicomico, Somerset, and Worcester counties

To model economic impacts, the team synthesized data from a number of sources, including Pathways output and estimates of program costs from state agencies. Additionally, the team conducted public health modeling to estimate the economic impact associated with improved air quality under each policy scenario.

5.2.2 Criteria for Evaluating the Economic Impact of Policy Scenarios

In addition to satisfying emission requirements through 2030, the policies selected by the State of Maryland to reduce carbon emissions must provide a net benefit to the Maryland economy. To determine whether each policy scenario meets this mandate and qualifies as meeting the economic goals of the GGRA, the team used the following set of indicators:

- Average positive job growth through 2030;
- Positive cumulative personal income growth through 2030 with a 3 percent discount rate; and
- Positive cumulative gross state product (GSP) growth through 2030 with a 3 percent discount rate.

In addition to these three metrics, the team considered other measures of economic well-being, including:

- The impact across different sectors of Maryland's economy, including manufacturing;
- The impact on consumer prices;
- Distributional impacts in terms of income, education and training, and race/ethnicity; and
- The regional distribution of jobs.

Reducing carbon emissions and ensuring net benefits to Maryland's economy are not mutually exclusive goals. The following sections will outline the various policy bundles that the Project Team considered, as well as the results of the analysis.

5.2.3 Overview of Policy Scenarios One, Two, and Three

In evaluating policies to reduce carbon emissions in Maryland and achieve the goals set forward in the GGRA plan, the Project Team evaluated a total of four policy scenarios. This section provides an overview of the first three scenarios. The results of these three policy bundles were then examined, and feedback was solicited from policy-makers to arrive at the final policy scenario, highlighted here in Section 5.2.4 and discussed fully in Section 7.6 of Appendix G.

Policy Scenario 1

Policy Scenario 1 represents a continuation of current policies. Under Policy Scenario 1, energy efficiency is extended as EmPOWER investment continues through 2050, rather than ending in 2023. This corresponds with increased sales of efficient appliances and reductions in electricity usage through behavioral conservation. In addition to increased energy efficiency, Policy Scenario 1 contains extensions of the Zero Emissions Vehicle MOU, leading to increased sales of EVs through 2050. This policy scenario results in 300,000 additional ZEVs in 2050, relative to the reference scenario. Additionally, transportation policies proposed by the Maryland Department of Transportation (MDOT) will reduce vehicle miles traveled (VMT) for both heavy- and light-duty vehicles.

Policy Scenario 1 also contains an increase in the RPS from 25 percent by 2020 to 50 percent by 2030. This increase is modeled after proposed state legislation.[110]

[110] The increase in Maryland's RPS is consistent with HB1435 and SB0732 proposed in the 2018 legislative session.

Policy Scenario 2

Policy Scenario 2 represents an extension of Policy Scenario 1 designed to achieve deeper reductions in carbon emissions. Instead of generally continuing existing policies, Policy Scenario 2 also contains a number of new programs. For example, Policy Scenario 2 replaces the RPS with a 100 percent Clean and Renewable Energy Standard (CARES) goal by 2040. CARES encompasses other sources of generation beyond renewable energy, including combined heat and power (CHP) and nuclear power.

Additionally, Policy Scenario 2 models rapid adoption of ZEVs. ZEVs are assumed to be 50 percent of new sales by 2030 and 100 percent of light-duty vehicle sales by 2050. In addition to these sales of light-duty vehicles, the team assumed that 95 percent of heavy-duty vehicle sales in the state would be EVs or diesel hybrids by 2050. Regarding energy efficiency, the team modeled 100 percent of electric and natural gas appliance sales in Maryland as high-efficiency by 2030.

Policy Scenario 3

While the other policy scenarios were developed by MDE, Policy Scenario 3 was developed by the Mitigation Working Group of the MCCC. Similar to Policy Scenario 2, Policy Scenario 3 uses Policy Scenario 1 as a foundation. In addition to the measures discussed in Policy Scenario 1 under Section 5.2.2 above, Policy Scenario 3 contains carbon pricing as a strategy to reduce carbon emissions instead of regulations. The carbon price for this scenario was modeled as starting at $20 per metric ton in 2020, rising to the social cost of carbon in 2030 and beyond.

Revenue from the carbon pricing scheme is allocated based on the Regional Cost Collection Initiative (RCCI) bill, or House Bill 939, introduced in the Maryland General Assembly in 2018, with modifications:

- $10 million each year is allocated towards administration of the program;
- 50 percent of total revenue, less $10 million, is rebated to consumers in lower income brackets;
- 30 percent of total revenue each year is allocated to additional carbon mitigation measures beyond those modeled in Policy Scenario 1;
- 10 percent of total revenue is allocated to adaptation and resilience policies, which help vulnerable communities to prepare for and react to climate change; and
- 10 percent of total revenue is allocated to just transition efforts, which provide job retraining efforts and assistance for workers and communities impacted by the transition away from fossil fuels.[111]

5.2.4 Results of Policy Scenarios One Through Three

Overall, as summarized in Table 5.2-1 the first three policy scenarios all achieve the 2030 economic goal. Additionally, Policy Scenario 2 and Policy Scenario 3 meet both the 2020 and 2030 emissions goals.

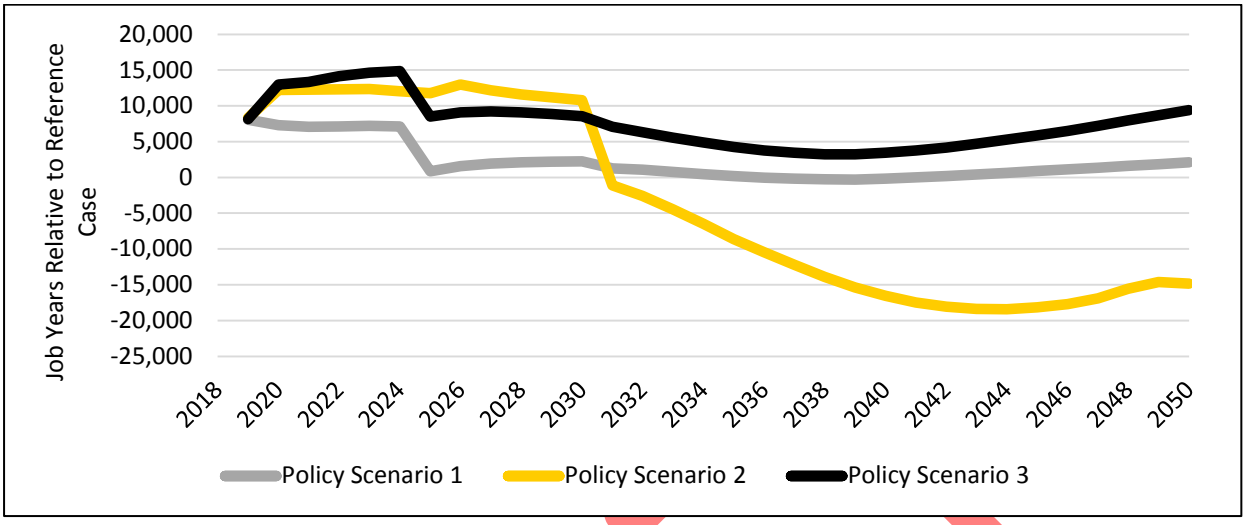
Table 5.2-1. Summary of Policy Scenarios.

Policy Scenario	Achieve 2020 Emissions Goal?	Achieve 2030 Emissions Goal?	Achieve 2030 Economic Goal?
Policy Scenario 1	Yes	No	Yes
Policy Scenario 2	Yes	Yes	Yes
Policy Scenario 3	Yes	Yes	Yes

Source: RESI

[111] H.B. 939, Session of 2018 (Mar. 2018), p.1, http://mgaleg.maryland.gov/2018RS/fnotes/bil_0009/hb0939.pdf.

In terms of employment, as illustrated in Figure 5.2-1, all three policy scenarios exhibit average positive job growth through 2030.



Sources: REMI PI+, E3, MDE, MDOT, RESI

Figure 5.2-1: Total Employment for Policy Scenarios 1, 2, and 3.

Policy Scenario 2 produces the most jobs between 2019 and 2030, averaging 11,665 jobs, while Policy Scenario 1 produces the least at 4,564 jobs. By 2050, these numbers are significantly lower across all policy scenarios, with Policy Scenario 2 losing an average of 3,811 jobs between 2019 and 2050, but Policy Scenarios 1 and 3 still maintaining positive job growth.

To summarize, these results are due to a number of aspects contained in each bundle of policies:

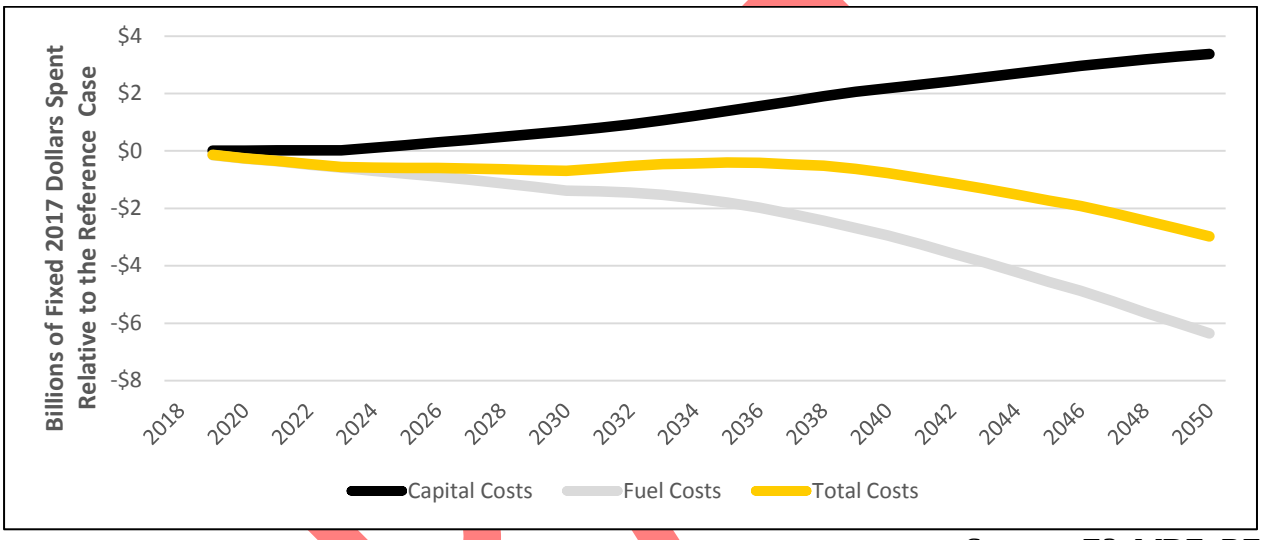
- **Transportation infrastructure spending** - Policy Scenario 2, in particular, shows large near-term employment increases due to the I-495 and I-270 lane expansion projects. Both Policy Scenarios One and Three begin the same, but the divergence in 2020 is due to the presence of the carbon fee as a funding source for infrastructure projects.
- **Carbon fee and dividend** - The carbon fee plays a pivotal role in boosting employment numbers for Policy Scenario 3 in the long run. The revenue from this fee is able to mitigate some of the negative effects of Policy Scenario 1 by providing rebates to consumers for increased energy prices, as well as the provision of funding for additional job-creating mitigation measures. The rationale behind this job-creating policy is that the fee acts as a filter, redirecting funds that would have previously flowed out of the state towards job creation activities within the state.
- **In-state wind and solar generation** - Because Maryland is traditionally a net importer of energy, increasing the percentage of self-supplied energy enables money that would have been spent out of the state, to stay within the state.

Although the employment impacts displayed in Figure 5.2-1 appear large, they in fact represent a very small proportion of Maryland's total economy. Employment impacts, both positive and negative, do not vary more than one percentage point beyond the levels forecast in the reference case. Even under Policy Scenario 2, which contains aggressive policies aimed at reducing carbon emissions in the state, employment is expected to decline by less than 0.5 percent at its most extreme point. Given the scale of the spending occurring under each policy as described later in Section 7.5.1 of Appendix G, employment impacts are relatively muted.

5.2.5 Policy Scenario 4

After the emissions and economic impacts associated with Policy Scenarios 1 through 3 were estimated and analyzed, Policy Scenario 4 was constructed both to achieve the emissions requirements laid forth in the GGRA and provide a blueprint for future efforts to reduce GHG emissions. Policy Scenario 4 uses Policy Scenario 1 as its foundation. Policy Scenario 1 represents a collection of policies that are either a continuation or extension of current programs. In addition to these measures, Policy Scenario 4 consists of new programs explored in Policy Scenario 2. For example, as in Policy Scenario 2, Policy Scenario 4 includes a 100 percent CARES goal by 2040 instead of the RPS modeled in Policy Scenario 1.[112] Other policies modeled similarly to Policy Scenario 2 include bus electrification, transportation programs, and forest management and healthy soils initiatives.

Similar to Policy Scenario 1, Policy Scenario 2, and Policy Scenario 3, Policy Scenario 4 meets the economic goals outlined in Section 7.3.7 of Appendix G. Notably, Policy Scenario 4 achieves these goals with low levels of spending. As illustrated in Figure 5.2-2, in every year in Policy Scenario 4, consumers and businesses spend less on capital costs and fuel costs relative to the reference case.



Sources: E3, MDE, RESI

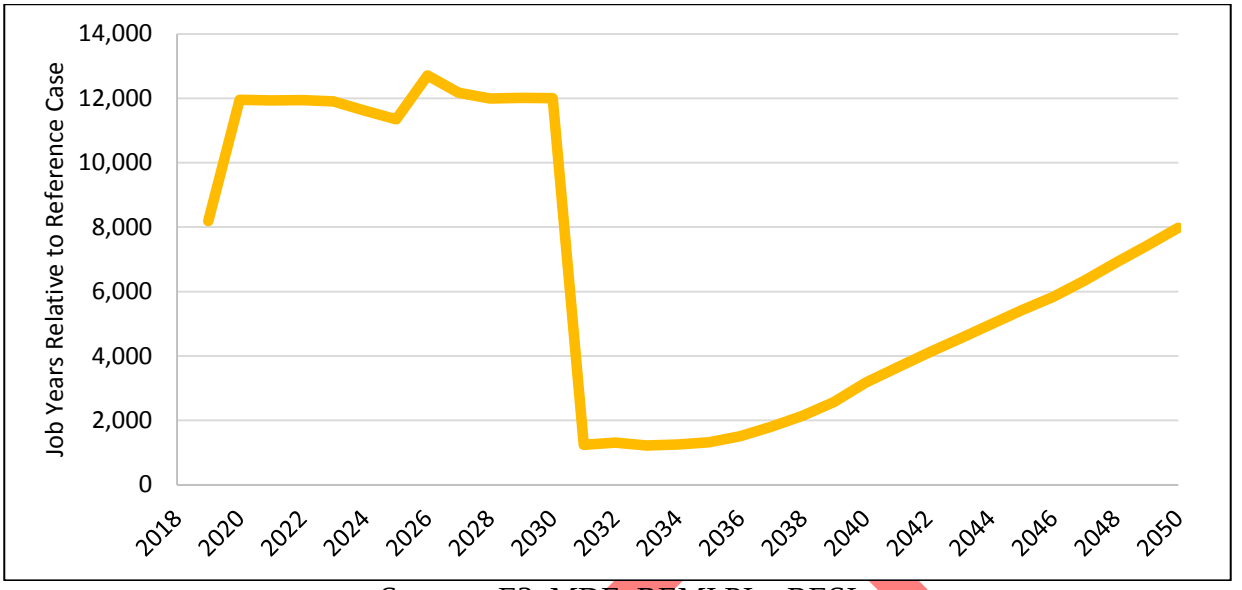
Figure 5.2-2: Total Costs from PATHWAYS in Policy Scenario 4 Relative to the Reference Case.

As seen in Figure 5.2-2, although consumers and businesses are spending more on capital costs (e.g., new energy-efficient appliances or new EVs) in Policy Scenario 4 than in the reference case, fuel savings exceed this amount every year. This is in contrast to the other policy scenarios and is attributable to two general trends:

- Spending on transportation infrastructure projects is high in Policy Scenario 4. These projects are generally due to policies aimed at reducing fuel usage through behavioral changes (e.g., increased mass transit usage or increased use of bike lanes) as well as more direct capital outlays (e.g., truck stop electrification or bus electrification). The level of spending on these projects is equal to the level in Policy Scenario 2, which is the highest level modeled.
- Capital costs are generally low. Through 2025, capital costs in Policy Scenario 4 are equal to those in Policy Scenario 1, the scenario with the lowest spending on capital costs. Although capital expenditures after 2025 are higher in Policy Scenario 4 than in Policy Scenario 1, they never approach those in Policy Scenario 2 or Policy Scenario 3.

The impacts of infrastructure spending and capital costs can both be seen when examining the economic impacts of Policy Scenario 4. As seen in Figure 5.2-3, Policy Scenario Four supports an average of 11,649 jobs each year through 2030 relative to the reference case.

[112] However, the CARES program modeled in Policy Scenario 4 contains different carve outs than the CARES program modeled in Policy Scenario 2. In Policy Scenario 2, carve outs include 12.5 percent for in-state solar, 12.5 percent for offshore wind, and 25 percent for tier one renewables. In Policy Scenario 4, the carve outs include 15 percent for in-state solar, 10 percent for offshore wind, and 20 percent for tier one renewables.



Sources: E3, MDE, REMI PI+, RESI

Figure 5.2-3: Employment in Policy Scenario 4 Relative to the Reference Case.

Through 2030, these employment impacts are driven by transportation infrastructure projects, as seen in other policy scenarios. After 2030, employment impacts remain positive relative to the reference case. The steady increase in employment after 2030 is due in part to the relatively low capital costs seen in Policy Scenario 4. Because spending on capital is lower, consumers have more money to spend on other goods and services, and businesses are more profitable. These positive impacts, coupled with reductions in spending on fuel, resulting in a slow albeit steady increase in jobs supported relative to the reference case.

To visualize the impact of spending on transportation infrastructure on the economic impact results for Policy Scenario 4, Figure 5.2-4 below shows employment differences in Policy Scenario 4 with and without this spending.

Sources: E3, MDE, REMI PI+, RESI

Figure 5.2-4: Employment in Policy Scenario 4 With and Without Transportation Spending Relative to the Reference Case.

The impact of transportation spending in Policy Scenario 4 is similar to the impacts in the other three policy scenarios. On average through 2030, transportation infrastructure measures support 10,013 more jobs compared to

the scenario without this spending. This is illustrated above as the difference between the two lines. Regardless of the status of the transportation spending, however, employment impacts are steadily positive for Policy Scenario 4.

In sum, as shown in Table 5.2-2, all four policy scenarios achieve the 2030 economic goals and three policy scenarios meet both the 2020 and 2030 emissions targets as well.

Table 5.2-2. Summary of Policy Scenarios.

Policy Scenario	Achieve 2020 Emissions Goal?	Achieve 2030 Emissions Goal?	Achieve 2030 Economic Goal?
Policy Scenario 1	Yes	No	Yes
Policy Scenario 2	Yes	Yes	Yes
Policy Scenario 3	Yes	Yes	Yes
Policy Scenario 4	Yes	Yes	Yes

Source: RESI

Sensitivity analyses were performed for Policy Scenario 4 under a number of different scenarios, including:

1. A decrease in future renewable energy credit (REC) prices.
2. A rollback of the federal level Corporate Average Fuel Economy (CAFÉ) program. Removing the CAFÉ standards for fuel efficiency means an increase in emissions from vehicles and less pressure for consumers to purchase zero emissions vehicles.
3. Reduced consumer adoption of energy efficient appliances and ZEVs. Under this sensitivity, consumer purchases of efficient appliances and ZEVs are 50 percent lower than originally modeled, leading to increased emissions, reduced capital costs, and reduced fuel savings.
4. A sensitivity analysis combining the rollback of the CAFÉ standards with the reduced consumer adoption sensitivity.

The results indicate that the economic outcomes of Policy Scenario 4 are robust to large changes in policies, consumer behavior deviations, and an uncertain economic environment. Under all the sensitivity analyses, the economic goals are still met.

5.2.6 Further Explanation

Please refer to Appendix G for a more detailed explanation of the economic impacts of the *2019 GGRA Draft Plan*.

Chapter 6
Social Equity

6.1 Risk and Vulnerability

6.1.1 Risk and Vulnerability

Risk is a term used frequently in discussing both present and future scenarios related to climate change impacts. It can be defined as the relationship between the likelihood of exposure to a given hazard, and the damage expected if exposure occurs. A basic qualitative risk assessment can be visualized across a matrix, such as the one in Figure 6.1-1. Considering the relative risk posed by potential future impacts, under a variety of scenarios, is an important component of informed decision-making.

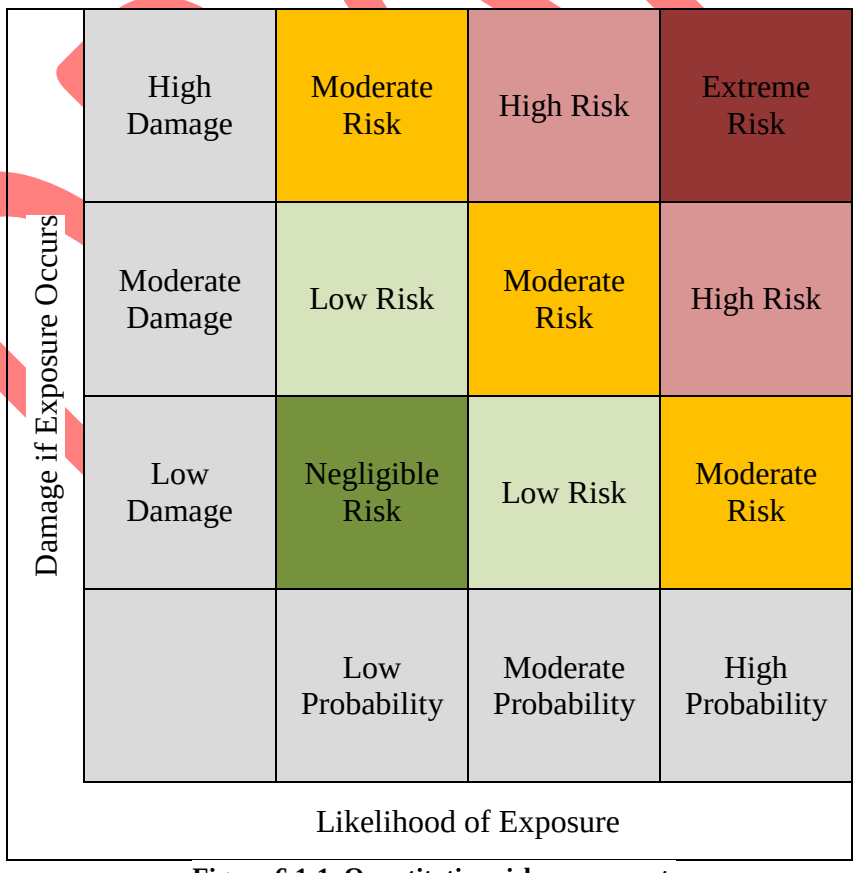


Figure 6.1-1. Quantitative risk assessment.

Risks associated with the impacts of climate change, however, are not the same for all Marylanders. Nor are the risks or costs associated with certain mitigation or adaptation actions. Qualities of an individual or community such as geographical location, pre-existing health conditions, or socioeconomic status will influence the factors that go into determining both the likelihood of exposure and the damage expected if exposure occurs, ultimately impacting the associated risk for these groups.

Individuals or groups may therefore be considered more vulnerable to climate impacts compared to the general population if they have a higher likelihood of exposure to climate impacts, or are expected to suffer greater damage than the average person if exposed. Expected damage may be affected either by a sensitivity to the particular impact, or by the capacity to adapt or react to the impact (Figure 6.1-2). Communities that live along the coast, for example, are clearly more likely to be exposed to impacts caused by sea level rise than those who live in Garrett County. Among this coastal group, some individuals may not have access to the financial resources to rebuild or relocate if flooding or storm damage does occur. This group has a reduced adaptive capacity, or a decreased ability to respond to the consequences, increasing the damage they experience if flooding does occur. A third important factor, also related to damage caused by exposure, is sensitivity. This is most often thought of in relation to health impacts, for example the elderly and children are considered more sensitive to extreme heat (for a variety of specific reasons), and are therefore more likely to experience a negative impact due to extreme heat exposure.

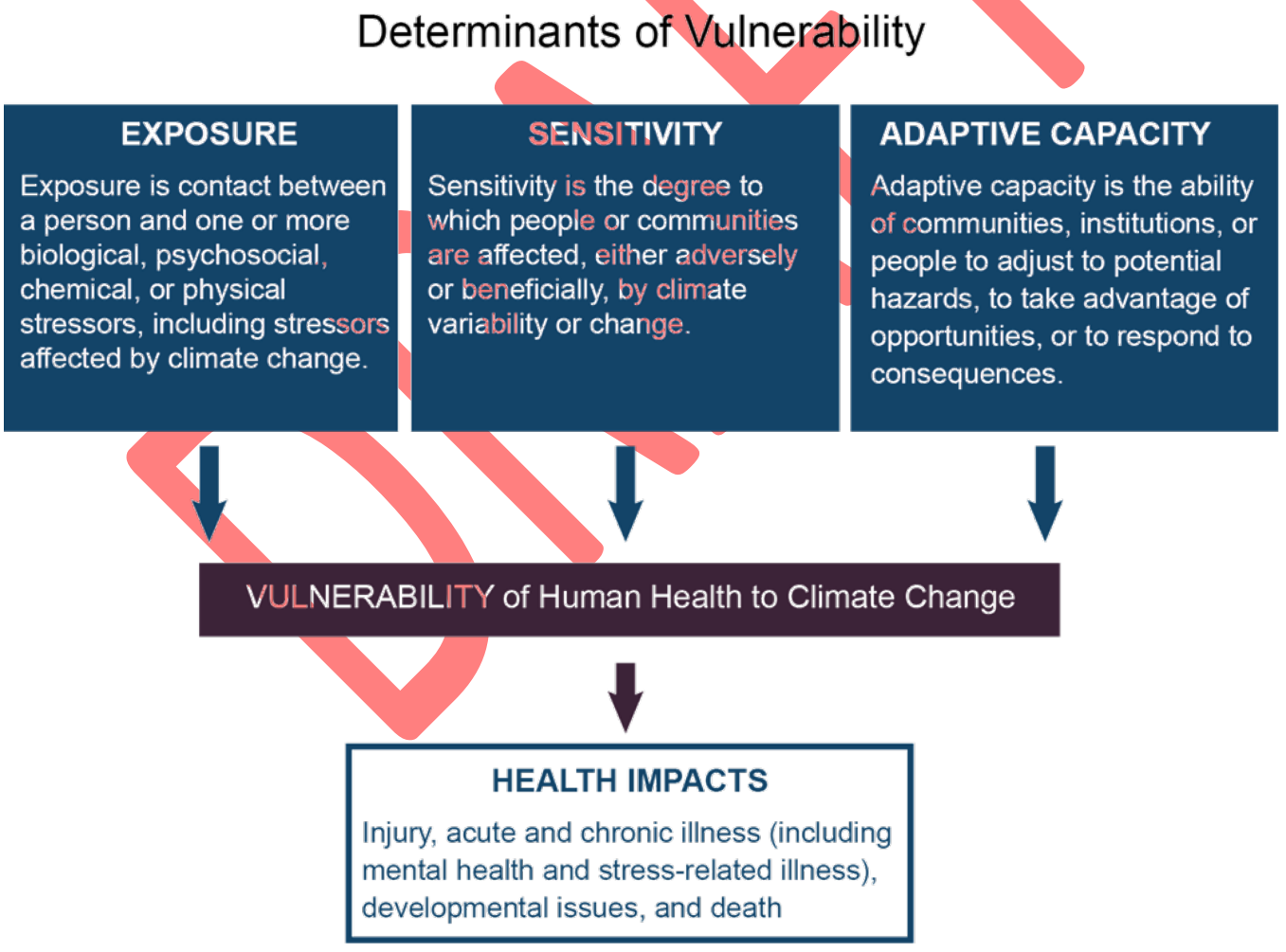


Figure 6.1-2. Determinants of vulnerability.

The U.S. Global Change Research Program (USGCRP) refers to vulnerable groups as "populations of concern," and identifies that these include "those with low income, some communities of color, immigrant groups (including those with limited English proficiency), Indigenous peoples, children and pregnant women, older adults, vulnerable occupational groups, persons with disabilities, and persons with preexisting or chronic medical conditions"[113]. Furthermore, some communities may have less ability to respond to climate impacts and climate-change-related events based on socioeconomic status. Since all Marylanders are not starting out on equal footing, it is essential that these differences and disadvantages are taken into account during decision-making regarding resource allocation and prioritization of actions.

6.1.2 Environmental Justice and Equity

Significant overlap exists between "populations of concern" and historically disadvantaged communities, which may be defined by race, color, national origin, or income. Some of the challenges faced by these groups include proximity to polluting facilities, barriers to participating in decision-making processes, disproportionate levels of chronic disease, neighborhood disinvestment, and poor or no access to jobs and services[114]. In the context of pollutants and other environmental concerns, these communities are often discussed in terms of environmental justice (EJ).

Environmental equity in the most basic sense can be defined by distinguishing it from equality. It is related not to equal but to fair distribution of both the costs and the benefits of an environmental action or inaction. The United States Environmental Protection Agency (EPA) encourages its staff to evaluate the distribution of not only risk and burdens, but also positive environmental and health outcomes related to actions[115]. For the specific purposes of the *2019 Greenhouse Gas Emissions Reduction Act (GGRA) Draft Plan*, equity has been evaluated in terms of environmental justice and, more specifically, climate justice. How equitable actions are determined, balanced with other important factors, and executed through policy is complex but critical for holistic and sustainable climate action in Maryland.

6.2 Health Impacts

A number of health impacts were discussed in Chapter 5 of this report, under the cost of inaction. These include issues with extreme heat and air quality; water quality and extreme precipitation; infectious diseases; and food and energy security. As we have been discussing in this chapter, health outcomes are ultimately influenced by a variety of social and institutional factors that may increase the likelihood of exposure to an impact of climate change, or the probability of a negative outcome from that exposure (Figure 6.1-2). Climate change may even impact one or more of these factors, altering the ability of a community or an individual to respond to health concerns, rendering them unable to take appropriate measures to prevent or treat an illness or injury[113]. The State has a number of programs related to the wide variety of factors involved in expected health impacts and their causes. For example, Maryland Department of Health (MDH) is working to provide tools, resources, and technical assistance to citizens, communities, and other such groups to help combat these impacts[116]. This section provides some specific examples of equity concerns related to the public health impacts of climate change that were discussed in the previous section. State measures are expanded upon later in this chapter under section 6.4.2.

6.2.1 Extreme Heat and Air Quality

[113] U.S. Global Change Research Program, The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment, A. Crimmins, J. Balbus, J. Gamble, C. Beard, J. Bell, D. Dodgen, R. Eisen, N. Fann, M. Hawkins, S. Herring, L. Jantarasami, D. Mills, S. Saha, M. Sarofim, J. Trtanj and L. Ziska, Eds., 2016.
[114] U.S. EPA, 2018. "Smart Growth and Equitable Development". <https://www.epa.gov/smartgrowth/smart-growth-and-equitable-development>
[115] U.S. EPA, 2016. "Technical Guidance for Assessing Environmental Justice in Regulatory Analysis". <https://www.epa.gov/sites/production/files/2016-06/documents/ejtg_5_6_16_v5.1.pdf>
[116] Maryland Department of Health, 2018. "Maryland Public Health Strategy for Climate Change". <https://phpa.health.maryland.gov/OEHFP/EH/Pages/Climate_Change.aspx>

As discussed previously, extreme heat events have been and are expected to continue increasing in frequency and air quality in general is projected to continue declining due to a number of factors. Exposure to extreme heat events is greater for certain individuals, such as those who lack access to air conditioning or have an outdoor job. Individuals at already increased risk of health problems from extreme heat, such as children and the elderly, are more likely to experience a negative health outcome if exposure occurs[113,117]. Mitigation is clearly one of the most important activities that Maryland is engaged in to protect all of its citizens, with a 2°C scenario projected to avoid 13,000 premature deaths in 2050 and 57,000 in 2100 nationwide due to impacts from ozone and particulates[4]. Low-income energy efficiency programs through the Regional Greenhouse Gas Initiative (RGGI) help to ensure that all Marylanders are able to cover their electricity bills and keep cool during heat waves. The State also provides *Air Quality Alerts* when conditions are expected to be hazardous, allowing the public to limit their exposure to unhealthy air whenever possible. This information is available through a wide variety of media, including via email or phone alerts, and by checking online or calling a hotline number.

6.2.2 Extreme Precipitation and Water Quality, and Infectious Disease

As discussed in section 6.2.3 of this report, the people and infrastructure of Maryland's coastal region are at particular risk from impacts of sea level rise such as flooding, saltwater intrusion, storm surge, and erosion[117]. Certain inland areas are also at increased risk of flooding, in large part due to the combined impact of impervious surfaces and extreme precipitation events. Other factors that increase the risk of exposure to flooding events in inland communities includes the amount of impervious surfaces, proximity to rivers, and stormwater control measures (including natural features) that are in place. Among those exposed to flooding and other storm impacts, the physical and mental health outcome will still be affected by available income and access to other resources before, during, and after the event. Some examples include an ability to: be aware of and properly prepare for an impending storm; directly address resulting injuries or health issues; remediate structural damage caused by flooding such as mold growth and repairs to a home or local business; garner aid from local, state, or federal resources; relocate to avoid future damage; and take time off work to handle the aforementioned issues. Much of the early adaptation at the State level has been focused on the coastal region, including living shoreline projects, the Coast Smart Construction program, and the State Highway Vulnerability Assessment; but attention has turned inland over the past few years to address riverine flooding such as occurred in Ellicott City in 2016 and 2018. Furthermore, the Maryland Department of Planning (MDP) completed a review of local comprehensive plans in 2017 to assess whether different county-level approaches for addressing expected impacts of climate change, the first step to tailoring adaptation planning assistance based on current capacity and specific local needs[118].

Even during storms that may not lead to widespread flooding, extreme precipitation events can still overburden stormwater and drainage systems, which can discharge untreated sewage into waterways or cause back-ups into homes located in cities with combined storm and sewer systems. This creates the potential for exposure to human pathogens such as those that cause diarrhea. In cities with aging infrastructure, even those with separate storm drains and sewers may still be vulnerable to overflows during periods of heavy or prolonged rainfall. In Baltimore, this occurs frequently as stormwater infiltrates the sewer pipes and excess volume is released through structured overflows, or damage from storm debris causes ruptures and leakage[119,120,121,122,123]. Adaptation measures that

117 U.S. Environmental Protection Agency, 2016. "Climate Change Indicators in the United States". Std. Num. EPA 430-R-16-004.
118 Maryland Commission on Climate Change, 2018. "2018 Annual Report". <https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/MCCC_2018_final.pdf>
119 Baltimore City Department of Public Works, "Press Release: DPW Reports Updated Sewer Overflow Totals," 30 July 2018. [Online]. Available: https://publicworks.baltimorecity.gov/news/press-releases/2018-07-30-dpw-reports-updated-sewer-overflow-totals.
120 Baltimore City Department of Public Works, "Press Release: Heavy Labor Day Weekend Rain Leads to SSOs," 5 September 2018. [Online]. Available: https://publicworks.baltimorecity.gov/news/press-releases/2018-09-05-heavy-labor-day-weekend-rain-leads-ssos.
121 Baltimore City Department of Public Works, "Press Release: SPW Moves to Address Sanitary Sewer Overflows," 7 June 2018. [Online]. Available: https://publicworks.baltimorecity.gov/news/pressreleases/2018-06-07-dpw-moves-address-sanitary-sewer-overflows.
122 Baltimore City Department of Public Works, "Press Release: Sanitary Sewer Overflow Numbers in Steady Decline," 12 December 2017. [Online]. Available: https://publicworks.baltimorecity.gov/news/pressreleases/2017-12-12-sanitary-sewer-overflow-numbers-steady-decline.
123 Chesapeake Bay Foundation, "Baltimore City Sewage Overflow: Past Time to Fix the Pipes," 2018. [Online].
Available: http://www.cbf.org/about-cbf/locations/maryland/issues/baltimore-city-sewage-overflow.html.
[Accessed 22 October 2018].

update aging stormwater/sewer infrastructure are critical to safely maintaining these systems, and in Baltimore, those already underway are expected to alleviate 83 percent of the overflow volume by 2021 under the Sanitary Sewer Consent Decree Program[124].

6.2.3 Food and Energy Security

Climate change is predicted to expose consumers to pathogens, toxins, and chemical contaminants through food, and to increase the risk of disruptions to distribution systems, as described in the previous chapter. In the event that prices are driven up by decreased supply, household food security may become a concern. The United States Department of Agriculture (USDA) estimated that around 11.8 percent of U.S. households (15 million) were food insecure in 2017, meaning at some time during the year, they did not have the resources to provide adequate food to all family members[125]. Although Maryland tends to fare better than the national average (about 10.4 percent average 2015 to 2017)[125], that is still a large number of households in the State that are likely vulnerable to further climate impacts.

Extreme weather events are likely to disrupt infrastructure, and while transportation was discussed at length, this also includes electricity, food and water, and communication services that are important not only to daily life, but also emergency response services; reducing capacity to respond to and recover from an event[113]. An extended loss of electricity may impact human health by restricting access to clean water (pumping stations, water treatment plants, and household well pumps), temperature control (A/C units, fans, and electric heating), safe food storage and preparation (refrigerators, freezers, and electric stoves), and certain emergency medical services[113,126].

6.2.4 The Co-Pollutants of Combustion

The most immediate human health concern caused by the burning of fossil fuels is not the release of CO_2, but the co-pollutants associated with combustion. For fossil fuel-fired power plants, these include sulfur dioxide, carbon monoxide, hydrocarbons, and particulates, which affect communities in the surrounding area. Some of these pollutants cause issues directly, while others undergo reactions in the atmosphere to create harmful secondary pollutants, such as ground-level ozone, acid rain, and photochemical smog. Several pollutants related to the production and combustion of fossil fuels[127] are federally regulated as toxics under the Clean Air Act, including nine of the 30 pollutants identified as Urban Air Toxics[128]. Polycyclic aromatic hydrocarbons (PAHs), a category of hydrocarbons that include known and probable human carcinogens, are formed primarily from the combustion of fossil fuels[129]. In fact, of the EPA's six criteria pollutants regulated under the Clean Air Act, five are associated with the combustion of fossil fuels used in power plants. Reducing the prevalence of this method of electricity generation, such as through the RGGI program, is therefore accompanied by the significant co-benefit of decreasing human health risks from hazardous air pollutants.

6.3 Inequitable Economics

The GGRA legislation has numerous safeguards to protect Maryland jobs and economic prosperity at the State level, as well as some considerations for specific groups, listed below. Additional considerations have been made by the Maryland Department of the Environment (MDE) to examine the equity of plan's economic impacts, such

[124] Baltimore City Department of Public Works, "Sanitary Sewer Consent Decree Program," [Online]. Available: https://publicworks.baltimorecity.gov/sewer-consent-decree. [Accessed 22 October 2018].
[125] A. Coleman-Jensen, M. Rabbitt, C. Gregory and A. Singh, "Household Food Security in the United States in 2017," U.S. Department of Agriculture, Economic Research Service, 2018.
[126] S. L. Cutter, W. Solecki, N. Bragado, J. Carmin, M. Fragkias, M. Ruth and T. J. Wilbanks, "Chapter 11: Urban Systems, Infrastructure, and Vulnerability," in *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. Melillo, T. Richmond and G. Yohe, Eds., U.S. Global Change Research Program, 2014, pp. 282-296.
[127] These pollutants are mostly attributable to combustion of coal and oil specifically, rather than natural gas.
[128] National Center for Biotechnology Information, U.S. National Laboratory of Medicine. PubChem Database. <https://pubchem.ncbi.nlm.nih.gov/>
[129] U.S. EPA, "Hazardous Air Pollutants". <https://www.epa.gov/haps>

as analyzing the geographic distribution of changes, and impacts to vulnerable populations or historically disadvantaged communities.

- In general, COMAR Environment Article §2-1206 (8) requires that the plan produce a net economic benefit to the State's economy, and a net increase in jobs in the State.

- §2-1205 (f)(1) prohibits the GGRA plan from requiring greenhouse gas (GHG) emission reductions from the State's manufacturing sector, or otherwise causing significant cost increases in this sector, unless an existing law already requires such regulation. This is based on the finding in §2-1201 (10) and (11) that GHG emissions from the manufacturing and commercial services sectors are most effectively regulated on a national level, in order to maintain competitiveness with other states or countries and to preserve existing jobs in the State. Further, §2-1206 (8) requires that the plan ensure measures do not directly cause job loss in the manufacturing sector. These regulations help protect workers.

- §2-1206 (5) and (6) require MDE to ensure that the plan doesn't threaten the reliability and affordability of electrical service and statewide fuel supplies, and to consider whether it will increase electricity costs to consumers. The household energy burden is a significant issue for low- and moderate-income Marylanders.

- §2-1206 (8) requires MDE to ensure that the plan does not disproportionately impact rural or low-income, low- to moderate-income, or minority communities, or any other particular class of electricity rate-payer.

- This same section also requires the plan to encourage new employment opportunities in the State related to energy conservation, alternative energy supply, and GHG emissions reduction technologies.

6.3.1 The Energy Burden

According to a 2017 report (by Fisher, Sheehan and Colton), the nearly 220,000 households in Maryland that live at or below the federal poverty level spend at least 19 percent of their income on home energy bills alone, and those below 50 percent spend of the federal poverty level spend 36 percent[130]. As hotter summer temperatures increase peak cooling demand, an increased energy burden may lead low-income households to either reduce usage of air conditioning or to increasingly pull funds from other goods and services. Decreasing A/C usage during heat waves increases exposure to extreme heat; which, as previously discussed, increases the risk of cardiovascular impacts, especially for the very young or elderly populations. Increasing A/C usage to maintain a healthy indoor temperature during heat waves will inevitably increase the energy burden of that individual or family, and may bean they have less money to spend on healthy food, for example. Several energy programs in Maryland are specifically targeted to assist low-income households, both with direct bill payments and long-term solutions, and are discussed later in this chapter.

6.3.2 Jobs

While impacts on sectors such as agriculture, fisheries and tourism were discussed earlier in this report in terms of jobs and the economy, it must not be overlooked that negative impacts to these industries have a very real and direct impact to individuals and families whose livelihoods depend on their yearly success. If regions or communities become unfavorable for an activity or industry that was historically a large part of their economy, they may need to shift or diversify quickly to avoid substantial economic impact. In general, this is likely to be a disproportionate burden on rural communities, which tend to have less diverse economic portfolios[131]. This section

130 Fisher, Sheehan & Colton, 2017. The Home Energy Affordability Gap, 2016. <https://www.solarunitedneighbors.org/wp-content/uploads/2017/06/Maryland-2016-HEAG-Fact-Sheet.pdf>

131 D. Hales, W. Hohenstein, M. D. Bidwell, C. Landry, D. McGranahan, J. Molnar, L. W. Morton and M. Vasquez, "Chapter 14: Rural Communities," in Climate Change Impacts in the United States: The Third National Climate Assessment, J. Melillo, T. Richmond and G. Yohe, Eds., U.S. Global Change Research Program, 2014, pp. 333-349.

provides a few examples of equity concerns in sectors for which general impacts were discussed in more detail previously.

Agriculture is currently the largest commercial industry in the State, employing approximately 350,000 Marylanders[132]. In 2016, the average net income was only $42,091 *per farm*[132], meaning that impacts to productivity and yield will challenge already slim margins for farmers. Potential agricultural impacts due to climate change are broad and varied. They are caused by increased summer temperatures (affecting cooling costs, crop yield, animal mortality and milk production), and changes in the growing season and precipitation patterns (affecting what crops can be grown). Farmers on the Eastern Shore are additionally at risk from saltwater intrusion due to sea level rise and over-pumping of groundwater, and flooding during storm events. Farmers may be able to adapt in part to the impacts of climate change by exploring new crop options or adjusting management practices, but as the *Third National Climate Assessment* notes, "these adaptations are not cost- or risk-free"[133], and may be especially challenging for those who maintain orchards and vineyards, as these perennial crops represent a significant long-term investment. Though introducing varieties from other areas could be an effective form of adaptation, existing orchards and vineyards represent a significant investment, and replacing them with an entirely new stock may not be financially feasible.

The majority of the 5,195 direct employees of the forestry industry in Maryland reside in rural Garrett and Allegany counties[134]; and the forest products industry is the largest employer in these counties[135]. Forestry is also a major employer on the Eastern Shore, coming in second. This means that any changes in the productivity of the forestry industry are likely to have a disproportionate impact on communities and individuals in this area. For example, forestry on the Eastern Shore is likely to be impacted similarly to agriculture, with sea level rise and saltwater intrusion impinging upon suitable habitat.

Many tourist attractions in Maryland are regional activities: skiing, boating, and mountain scenery in the west; national sports, restaurants, and shopping in the cities; winery tours, fishing, and historic and natural history in the central and southern regions; and seafood, beaches, and marshlands on the Eastern Shore[136]. Maryland's lower-elevation ski resorts such as Wisp Mountain Park are just one example of a local tourism economy. Wisp is a four-season resort but more significantly a winter sports destination whose employment jumps from 220 to 600 during the winter ski season, ranking it among the top employers in Garrett County[137]. Though there have always been good and bad skiing seasons, and individually these are not specifically attributable to climate change, the inability to keep snow on the ground during unseasonably warm weather does demonstrate how important dependable cold weather is to the resort's seasonal functionality, which increasing global temperatures could debilitate. The resort is also a good example of how diversification may become significant, potentially increasing its attractions in the other three seasons to make up for lost revenue in winter. This year it advertised off-season events and activities such as golf, white water rafting, a beer and music festival, and Escape Games[138].

Certainly, new opportunities can arise due to climate change; however, as with many of the anticipated changes, the speed that they are occurring is the key factor. Adaptation at a matching pace could be challenging and not always entirely feasible, especially when considering the time and money invested, such as in equipment or training for a particular vocation. Efforts in mitigation are therefore required in addition to plans for adjusting to these changes, to reduce the extent and pace of adaptation that is needed and make it more manageable.

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[132] Maryland State Archives, "Maryland at a Glance: Agriculture," [Online]. Available: http://msa.maryland.gov/msa/mdmanual/01glance/html/agri.html. [Accessed 28 September 2018].

[133] R. Horton, G. Yohe, W. Easterling, R. Kates, M. Ruth, E. Sussman, A. Whelchel, D. Wolfe and a. F. Lipschultz, "Chapter 16: Northeast," in *Climate Change Impacts in the United States*, 2014, pp. 371-395.

[134] Maryland State Archives, "Maryland at a Glance: Forests," [Online]. Available: http://msa.maryland.gov/msa/mdmanual/01glance/html/forests.html. [Accessed 28 September 2018].

[135] U.S. Department of Agriculture, 2017. "2016 Forest Health Maryland: Highlights". <https://www.fs.fed.us/foresthealth/docs/fhh/MD_FHH_2016.pdf>

[136] Maryland Office of Tourism Development, "Visit Maryland," 2017. [Online]. Available: http://www.visitmaryland.org/. [Accessed 28 September 2018].

[137] Maryland Department of Commerce, "Brief Economic Facts: Garrett County, Maryland," 2018.

[138] Wisp Resort, "Mountain Message Blog," [Online]. Available: https://www.wispresort.com/Blog/. [Accessed 28 September 2018].

6.4 Equity in the 40 by 30 Plan

The State gives full consideration to climate change impacts as they relate to community concerns, and engages this issue through multiple avenues, including the legislation of the GGRA, the Commission of Environmental Justice and Sustainable Communities (CEJSC), and the Maryland Commission on Climate Change (MCCC). Input and advice from vulnerable communities will be sought on this published draft of the GGRA Plan, in order to ensure that the concerns of all Maryland stakeholders have been considered. Other specific examples of community outreach activities that the State is engaged in can be found in section 6.5 of this report.

There are numerous safeguards in the Code of Maryland Regulations (COMAR) related to the GGRA, which specifically address considerations for a variety of vulnerable populations and historically disadvantaged communities that have been evaluated. These include consideration of the impacts of implementation of the 40 by 30 Plan may have on: electricity costs; the availability of reliable and affordable electrical service and fuel supplies; the State's agricultural and manufacturing sectors; and rural or low-income, low- to moderate-income, or minority communities. Specific protections related to public health, jobs, and the economy are discussed earlier in this chapter.

6.4.1 Modeling Equity

While equity cannot be completely captured using quantitative modeling, and modeling is unavoidably limited by monetary and financial restraints, MDE did include specific parameters and analyses for the purpose of evaluating the distribution of potential health and economic impacts. Some of the economic parameters evaluated in the modeling included average job growth, cumulative personal income growth, and cumulative gross state product. MDE modeled how job losses or gains would be distributed among various jobs based on type (construction; sales; transportation; management, business and financial; and maintenance and repair), wages (low wage, medium wage, and high wage jobs), required education /training (a range from low to high, labeled zones 1-5), and distribution across racial and ethnic groups (white non-Hispanic, black or African American, Asian, Hispanic, and other). This was done for each of the policy scenarios modeled, and allowed for comparison of the scenario outcomes through an equity lens.

6.4.2 State Programs

The GGRA Plan has multiple objectives beyond reducing GHG emissions, intended to balance costs and complement benefits to produce positive results for Maryland overall. As mentioned earlier in this chapter, the way that equitable actions are implemented within policies and programs is complex, but critical to achieving our goals of holistic and sustainable climate action. The programs that form the *2019 GGRA Draft Plan* are managed by numerous State agencies, including the Departments of the Environment, Natural Resources, Planning, Housing and Community Development, General Services, and Agriculture, as well as the Maryland Energy and Insurance administrations. The following examples illustrate how equity considerations have been incorporated into specific programs under the *2019 GGRA Draft Plan*.

Energy Programs

RGGI works to continually reduce CO_2 emissions from certain electric generating units (EGUs) through a cap-and-invest program. One indirect benefit of this program is the reduction of co-pollutants from fossil fuel combustion, such as particulates and tropospheric ozone. The program's design allows for trading among EGUs, and therefore does not manage the distribution of co-pollutant emissions. While not inherently inequitable, it does allow for potential creation or exacerbation of pollution 'hotspots' in historically disadvantaged communities[139].

[139] Skeo Solutions and Town Creek Foundation, 2015. "Planning for Climate and Energy Equity in Maryland". <http://mdehn.org/wp-content/uploads/2016/03/Planning-for-Climate-and-Energy-Equity-in-Maryland-Final-12-30-2015-3.pdf>

Additionally, since the controls only apply to those units over 25 MW, the RGGI program does not target peak polluters who may emit both CO_2 and co-pollutants in certain areas during periods of high demand, such as the summer months. These equity considerations are, however, addressed by permitting at individual plants, which also accounts for other regulations such as those meant to limit tropospheric ozone formation.

A suite of loan and grant programs fund energy conservation and efficiency projects for Maryland homeowners, renters, and other building owners. These programs (explored in more detail in Chapter 4), are designed to reduce energy costs and address critical health and safety issues for Maryland residents and limited income families. Two programs are specifically targeted at low-income households. The *Weatherization Assistance Program* installs energy conservation measures for limited income households with funding from the U.S. Department of Energy and Maryland's Strategic Energy Investment Fund (SEIF). *EmPOWER Maryland* uses funding from participating utilities to help limited income households and affordable housing managers install energy conservation measures, as well as for direct bill assistance. Energy efficiency measures help reduce total household energy usage, thereby decreasing electrical bills and the energy cost burden for low-income families.

Maryland began a three-year *Community Solar Pilot Program* in 2018[140]. Community solar expands the benefits of access to renewable energy to individuals who do not own land or rooftop space, or may not be able to cover the up-front costs of a complete installation, allowing them to buy a share of the electrical output from a solar energy generating system located elsewhere in their service area. Furthermore, a portion of the program is restricted to projects that serve a significant percentage of low- and moderate-income customers. In the first year of the pilot program, BGE alone had over 10 MW of capacity approved for solar projects serving low-/moderate-income customers[141]. Most of the solar arrays planned under the pilot program are still under development, and applications have started to be submitted for year two; benefits are anticipated after the projects come online, and are expected to accrue long-term.

Recent updates to the Maryland Renewable Portfolio Standard (RPS) include the following considerations for environmental equity: (1) The bill provides for workforce development and job creation by establishing a Clean Energy Workforce Account, which would be used to invest in pre-apprenticeship, apprenticeship, and other similar programs to establish career paths in the clean energy industry. (2) The bill supports certain historically disadvantaged group by allocating a specific amount of funding for small, minority, women, and veteran owned businesses in the clean energy industry. (3) The bill provides for the support of low-income residents by requiring certain compliance fees to only be used for loans and grants to support the creation of Tier 1 or new solar energy sources that are owned by or directly benefit low-income residents. (4) The bill supports local jobs by specifying that at least 80 percent of workers participating in a project/program that receives money from the fund must reside within 50 miles.

Transportation Programs

Motor vehicle emission and fuel standards can help protect air quality, especially in historically disadvantaged urban populations. The *Clean Cars Program* requires a reduction in volatile organic compounds, nitrogen oxide (NO_X), and CO_2, helping to limit both GHGs and the formation of ground-level ozone (or smog), which is hazardous to human health. Similarly, the National Fuel Efficiency and Emission Standards help to reduce emissions and improve fuel efficiency in a variety of vehicle types and model years. Other sources of concern include marine ports, rail yards, freight transport facilities, and interstate trucking routes, which expose neighboring communities to harmful diesel emissions, including particulate matter[139]. Since diesel engines can operate for decades, the turn-over rate is low and it will take some time before new vehicle emission standards

[140] Maryland Public Service Commission, 2018. <https://www.psc.state.md.us/electricity/community-solar-pilot-program/community-solar-pilot-program-frequently-asked-questions/>

[141] Baltimore Gas and Electric, 2018. "BGE Community Solar Pilot Program". <https://www.bge.com/SmartEnergy/InnovationTechnology/Pages/BGECommunitySolarPilotProgram.aspx>

make any impact. Maryland's anti-idling campaign, *Idle Free MD*, works to reduce these emissions along freight transportation corridors.

Land Use and Conservation Programs

Maryland aims to manage its forests in a way that both serves carbon sequestration goals and supports the local communities that depend on forestry for their economy. In the long-run, these goals are parallel, since greater global warming is more likely to have devastating effects on the Maryland forest ecosystem[142]. An analysis published in 2018 by the BEACON institute of Salisbury University entitled *The Impact of Resource Based Industries on the Maryland Economy* demonstrates that in 2015 the forest industry contributed $3.5 billion annually to Maryland's economy, and $133 million in state and local tax revenue, making it one of the largest contributors. This analysis also found that the forestry industry supports over 15,000 jobs.

Maryland works to promote the preservation and restoration of forested, grassed, and wetland areas on agricultural land. This is mainly accomplished through POS, RLA, MALPF and CREP. MALPF helps preserve the economic functionality of rural lands by establishing permanent easements to maintain prime farmland and woodland as a viable local base of food and fiber production. CREP offers rental payments and other incentives for protection of land, wildlife habitat, and improvements that reduce nutrient and sediment loss.

Among the tree-planting programs in Maryland, the urban tree canopy provides health benefits, relief from the summer heat, and energy savings to those communities. According to the Maryland Department of Natural Resources (DNR), urban forests also provide benefits such as recreation, aesthetics, wildlife habitat, stormwater management, carbon storage, air pollution reduction, and social benefits[143,144]. Research since the early 90s[145] has confirmed this wide variety of benefits, and thus the critical question moving forward is how to execute a program that provides for the equitable distribution of the benefits.

Thirty-six communities in Maryland have committed to participating in the Urban Tree Canopy goals, including Baltimore City, Cumberland, and Greenbelt[146]. These goals are accomplished through several programs, including *Tree-Mendous Maryland* (run by the Maryland Forest Service), which has a goal of providing Maryland residents access to affordable trees to plant on public lands such as parks, schools, roadways and more[147]. The DNR annual report also lists the *MUCFC Grants Program*, which provides grants to groups such as schools, service organizations, and volunteer-based groups to plant trees on public lands in parks, metropolitan areas, cities or towns through Tree-Mendous Maryland[148].

Per EPA, *Smart Growth* programs can help address the environmental, health, and economic disparities experienced by historically disadvantaged communities[149]. Such programs focus funding on reinvesting in existing neighborhoods. Since 1997, the State has focused investment in infrastructure and growth-related needs to designated Priority Funding Areas (PFAs); and FY18, 74 percent of growth-related spending occurred in PFAs[150]. Furthermore, there are protections in place to grant exemptions, which would allow funding of projects outside the PFA, if "failure to fund the project in question creates an extreme inequity, hardship, or disadvantage that clearly outweighs the benefits from locating a project in a PFA"[150].

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[142] MCCC 2018 Report
[143] Maryland Department of Natural Resources, 2018. "Urban & Community Forestry". <https://dnr.maryland.gov/forests/Pages/Urban-Community.aspx>
[144] Maryland Department of Natural Resources, 2018. "Maryland Roadside Tree Law". <https://dnr.maryland.gov/forests/Pages/programapps/newrtlaw.aspx>
[145] F. Dwyer, John & Mcpherson, E & Schroeder, Herbert & A. Rowntree, Rowan. (1992). Assessing the benefits and costs of the urban forest. J. Arbor.. 18.. <https://www.researchgate.net/publication/241215157_Assessing_the_benefits_and_costs_of_the_urban_forest>
[146] Maryland Department of Natural Resources, 2018. "Chesapeake Bay Urban Tree Canopy Goals". <http://dnr.maryland.gov/forests/Pages/programs/urban/treecanopygoals.aspx>
[147] Maryland Department of Natural Resources, 2018. "Tree-Mendous Maryland". <https://dnr.maryland.gov/forests/Pages/treemendous/default.aspx>
[148] Maryland Department of Natural Resources, 2018. "MUCFC Grants Program". <https://dnr.maryland.gov/forests/Pages/programs/urban/mucfcgrant.aspx>
[149] U.S. EPA, 2018. "Smart Growth and Equitable Development". <https://www.epa.gov/smartgrowth/smart-growth-and-equitable-development>
[150] Maryland Department of Planning, 2019. "Implementation of the Smart Growth Areas Act, Fiscal Year 2018". < https://planning.maryland.gov/Documents/OurProducts/Publications/OtherPublications/2018-smart-growth-implementation-report.pdf>

Agricultural and Food Programs

The main equity consideration for the *Buy Local for GHG Benefits* program is ensuring equal access to fresh, healthy food, including organically grown produce. The State works with farmers, local governments, restaurants, food distributors and retailers, value-added producers, public and private institutions, and trade associations to maintain and expand its Buy Local program. Currently, MDA has largely achieved its goal of increasing the number of farmers markets by 20 percent from 2012 by 2020, and has met the goal of having at least one market located in every Maryland county and Baltimore City[151]. MDA participates in a number of programs that provide financial assistance to help purchase the fresh fruits, vegetables, and other farm products available. USDA's *Farmers Market Nutrition Program* provides financial assistance to low-income senior residents and WIC participants for the purchase of fresh produce. All Maryland farmers markets participate in this program, and approximately one third also participate in the USDA's *SNAP Program*. The *Maryland Market Money Program* offers additional spending dollars to those using the USDA benefits at 17 participating markets, matching from $5 to $20 per week based on available funding[152]. Low-income residents can also make purchases using electronic benefit transfer cards and, point-of-sale machines installed at farmers markets for this purpose. Funding and other maintenance of all these programs are critical parts of ensuring equitable access to the benefits provided by the Buy Local for GHG Benefits program.

Buying local generates more jobs and wealth in farm community economies and helps to reduce secondary pollutant emissions from long-distance transportation[153]. It also provides specialty markets for growers outside of the major grain crops, increases agro-biodiversity, and encourages beneficial environmental practices.

Jobs Programs

Equity considerations for job creation and economic development are related to the impacts of both climate change and climate change mitigation on communities who depend on specific sectors that are being impacted. The main mitigation-based example is ensuring a 'just transition' for workers and communities dependent on the fossil fuel industry. Though some jobs will be created in the green energy fields, these are not inherently of the same quality, in the same location, or otherwise accessible to the displaced workers. Therefore, a just transition will require workforce development and job training programs in alternative in-demand fields that are or will be made accessible to affected communities. This subject is covered in more detail in Chapter 7.

One example of how Maryland is preparing for this transition is through the *P-TECH Program*, which provides a no-cost, six-year education (from high school to career) for students in the State's most economically underperforming areas[154]. The holistic program, co-developed by New York State and IBM, is made possible through public-private partnerships, including support from local high schools, community colleges, and businesses[155]. Graduates obtain both a high school diploma and an Associate Degree in applied science, engineering, computers, and other STEM disciplines[154]. First launched at two Baltimore City schools during the 2016-2017 school year, Maryland's P-TECH program expanded to five additional schools in 2018.

Adaptation Programs

While not explicitly a component of reducing GHGs, adaptation to the consequences of climate change is an integral part of Maryland's overall plan to address climate change. As stated in the 2018 report from the MCCC,

[151] Maryland Department of Agriculture, 2018. "2018 Maryland Farmers Market Directory". <https://mda.maryland.gov/maryland_products/Documents/2018_Farmers_Market_Directory.pdf>
[152] Maryland Hunger Solutions, 2018. "With Maryland Market Money, SNAP, WIC-FVC, and FMNP Go Further at Farmers Markets". <http://www.mdhungersolutions.org/farmersmarkets/index.shtm>
[153] Maryland Commission on Climate Change, 2017. "Why Does Buying Local Matter: How buying local benefits all of Maryland". <https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Publications/FactSheet6BuyLocal.pdf>
[154] Maryland Chamber of Commerce, 2018. "P-TECH". <https://mdchamber.org/p-tech/>
[155] Maryland Public Schools, 2018. "Maryland P-TECH Sites". <http://www.marylandpublicschools.org/programs/pages/ptech/pilot.aspx>

"although successful mitigation can greatly reduce the risk of climate impacts, it will not eliminate the impact completely. Some changes are already underway, and the response of the environment to current levels of anthropogenic GHG emissions is still being realized."[156,157,158,159,160] Furthermore, even if Maryland were to affect zero net emissions tomorrow, significant reductions are still needed globally to slow and halt the progress of global climate change. Therefore, adaptation to expected impacts is critical to the health and safety of Marylanders, as well as their economic prosperity and overall well being.

Some overarching equity components of adaptation include ensuring economic diversification and access to jobs in areas where single sectors dominate and are expected to be negatively impacted, and/or adapting this sector to increase its resilience; ensuring access to healthcare to address the amplified or changing health impacts associated with climate change; ensuring relocation or other structural changes are economically feasible where necessary for coastal or riverine residential and commercial buildings; ensuring transportation and its infrastructure are able to effectively maintain their necessary functions in all communities, especially those in rural locations where there may only be one major route; and ensuring basic access to water, electricity, and other essential resources that may be threatened by climate change. Many of these impacts are discussed in the sector-specific segments of this report.

Much of Maryland's initial progress in adaptation had been focused on the coastal regions of the state, as these communities are apparently and directly vulnerable to changes in sea level rise and storm surge. This approach has broadened significantly over 2017-2018, as measures were taken in the fields of public health, transportation, and more. Several new and ongoing programs to address adaptation are highlighted in section 3.3 of the 2018 report from the MCCC[142].

6.5 Agency Outreach Efforts with Underserved Communities

6.5.1 Maryland Department of the Environment (MDE)

MDE is working to build partnerships with communities and other stakeholder groups interested in improving air quality and making progress to address climate change. To accomplish this, MDE is coordinating with the MCCC, the Commission's Education, Communication & Outreach Working Group (ECO), and Commission on Environmental Justice and Sustainable Communities (CEJSC). Developing these partnerships results in awareness of our role in improving air quality and addressing climate change, identifies new roles for communities, and creates partnership opportunities for collaborative projects.

A thorough list of community meetings that have occurred in the past two years can be found at: http://mde.maryland.gov/programs/Air/Pages/CommunityMeetings.aspx.

ARA plans to continue building these partnerships and is open to opportunities to establish new relationships with communities and other stakeholder groups. Additionally, these relationships will allow MDE to share this draft plan with stakeholders at various meetings across the state.

[156] Intergovernmental Panel on Climate Change, Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, R. Pachauri and L. Meyer, Eds., Geneva, 2014.
[157] U.S. Global Change Research Program, Climate Science Special Report: Fourth National Climate Assessment, Volume I, D. Wuebbles, D. Fahey, K. Hibbard, D. Dokken, B. Stewart and T. Maycock, Eds., Washington, DC, 2017, p. 470.
[158] Intergovernmental Panel on Climate Change, "Summary for Policymakers," in Global Warming of 1.5°C, 2018.
[159] J. Hansen, L. Nazarenko, R. Ruedy, M. Sato, J. Willis, A. Del Genio, D. Koch, A. Lacis, K. Lo, S. Menon, T. Novakov, J. Perlwitz, G. Russell, G. A. Schmidt and N. Tausnev, "Earth's Energy Imbalance: Confirmation and Implications," Science, vol. 308, pp. 1431-1435, 2005.
[160] D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, B. DeAngelo, S. Doherty, K. Hayhoe, R. Horton, J. P. Kossin, P. C. Taylor, A. M. Waple and C. P. Weaver, "Executive Summary," in Climate Science Special Report: Fourth National Climate Assessment, Volume I, D. Wuebbles, D. Fahey, K. Hibbard, D. Dokken, B. Stewart and T. Maycock, Eds., Washington, DC, U.S. Global Change Research Program, 2017, pp. 12-34.

Factsheets on Climate Change

During 2017 and 2018, MDE developed factsheets for six climate change topics that impact to Maryland. The topics include: Addressing Climate Change in Maryland, Maryland is Planning for Sea level Rise, Maryland's GGRA, Responding to Health Impacts of Climate Change, Increasing Resilience to Climate Change, Buying Local and Climate Change. The factsheets are available to citizens on the MCCC website, at events and festivals state agencies attend, and in state agency offices. They have reached over 1,000 stakeholders. The factsheets are well received at events and have encouraged stakeholders to recognize the impacts of climate change in their communities. MDE has also developed a poster that highlights the most important facts from the factsheets.

Idle free MD

Throughout 2018, MDE has worked extensively to develop and Idle Reduction Program for Maryland. The purpose of this program is to create awareness about the benefits of idle reduction. These efforts have included developing outreach material for all key components of the idle reduction program: a new webpage with sections devoted and aimed at each of the three pillars of this program, material that has been distributed at various outreach events, and implementing a successful social media presence. In addition to these efforts, EcoLogix has worked to identify and establish key partnerships with the community and industry. More information can be found in the Idle Free Maryland program (Section 4.5.9).

Climate Ambassadors - Pilot Program

Overview

The Climate Ambassador Pilot Program is an effort to educate key stakeholders on climate change, and the important actions Maryland is taking to address climate issues, in a way that allows these stakeholders to educate others on the same issues. In 2016, the ECO Working Group of the MCCC identified the need for a voluntary program that allows for education and training on the causes of climate change, its consequences, and actions that can be taken at the local level. The program trains Climate Ambassadors on climate science and how to inform others of climate change and the adaptation and mitigation measures the state is using to address the issue.

Programmatic Approach

In 2018-2019, MDE, in partnership with Maryland Delaware Climate Change Education Assessment and Research center (MADE CLEAR), implemented the initial pilot Climate Ambassadors training program with Bon Secours Community Works in West Baltimore. The curriculum is designed to train stakeholder participants around locally specific climate change concerns, impacts, and action steps. A "train the trainer" approach is used so that individuals can train and educate others, particularly among their peers. This approach encourages information sharing throughout communities and strengthens climate change action in Maryland. Individuals that become Climate Ambassadors are recognized for their participation.

The program endeavors to provide a deep knowledge base on climate change that reflects the interest of the community or organization receiving the training. The Climate Ambassador program can provide training on a variety of issues, including, but not limited to changing climate patterns, health impacts, social and economic impacts, equity, policy implications, and job creation. Specific frameworks and lessons learned will be shared between the Climate Ambassador Programs. The ECO Working Group serves as a conduit for this information sharing.

The development and implementation of Climate Ambassador Programs are supported by various agencies, including MDE, MDH and DNR, through their existing stakeholder engagement efforts. In addition, community

organizations, nonprofits, and environmental advocacy programs have shown interest in the training. MADE CLEAR has also played a key role in the Ambassador program.

Additionally, MDE has also engaged with the Executive Director of SAFE Alternative Foundation for Education to implement a Climate Ambassador Program for their students. MDE has conducted extensive outreach in underserved communities to identify opportunities to further implement the Climate Ambassador Program. MDH is also implementing a Community Ambassador program in Prince George's County tailored to middle and high school students.

Building Community Partnerships

MDE's Air & Radiation Administration (ARA) is working to build partnerships with communities and other stakeholder groups interested in improving air quality and making progress to address climate change. To accomplish this, MDE is coordinating with the MCCC, the Commission's Education, Communication & Outreach Working Group (ECO), and CEJSC. Developing these partnerships results in awareness of our role in improving air quality and addressing climate change, identifies new roles for communities and creates partnership opportunities for collaborative projects.

ARA plans to continue building these partnerships and is open to opportunities to establish new relationships with communities and other stakeholder groups. If your organization would like to meet with MDE about climate change and air quality, please email climate.change@maryland.gov. For information on individual partnership meetings, please see: http://mde.maryland.gov/programs/Air/Pages/CommunityMeetings.aspx

Partnership Activities

Turner Station Conservation Teams - Topic: Maryland's air quality and activities of the MCCC.
Outcome: Attendees provided feedback on increased flooding in their community that may be related to climate change and their interest in more localized air monitoring and diesel emission reduction opportunities. Discussions continue.

St. Helena Community Association/St. Helena Neighborhood Association/Old Dundalk Neighborhood Association - Topic: Maryland's air quality and activities of the MCCC.
Outcome: Attendees provided feedback on air quality and climate change. Discussion on diesel emission reduction partnership opportunities is ongoing.

Safe Alternative Foundation for Education (SAFE) - Topics: SAFE, a charitable foundation that provides after school and summer programs for middle school students in West Baltimore and the relationship of clean energy with improved air quality.
Outcome: Continued dialogue on potential collaborative partnerships to assist SAFE's students.

Bon Secours Community Works - Topic: MCCC initiatives, air quality/energy related issues, and potential partnership opportunities.
Outcome: MDE and MCCC representatives have worked with Bon Secours to develop a pilot Climate Ambassadors Program to train people to discuss climate change. Initial trainings are happening now.

Greater Baybrook Alliance (GBA) - Topic: Air and energy related concerns of residents in the Curtis Bay, Brooklyn and Brooklyn Park neighborhoods.
Outcome: After an initial meeting with leadership, the ARA Director and members of his staff attended GBA's Steering Committee meeting to provide an overview of Maryland's climate change and air quality programs, including a description of progress made and challenges ahead. Potential diesel emission reduction partnership also discussed.

Pasadena Area Communities – Topic: New sulfur dioxide (SO2) air quality standard and activities of the MCCC.
Outcome: Ongoing discussions of SO2 issues and citizen science monitoring projects.

Baltimore Port Alliance (BPA) - Topic: Potential partnerships on air quality improvement projects, including diesel emission reductions.
Outcome: ARA toured Port terminals with a variety of stakeholders to build awareness of Port operations and actions being taken to address air quality. Updates on the status of the VW Settlement Fund have been provided.

MD Chamber of Commerce - Topic: Ideas for the proposed Climate Champion Program and opportunities for partnerships with the Chamber's Energy and Environment Committee.
Outcome: The Climate Champion Contest via the Maryland Green Registry is now open. (http://bit.ly/2FfYYgN).

North Point Peninsula Community Coordinating Council - Topic: Maryland's air quality and activities of the MCCC.
Outcome: Attendees provided feedback on local air quality issues. Continuing discussions of partnership opportunities focused on diesel emission reductions and other air quality issues.

Inter-Agency Port Workgroup (MDE, MDOT and MDOT MPA) - Topic: Actions to implement the Port of Baltimore Voluntary Air Agreement to help improve air quality.
Outcome: Monthly meetings with the Maryland Port Administration (MDOT MPA) and the Maryland Department of Transportation (MDOT) resulting in an increased understanding of respective agency roles and responsibilities related to air quality and collaborative approaches to address citizen and advocacy group concerns. To date, over $2 million has been invested into diesel emission reduction activities around the Port.

Diesel Roundtable - Topics: (1) Detailed information on the technologies and grant programs available to reduce diesel emissions and progress made in achieving reductions and the challenges ahead. (2) The VW Settlement Fund process and the types of projects the fund may support.
Outcome: Continued dialogue with stakeholders that do not often come together, including community members, business representatives, advocacy groups, State and local agency personnel, and other stakeholders.

Dundalk Renaissance Corporation (DRC) - Topic: Community outreach and partnership opportunities.
Outcome: Ongoing discussions of diesel clean-up and other partnership opportunities with local community associations and schools.

Curtis Bay (several small group meetings) – Topic: Air quality, municipal waste combustors and climate change.
Outcome: Continued discussion on partnership opportunities. Broader meeting planned for 2018.

Maryland Community of Communities - Topic: Air quality and climate change concerns, other issues of interest and opportunities to work collaboratively.
Outcome: Continued discussions on a variety of air quality topics, including a citizen science monitoring partnership.

Maryland Environmental Health Network - Topic: Air quality and climate change concerns, other issues of interest and opportunities to work collaboratively.
Outcome: Continued discussions on a variety of air quality topics.

Frostburg State University - Topic: Panel discussion on climate change with an emphasis on State agency roles and actions being taken and additional briefings to university climate action team.

Outcome: The students were very engaged and developed an increased awareness of actions being taken in Maryland to address climate change. Additional engagement in western Maryland is planned.

HY-TEK Pilot Plant at Back River Wastewater Treatment Plant- Topic: Tour plan that uses a strain of algae to capture GHG

UMBC – Topic: Panel discussion on climate change to an upper-level public policy class
Outcome: An engaging conversation with students who are interested in climate policy.

Baltimore Industrial Group – Topic: Air quality, air policy and regulations, and the MCCC.
Outcome: Continued discussion on air quality improvements and efforts to share information with stakeholders

Baltimore Port Alliance – Topic: Air Quality and climate change, the GGRA, and Climate Champions
Outcome: Continued discussion on Maryland's climate efforts

6.5.2 Maryland Department of Transportation (MDOT)

MDOT's public outreach around climate change is directly linked to the efforts on encouraging the use of electric vehicles (EVs). MDOT works in coordination with the EVIC Communication Committee, the Maryland Energy Administration (MEA), and MDE to increase PEV awareness focused on workplace charging, vehicle dealership, and public education. These efforts have included presenting EV materials to 10,000 Marylanders, workplace charging workshops, and presenting at community events. This has also led to a new EVIC website with interactive information about where outreach has occurred and is planned for the future. More information can be found at MarylandEV.org.

6.5.3 Maryland State Department of Education

The primary 'outreach' on climate change is connected to the Next Generation Science Standards inclusion of performance expectations, specifically related to climate change. MSDE had partnered with MADE CLEAR during the project.

http://www.nextgenscience.org/ (this is the website for access to NGSS)
http://marylandpublicschools.org/about/Pages/DCAA/Science/index.aspx
https://madeclear.org/

6.5.4 Maryland Department of Health

The Maryland Department of Health has a robust outreach program, undertaken by the Maryland Climate Change and Health Adaptation Program (MCCHAP) and funded by the Centers for Disease Control (CDC).

These efforts have included:

Building Resilient Communities Stakeholder Forum

– December 2016 – MDH and University of Maryland School of Public Health – Maryland Institute for Applied Environmental Health (MIAEH) co-hosted a community centered forum, which provided data, information and climate and health connections to 80+ community members. We then solicited their feedback and experiences on the same topics.

Strong City Baltimore Neighborhood Summit

– April 14, 2016 – MCCHAP and the Maryland Environmental Tracking Portal led a workshop on the EPHT data portal and covered how to use the data on environmental and health indicators to enhance their understanding and inform actions.

Ongoing

1. Presentations on climate and health connections and the program actions. A few previous presentations took place at the following meetings or conferences: Weather It Together (Annapolis), Hood College, Delaware Climate and Health Conference, 2017 National Health Outreach Conference, Baltimore Leadership Coalition, DNR Brown Bag, A Conversation about Health Equity Conference.
2. Website (here): with resources, presentations and tools.
3. Community Ambassador Pilot Program – an in-development pilot program to engage, educate and EmPOWER youth to take action on climate considerations in their immediate communities (home, school, church, etc.).
4. University of Maryland Extension Partnership – through a partnership with the University of Maryland Extension program, MCCHAP is co-developing training curriculum for two groups of individuals, extension educators and community health workers. The goal is to strategically inform and train up those individuals on climate change concerns in Maryland and how they impact their patients or students. We are implementing a train the trainer approach. For this curriculum, we have brought in experts in both the emergency preparedness and chronic disease management bureaus to ensure we cover all climate and health concerns of Marylanders.

Planned

1. Urban Heat Island Citizen Science Mapping – August 2018 – MCCHAP is part of a team led by the Science Museum of Virginia to use citizen scientists, community organizations and anyone interested in the area, to collect data via the validated methodology to map urban heat islands. The date is TBD, because the weather forecast has yet to cooperate. The data will be used to inform where urban heat islands are, and hopefully influence interventions to reduce their impact, which will enhance climate resilience.
2. 2018 Building Resilient Communities Stakeholder Forums – October/November 2018 – we are replicating the approach from the 2016 community forum, this time hosted in western Maryland and Eastern Shore.
3. Development and release of two climate and health PSAs with accompanying outreach activities – in the next year, MDH plans to develop and release two climate related PSAs for vector borne illness protection and asthma and air pollution.

6.5.5 Maryland Department of Planning (MDP)

MDP reviewed comprehensive plans for Maryland's 23 counties and Baltimore City to determine how the current plans are addressing worsening hazards due to climate change. This research was done to assist DNR in determining local capacity for climate change adaptation planning.

Three levels of review were completed:

1. To determine what jurisdictions specifically mentioned climate change and/or the effects of climate change (Planning identified 15 counties and Baltimore City);

2. Of these 16 jurisdictions, the plans were reviewed to determine what general climate change terms were used – 12 specifically stated climate change, 14 noted sea level rise and one identified coastal resiliency; and

3. To identify what specific hazards were included and whether it was mentioned with a direct or indirect reference to climate change.

This analysis will assist DNR and MDP in developing regional meetings to solicit local and regional climate adaptation priorities and support local adaptation efforts as recommended by the Climate Change Commission. The regional meetings are intended to offer scientific, technical, logistical and planning resources that provide climate change adaptation planning assistance and that capitalize on existing engagement efforts and regional bodies or organizations.

6.5.6 Maryland Department of Natural Resources

At DNR, education, outreach, monitoring and research are all priorities in our climate change efforts.

DNR's climate efforts include:

Climate Leadership Academy:

The Maryland Climate Leadership Academy is the nation's first state-led program aimed at helping community leaders, critical infrastructure, local governments and state agencies effectively plan for and implement climate change initiatives. The Maryland Climate Leadership Academy's first cohort began in November with a three-part series offered at community college and university campuses across the state. Each course provides participants with critical training on climate preparedness, economic impacts, energy and water management, entrepreneurship, governance and risk management. This series of courses is designed for executive and senior staff in both the private and public sectors. The state has engaged the Association of Climate Change Officers, a professional society and credentialing body, to administer and develop programming for the Maryland Climate Leadership Academy. The association is leveraging its existing education and training curriculum and making its existing and future credentialing programs available to academy participants. Additional certificate programs, online education resources and workshops will also be announced later this fall. Additional information about the Maryland Climate Leadership Academy is available at: MDClimateAcademy.org. This program has now completed four cohorts and two more will be held in the fall of 2019.

Clean Marinas:

Last winter at DNR's annual Clean Marina workshops, DNR provided materials on resiliency to climate change and severe weather impacts to marinas. Insurance experts also talked about the impact that extreme storms in the south in 2017 had on marinas, and what impacts Maryland marinas and boats experience during typical and atypical storms.

A section has been added to DNR's Clean Marina web page dedicated to resiliency. http://dnr.maryland.gov/boating/Pages/Hurricane-Storm-Preparations.aspx

Center for Conservation Education and Stewardship:

Shoring Up Resiliency Through Education (SURE)

This Somerset County project aims to support Somerset County Public Schools in addressing regional vulnerability to climate impacts and community resilience through understanding how environment, science, and

cultural heritage work together to strengthen a community. Students in fifth, seventh, and ninth grades experience, study and understand trends in local conditions such as weather and water quality that affect the natural resources, upon which much of their local economy depends. Participating teachers received professional development, and have begun to write lessons to support this project. This project is in development. DNR's partners include the Maryland Department of Health, and Somerset County Public Schools.

Conferences

DNR participated in multiple public speaking opportunities regarding climate communication, throughout the year for general audiences. This included a presentation at the Eastern Shore Land Conservancy's Culture and Climate Change Conference. Additionally, conferences were held for teachers, including one hosted by the Maryland Association for Environmental and Outdoor Education (MAEOE), where lessons were presented on understanding climate. Partners included NOAA, Maryland Audubon, and Partners Advancing Climate Change Education.

Aquatic Resources

DNR has incorporated Climate Change Education into Project WET (Water Education for Teachers) Educator workshops, WOW! The Wonder of Wetland Workshops, and Invasive Species Workshops.

Maryland Park Service:

DNR's Maryland Park Service has incorporated climate change education into its programs, including training and awareness for staff. For example, park rangers attended a day long Climate Change Academy in 2015 hosted by MADE CLEAR (Maryland and Delaware Climate Change Education, Assessment, and Research). In addition, DNR's Chesapeake & Coastal Service provided all park managers with climate change awareness training. Climate change themes are incorporated in Meaningful Watershed Educational Experiences programming, Scales and Tales outreach and nature centers in state parks, which reach tens of thousands of students and visitors.

Resource Assessment Service:

Based on climate change projections, Maryland's streams are likely to become warmer and the flows are likely to become more extreme. Some coastal streams could also become inundated as a result of sea level rise. These changes may alter the ecology, water quality, and physical habitat of streams. DNR's Maryland Biological Stream Survey (MBSS) tracks trends in factors such as aquatic species distributions, water temperature, and erosion that are indicators of potential climate change influences on Maryland's streams. Based on temperature and species distribution information, the MBSS has also specifically identified stream animals that prefer cold water and, as a result, may be particularly sensitive to stream temperature increases. Detailed stream temperature information from the MBSS may also help identify streams with particularly cold water and thus are likely to be resilient to temperature increases.

In addition to representative sampling of Maryland's streams, the MBSS has been monitoring 29 "Sentinel" streams since 2000 to specifically examine for potential influences of factors such as climate and weather on Maryland's stream ecology, temperature, water quality, and physical habitat. For more information - http://dnr.maryland.gov/streams/Publications/2014SentinelSiteReportWEB.pdf.

Since 2000, along with biological, water quality, and habitat data, the MBSS has deployed data loggers in thousands of streams that measure the water temperature throughout the summer. These data are useful for determining habitat for stream biota and for tracking stream temperature conditions. From 2014 to 2018 the MBSS returned to about 200 streams where initial sampling occurred 14 years ago to help represent the condition of Maryland's streams at that time. The data from this repeated survey will be used to evaluate change over time in the factors measured. For more information, please visit: http://dnr.maryland.gov/streams/Pages/round4.aspx

DNR's Maryland Biological Survey also participated in EPA's Regional Monitoring Network (RMN) and assisted EPA with determining temperature sampling protocols for this network. The goal of the RMN project is to partner with state agencies and select stream sites that can be sampled to establish a long-term record of biological and physical parameters that can be used to assess the vulnerability and response of these streams to climate change. For more information - https://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=30797

Since 1986, Maryland's ambient water quality monitoring program has measured water quality from more than 120 locations in Chesapeake Bay, Coastal Bays, and non-tidal large rivers on a monthly basis. This sampling is used to determine trends in conditions for nutrients, temperature, and other water quality-related factors that could be influenced by climate change. Benthic macroinvertebrate samples have also been collected from select large rivers and used to track biological changes over the more than 30-year period.

DNR also partners with USGS for tracking stream and river flows throughout the state and RAS measures stream flow in two streams where the Chesapeake and Atlantic Coastal Bays Trust Fund supports practices to improve pollution runoff.

Maryland Geological Survey:

DNR's MGS is invested in research and documentation regarding geologic CO_2 sequestration. DNR has multiple geologic avenues it is exploring including: offshore injection, saline aquifer injection, and rift basin injection. All of these vary in the manner of sequestration as some are structural sequestration and some of these are mineral re-crystallization sequestration. These projects are coordinated with 11 different states, several private companies, and two federal agencies (USGS and DOE). This group has partnered with several different energy companies and academic institutions (Core Energy and University of Kentucky) to demonstrate CO_2 injection and sequestration.

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Chapter 7
Protecting Manufacturing

7.1 Impact Analysis of GGRA on the Manufacturing Industry in Maryland - 2022

The Greenhouse Gas Emissions Reduction Act (GGRA) - Reauthorization (GGRA of 2016) requires in 2022 an independent study of the economic impact of requiring greenhouse gas (GHG) emissions reductions from the State's manufacturing sector. The GGRA of 2016 also requires that this study be overseen by the Maryland Commission on Climate Change. This chapter serves as a placeholder until the completion of that study.

7.2 Impact Analysis of GGRA on the Manufacturing Industry in Maryland - 2015

The GGRA of 2009 required an independent study of the economic impact of requiring GHG emissions reductions from the State's manufacturing sector. The Maryland Department of the Environment (MDE) tasked the Regional Economic Studies Institute (RESI) at Towson University to complete an analysis of the impacts the *GGRA 2012 Plan* would have on Maryland's manufacturing industry. In their analysis, 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 and assumed that all GGRA initiatives were implemented. Results were 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 through a series of interviews. Included in the report were case studies of GHG reduction measures taken by these firms to remain compliant with governmental environmental mandates. RESI and representatives from MDE visited these manufacturers to witness their GHG reduction methods and to understand the challenges faced with reducing GHG emissions, if any.

7.2.1 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 indicated that average weekly wages increased by $16 between 2012 and 2013—an increase from $1,324 in 2012 to $1,340 in 2013.[161]
- The industry accounted for 5.9 percent of Maryland's total output in 2012.

[161] "Quarterly Census of Employment and Wages," Bureau of Labor Statistics, accessed April 9, 2014, http://data.bls.gov/pdq/SurveyOutputServlet.

In 2015, the industry remained a vital component of Maryland's economic base, despite declines since the economic recession in the preceding years. Industry data indicated that the workforce shifted 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 the Maryland Public Service Commission (PSC) and the Maryland Energy Administration assisted manufacturers through funding opportunities to meet energy efficiency goals.

National partnerships were found to be key in building the needed workforce, such as those with Manufacturing Extension Partnership (MEP) and the National Institute of Standards and Technology. These partnerships sought to build and establish training to meet the higher skill needs of employers by the local workforce. As the industry shifted towards a higher skill-based workforce, partnerships such as those between industry leaders, State agencies, and federal agencies were found to be vital to producing the workforce needed to implement the policies outlined in the GGRA of 2009.

7.2.2 Economic Impact Findings

RESI analyzed the initiatives outlined in the *2012 GGRA Plan* to determine the economic impacts on the manufacturing industry. Using agency-provided data along with external research, RESI found the following in 2015:

- 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 GHG 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 confirmed historical and current trend analyses. To implement the strategies outlined in the GGRA of 2009, Maryland would need to create an additional 113 jobs in the manufacturing industry by 2020. Of these 113 jobs, nearly 54 percent would need to 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 would see minimal job declines between 2010 and 2020 as the industry shifted to a higher-skilled workforce demand to meet policy implementation associated with the GGRA of 2009. Despite all the change in Maryland's manufacturing industry, RESI determined that there was no conclusive evidence that any closures or relocations outside Maryland were directly attributable to the *2012 GGRA Plan* or climate change planning. Based on the analysis provided within that report, RESI found no discernible impacts on the manufacturing sector as a result of the *2012 GGRA Plan* programs. Furthermore, RESI recommended based on that analysis that Maryland not adopt any manufacturing-specific provisions related to the manufacturing sector.

7.2.3 Further Explanation

Please refer to Appendix H for a more detailed explanation of the impact analysis of the *2012 GGRA Plan* on the manufacturing sector in Maryland.

7.3 Just Transition

7.3.1 Overview

As Maryland considers transitioning its energy mix away from fossil fuels and towards less carbon-intensive fuel sources, it is important to consider the impact of this transition on workers in fossil fuel-reliant industries. Some workers involved in aspects of the fossil fuel supply chain may lose their job and find it difficult to switch industries or occupations. In 2019, MDE tasked RESI with evaluating economic dislocations resulting from potential carbon mitigation strategies. These economic dislocations included direct impacts to fossil fuel-reliant workers, fiscal impacts resulting from industry changes at the local level, and other related disparities associated with the State's efforts to reduce GHG emissions. Additionally, to meet the objectives set in the State's 40 by 30 Plan, MDE requested strategies for transitioning impacted fossil fuel-reliant workers and mitigating other economic dislocations associated with GHG reduction efforts. To meet the project objectives, RESI utilized a five-fold methodology:

- Identified major fossil fuel-reliant industries within the state, focusing on industries related to the fossil fuel supply chain;
- Estimated fiscal impacts to state and local governments resulting from a single firm closure within each major industry of focus;
- Determined key threatened occupations within the industries of focus;
- Analyzed related job opportunities for displaced employees; and
- Researched typical employment requirements and training opportunities within the state.

Major findings for each aspect are summarized below.

The fossil fuel-reliant industries of focus identified through the analysis are illustrated in Table 7.3-1 below. Data reflect 2017 annual averages.

Table 7.3-1. Industries of Focus.

NAICS	Industry	Maryland Employment	Total Wages
221112	Fossil Fuel Electric Power Generation	2,298	$388,125,553
4471	Gasoline Stations	11,476	$261,048,950
3241	Petroleum and Coal Products Manufacturing	848	$70,113,044
2212	Natural Gas Distribution	587	$50,083,767
3312	Steel Product Manufacturing from Purchased Steel	169	$10,645,755
2121	Coal Mining	80	$5,145,469

Sources: RESI, U.S. Bureau of Labor Statistics

As shown above, total Maryland employment in the industries of focus ranged from 80 to 11,476 workers. In sum, these six industries employ over 15,000 Maryland residents who earn just over $397 million in wages each year. However, as a proportion of total employment in the State, these six industries are relatively small, constituting 0.7 percent of the state's workforce. Table 7.3-2 below shows a summary of annual fiscal revenue losses estimated if a single Maryland firm in each industry of focus was to close. Inputs were based on the most recently available 2017 data, while impacts are shown in 2019 dollars.

Table 7.3-2. Summary of Fiscal Impacts per Average Industry Firm.

Industry	State Taxes	Local Taxes	Total
Fossil Fuel Electric Power Generation	$7,203,040	$6,288,787	$13,491,826
Gasoline Stations	$57,020	$47,939	$104,959
Petroleum and Coal Products Manufacturing	$147,973	$116,210	$264,181

Natural Gas Distribution	$1,036,774	$906,343	$1,943,118
Steel Product Manufacturing from Purchased Steel	$314,372	$249,786	$564,160
Coal Mining	$1,123,723	$988,172	$2,111,896

Sources: IMPLAN, RESI, U.S. Bureau of Labor Statistics, U.S. Census

Estimated total annual fiscal losses to State and local governments had a considerable range, with a low of $104,959/year per gasoline station to $13,491,826/year per fossil fuel electric power generation firm.

Table 7.3-3 below shows five key threatened occupations identified within the six industries of focus. Threatened occupations are those with the most workers in fossil fuel-reliant industries. Employment figures include both total Maryland employment and the number of workers in these occupations who work in fossil fuel-reliant industries. For example, of the 79,000 cashiers employed across Maryland, an estimated 7.545 (~10 percent) work in fossil fuel reliant industries.

Table 7.3-3. Key Threatened Occupations in Maryland.

Occupation	SOC Code	Total Maryland Employment	Employment in Fossil Fuel-Reliant Industries
Cashiers	41-2011	79,000	7,545
Machinists	51-4041	2,820	626
First-Line Supervisors of Production and Operating Workers	51-1011	6,780	257
Petroleum Pump System Operators, Refinery Operators, and Gaugers	51-8093	140	140
Inspectors, Testers, Sorters, Samplers, and Weighers	51-9061	4,060	168

Sources: RESI, U.S. Bureau of Labor Statistics

As detailed above, the occupation with the greatest number of workers in fossil fuel-reliant industries are cashiers, with 7,545 workers. The greatest proportion of potentially affected employees was in petroleum pump system operators, refinery operators, and gauges occupation with all employees working in fossil fuel-reliant industries.

For each treated occupation, related occupations were identified based on skill transfers, existing patterns of employment changes, growth projections, and salary expectations. The related occupations identified are listed in Table 7.3-4 below.

Table 7.3-4. Related Occupations.

Related Occupation	Associated Threatened Occupation
Nursing Assistants	Cashiers
Receptionists and Information Clerks	Cashiers
Computer Numerically Controlled Machine Tool Programmers of Metal and Plastic	Machinists
Heavy and Tractor-trailer Truck Drivers	Machinists; Petroleum Pump System Operators, Refinery Operators, and Gaugers
First-line Supervisors of Construction Trades and Extraction Workers	First-Line Supervisors of Production and Operating Workers
First-line Supervisors of Mechanics,	First-Line Supervisors of Production and Operating

Installers, and Repairers	Workers
Engineering Technicians, Except Drafters	First-Line Supervisors of Production and Operating Workers and Machinists; Petroleum Pump System Operators, Refinery Operators, and Gaugers
Operating Engineers and Other Construction Equipment	Petroleum Pump System Operators, Refinery Operators, and Gaugers
Life, Physical, and Social Science Technicians, All Other	Inspectors, Testers, Sorters, Samplers, and Weighers
Stationary Engineers and Boiler Operators	Inspectors, Testers, Sorters, Samplers, and Weighers; Petroleum Pump System Operators, Refinery Operators, and Gaugers

Sources: Maryland Workforce Exchange, O*Net, RESI, U.S. Bureau of Labor Statistics

For each related occupation above, typical requirements for entry into the profession were researched including educational attainment and on-the-job training needed. Additionally, a survey of available training opportunities within the state was conducted.

For example, cashiers, the occupation with the most jobs within a fossil fuel-reliant industry, could be transitioned to become nursing assistants or receptionists and information clerks. Both alternative occupations have strong projected growth and higher median wages than cashiers. Becoming a nursing assistant typically requires a postsecondary nondegree award, and there are over 100 certified CNA (certified nursing assistant) training programs offered in colleges, nursing homes, and freestanding institutions in the state.

Certification and degree opportunities exist at Maryland's colleges and universities for most of the occupations examined in greater detail in this report. Additionally, apprenticeship and less formal training programs exist to help prepare workers for new careers in the absence of formal programs. Partnering with local institutions and private employers can help to ensure workers in fossil fuel-reliant occupations statewide find high-quality, high-paying jobs to help support their families and their communities.

While the industries and occupations evaluated do not represent an exhaustive list of all those that may be affected by the State's 40 by 30 Plan, they provide a solid framework for evaluating potential economic and regional dislocations that may be incurred. Given the flexibility of job training and certification programs, scaling initiatives to respond to economic conditions is viable. Understanding the impacts and challenges related to GHG reduction policies enables the State to be better equipped when addressing these changes and taking steps to ensure an equitable and fair outcome for those affected.

7.3.2 Further Explanation

Please refer to Appendix I for a more detailed evaluation of economic dislocations resulting from potential carbon mitigation strategies of the *2019 GGRA Draft Plan*.

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Chapter 8

Meeting Longer-Term Goals

8.1 Overview

The Greenhouse Gas Emissions Reduction Act (GGRA) of 2009 and the Greenhouse Gas Emissions Reduction Act – Reauthorization (GGRA of 2016) require incremental emission reduction steps intended to demonstrate progress towards a much deeper long-term goal. The 2009 law required a minimum 25 percent greenhouse gas (GHG) emission reduction by 2020 and the 2016 reauthorization of the law set a new incremental progress goal of a minimum 40 percent GHG reduction by 2030. Both laws established non-binding aspirational goals of 80 percent to 95 percent GHG reduction in the 2050 time frame. More recently, the concept of carbon neutrality has entered into the discussion of long-term goals and has become a major item of discussion between the state agencies implementing the GGRA and the Maryland Commission on Climate Change (MCCC).

The GGRA could be reauthorized again after December 31, 2023. It is almost certain that there will be a more in-depth discussion of long-term goals during reauthorization. It is very possible that a post-2023 reauthorization of the GGRA could specifically establish deeper emission reduction goals for the 2040 to 2050 time frame. The *2019 GGRA Draft Plan* was developed with the recognition that significantly deeper reductions in the 2050 time frame will be needed. The *2019 GGRA Draft Plan* will act as an important and meaningful stepping stone in achieving the much deeper long-term goals and provides a strong foundation to continue the States efforts to reduce GHG emissions within Maryland far into the future.

The *2015 GGRA Plan Update* (25 percent by 2020 goal) and the current *2019 GGRA Draft Plan* (40 percent by 2030 goal) demonstrate the States understanding of how critical it is to push for deeper long-term reductions. The *2015 GGRA Plan Update* and the *2019 GGRA Draft Plan* both achieve greater reductions than the mandated minimums in the law. The *2015 GGRA Plan Update* is expected to approach a 30 percent reduction by 2020 and the *2019 GGRA Draft Plan* is projected to generate a 45 percent or more reduction in 2030. The 2017 GHG inventory required by the law shows that the 20 percent reduction goal for 2020 may have been met three years early.

Both plans also include multiple strategies that generate increasingly deeper reductions through the 2050 time frame. The best examples of this kind of strategy are many of the mobile source strategies like the Maryland Clean Cars Program, the Tier 3 Vehicle and Fuel Standards and the GHG standards for heavy duty vehicles. These strategies are implemented using increasingly stringent tailpipe limits for new vehicles that are phased in over time. Emission reductions are achieved as fleets turn over, not automatically in one or two years. That means that there will be emission reductions in 2030, but even deeper reductions in the 2040 and 2050 time frame as newer vehicles become a larger part of the fleet and older vehicles are phased out.

Another critical piece of the State's plan to achieve deeper long-term goals is to legally challenge efforts to weaken federal rules that are critical to achieving very deep GHG reductions in the 2040 to 2050 time frame. Maryland is challenging the United States Environmental Protection Agency (EPA) over efforts to weaken key federal rules. There are over 20 areas where Maryland has initiated legal or administrative action to push back against efforts by the federal government to weaken key climate change programs.

To begin to focus quantitatively on deeper reductions in the 2050 time frame, the analysis in this *2019 GGRA Draft Plan* also includes several "what if" scenarios to estimate the future impact of various energy and climate policies that extend beyond the 2030 goal of the GGRA of 2016, including a scenario that achieves an 80 percent reduction in GHG emissions by 2050 (see "Policy Scenario 2" in Chapter 5). These analyses identified a number of potential measures and technologies that the state could deploy after 2030 to achieve deeper reductions by 2050.

Each of the areas above is discussed in more detail in Sections 8.2 to 8.5 below.

The *2019 GGRA Draft Plan* proposes a set of measures that are available and economically beneficial today, and that meet the 2030 goal. The *2019 GGRA Draft Plan* also includes quite a few measures that will continue to generate reductions in the 2040 to 2050 time frame. It also begins to identify a number of options for the State to continue to analyze for meeting long term goals. These control measure options will be monitored as new technologies mature, and many new options will begin to be deployed as markets drive those investments. The *2019 GGRA Draft Plan* places the State in a good position to continue to significantly reduce its GHG emissions beyond 2030.

8.2 A Increased Sense of Urgency

This section borrows heavily from the 2018 Annual Report of the MCCC. (https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Pages/MCCCReports.aspx)

In its' 2018 Annual Report, the MCCC, chaired by Maryland Department of the Environment (MDE) Secretary Ben Grumbles, introduced the report with the following:

> "A heightened sense of urgency is needed to build upon Maryland's impressive and steady progress on climate change, given the latest scientific information and policy challenges at the national level. The State continues to reduce greenhouse gas emissions, transition to cleaner and healthier environmental solutions, increase local resiliency and preparedness, and improve scientific understanding and public awareness. However, more emphasis is now needed for finding additional, bold innovations in energy, transportation, agriculture, and natural resources management, that will allow Maryland to meet its climate goals while ensuring positive impacts to jobs and the economy, and advance our shared commitment to public health and equity"

Experts agree that there is no convincing evidence that natural cycles and variability alone can account for the changes observed over the industrial era. Statements affirming the occurrence, danger, and anthropogenic nature of climate change have been issued by many reputable U.S. scientific organizations and national science academies; and the consensus among experts in the scientific community continues to be reinforced.

The climate of a region is defined by its long-term average temperature and precipitation trends, which shape many of the physical, chemical, and biological components of ecosystems as they develop. Significant and rapid changes in the climate, therefore, are expected to have pervasive and in some cases devastating impacts to ecosystems, and consequently to the resources and services, upon which humans rely. While both eco- and human systems have a certain capacity to adapt to change, these mechanisms operate most effectively over a much longer time scale and may have limited success at the unprecedented speed that effects are currently progressing. Continuation of society down a "business as usual" path will increase the likelihood and severity of potentially irreversible impacts to the

global ecosystems and interconnected human systems. Yet, as very active modifiers of the environment, humans also have the ability to affect the outcome. Actions taken at this time are still capable of lessening the damage of future impacts, while delayed action or inaction will lead to more severe impacts.

In October of 2018, the Intergovernmental Panel on Climate Change (IPCC) released a special report stating that "future climate-related risks depend on the rate, peak and duration of warming", emphasizing significantly increasing risks at 1.5°C and further at 2°C. The report also notes that future risk can be reduced through considerable multi-sectoral mitigation efforts along with adaptation measures. The U.S. Global Change Research Program's (USGCRP) 2017 *Climate Science Special Report* similarly concluded that significant reductions in GHG emissions are required to potentially maintain the rise in temperature to 2°C or less. Though the specifics in timing and magnitude may be uncertain due to basis in a wide range of variables, an urgent response is clearly crucial to minimizing both the costs and risks of climate change. As with any major adjustments, delaying action is expected to necessitate changes that are more dramatic and economically disruptive.

In order to limit the temperature increase to a 2°C threshold, the IPCC originally calculated that global GHG emissions must be reduced by 40 to 70 percent from 2010 levels by 2050, and further to near or below zero in 2100. The GGRA and the *2019 GGRA Draft Plan* acknowledge that, because these reduction goals were global and the U.S. has far greater per capita emissions than all but a few nations in the world, the U.S. emissions should strive to meet the upper end of the range.

In an October 2018 special report, the IPCC released a special report with updates that conveyed a new sense of urgency. The IPCC report stated that the modeled pathways, which provide a 66 percent probability of staying under the 2°C threshold, have global emissions declining by 20 percent by 2030 (from a 2010 baseline) and reaching net zero by 2075. The report also provided estimates for the more ambitious 1.5°C pathway to further reduce risks from future climate impacts, proposing 45 percent reductions by 2030 and net zero near 2050.

Because of this increased sense of urgency, the *2019 GGRA Draft Plan* strives to achieve reductions greater that the minimum 40 percent reduction by 2030 established in the law and sets the stage to achieve even greater reductions into the future.

8.3 Key Programs that Will Achieve Deeper Reductions in the 2040 to 2050 Time Frame

Many of the control programs in the *2019 GGRA Draft Plan* will not only achieve significant short-term GHG reductions in the 2030 time frame but also continue to generate even deeper reductions in the 2040 to 2050 time frame. The best examples of programs that generate increasingly greater reductions over time are the mobile source control programs. Many of these programs are designed to require new vehicles to meet stringent tailpipe standards whenever a new vehicle is purchased. The reductions are in essence phased in as the fleet turns over. As older vehicles are eliminated from the fleet and new vehicles subject to the stringent limits for new vehicles take their place, emission reductions increase every year. Some vehicles, like light duty vehicles, see the fleet turn over in a relatively short time frame like 10 to 15 years. Other mobile sources, like trucks and construction equipment have fleet turn over times that can be in the 30 to 50 year time frame.

Chapter 5 provides more detail on the long-term emission reductions associated with many of the control measures in the *2019 GGRA Draft Plan.* Section 8.3.1 below provides a snapshot of some of the more important programs that will continue to generate reductions beyond 2030.

8.3.1 Key Programs That Generate Deeper GHG Reductions After 2030

The Maryland Clean Car Program

Implements California's Low-Emission Vehicle (LEV) standards to vehicles purchased in Maryland. Adopted on November 19, 2007, The Maryland Clean Cars Program adopts California's stricter vehicle emission standards. The Clean Cars Program represented the first program that directly regulates carbon dioxide (CO_2) emissions from light duty vehicles. In addition to regulating GHG from passenger vehicles, the Clean Cars Program includes a Zero Emissions Vehicle (ZEV) mandate that car manufacturers must meet. These vehicles produce zero or near zero tailpipe emissions and will further help reduce pollutants from the transportation sector and reduce dependence on foreign oil.

Corporate Average Fuel Economy (CAFE) Standards for Light Duty Vehicles

This federal program for light duty vehicles requires that cleaner vehicles (greater fuel efficiency) be phased in over time.

Phase 1 covered model years 2012 through 2016. The fuel economy improvements in Phase 1 increased over time until an average 250 gram/mile CO_2 standard was met in the year 2016. This equates to an average fuel economy near 35 mpg.

Phase 2 covers model years 2017 through 2025. Again these standards are phased in and projected to result in an average 163 gram/mile of CO_2 by model year 2025. This equates to an average fuel economy of 54.5 mpg.

Corporate Average Fuel Economy (CAFE) Standards for Medium and Heavy Duty Vehicles

This federal program for medium- and heavy-duty vehicles requires that cleaner vehicles (greater fuel efficiency) be phased in over time.

Phase 1 covered model years 2014 through 2018. This phase included standards for three main regulatory categories: combination tractors, heavy-duty pickups and vans, and vocational vehicles

The Phase 2 fuel efficiency and GHG standards for medium- and heavy-duty vehicles cover model year 2018 and beyond. The standards apply to four categories of medium- and heavy-duty vehicles: combination tractors, heavy-duty pickups and vans, vocational vehicles and trailers to reduce GHG emissions and improve fuel efficiency. The standards phase in between model years 2021 and 2027 for engines and vehicles, and between model years 2018 and 2027 for trailers.)

The Tier II and Tier III Vehicle and Fuels Standards

The Tier II and Tier III programs are part of a comprehensive approach to reducing the impacts of motor vehicles on air quality and public health. The Tier III standard included a new gasoline sulfur standard that will enable more stringent vehicle emissions and will make emission control systems more effective. These federal regulations are being implemented throughout the country and will provide even greater benefits to Maryland. These programs are designed to address criteria pollutants like ozone and fine particulate, but they will also generate co-benefits for GHGs.

The Zero Emission Vehicle (ZEV) MOU

On June 20, 2018, nine Northeast and West Coast states released a new Multi-State ZEV Action Plan for 2018-2021 to support the successful implementation of the states' ZEV programs. This effort will drive reductions of GHGs and criteria pollutant emissions like nitrogen oxide (NOx). This plan will generate short-term and long-term benefits.

The Action Plan, which builds on the successes and lessons learned from implementation of an earlier 2014 ZEV Action Plan, presents 80 market-enabling action recommendations for states, automakers, dealers, utilities, charging and fueling companies and other key partners to rapidly accelerate mainstream consumer adoption of ZEVs, including plug-in hybrid, battery electric and hydrogen fuel cell vehicles.

The updated ZEV Action Plan is the work of the Multi-State ZEV Task Force, which was formed in 2013 under a Memorandum of Understanding (MOU) signed by the Governors of California and seven other states that have adopted California's ZEV program – Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island and Vermont. New Jersey became the ninth ZEV state to join the coalition when they signed the MOU in May. Together, the nine ZEV MOU states represent nearly 30 percent of the new car sales market in the United States.

The Transportation and Climate Initiative (TCI)

The Northeast and Mid-Atlantic states have been working to explore regional policies to reduce carbon emissions and other pollutants from the transportation sector. In the fall of 2017 and throughout 2018 the participating states engaged communities and businesses in listening sessions that explored the opportunities and benefits that could be achieved from coordinated action across the states.

On December 18, 2018, a coalition of nine states (including Maryland) and the District of Columbia announced their intent to design a new regional low-carbon transportation policy that would cap and reduce carbon emissions from transportation fuels. The program would invest the proceeds into low-carbon and more resilient transportation infrastructure. Maryland endorsed the statement and the goals stated that included reducing climate change pollution, creating economic opportunity, and improving transportation equity. This initiative will generate reductions to help Maryland meet long-term goals.

Federal Standards for Marine Engines

Marine engines are divided into three categories based on engine displacement. Category 1 and 2 marine diesel engines are used primarily to provide propulsion power on such vessels as tugboats, pushboats, supply vessels, fishing vessels, and other commercial vessels in and around ports. Category 3 marine diesel engines are used as propulsion engines on ocean-going vessels such as container ships, oil tankers, bulk carriers, and cruise ships.
Each category is governed by their own emission standards. For Category 1 and 2 the current Tier 4 emission standards emphasize the use of emission aftertreatment technologies and limit the amount of sulfur in fuel to 15 ppm. These emission standards regulate nitrogen oxide, PM, and HC emissions. Currently Category 3 engines are governed by Tier 3 standards that were adopted in 2009. These standards provide an 80 percent reduction of nitrogen oxide emissions below the Tier 1 levels. Emissions other than nitrogen oxide are not regulated.

Federal Standards for Locomotives

In June 2008, EPA finalized a three-part program aimed at reducing emissions from locomotives of all types – line-haul, switch, and passenger rail. Particulate matter emissions were cut by as much as 90 percent and nitrogen oxide emissions by as much as 80 percent. The standards apply to new locomotives built in 2015 and later and also apply to locomotives that are remanufactured.

Maryland Idle-Free Idling Reduction Program

In 2018, MDE kicked-off its *Idle Free MD* program. Idle Free MD is a partnership between the State, the private sector and Maryland schools, designed to reduce unnecessary idling through outreach, education and voluntary action. The goal of the Idle Free MD program is to significantly reduce unnecessary idling by building awareness of its impact on Maryland communities. The program establishes partnerships with motorists, communities, and

the transportation industries with the intention of reducing emissions from unnecessary idling by decreasing the social tolerance of idling through fact-based education.

8.4 Challenging the Federal Government Over Weakening Key Federal Programs that are Critical to Meeting Maryland's Long-Term Climate Change Goals

Over the past few years, the federal government has proposed numerous regulatory changes to weaken federal rules and programs designed to reduce GHG emissions. Many of these federal initiatives that are being rolled back are critical to Maryland, especially in terms of meeting long-term goals. Maryland has taken many legal actions, both alone and with other states, to challenge virtually all of the federal actions related to weakening federal rules that reduce GHG emissions.

Thirteen of these critical actions are described below.

8.4.1 Critical Actions

The Clean Power Plan (CPP)

This federal proposal was designed to significantly reduce GHG emissions from power plants across the Country. Maryland worked with EPA on the development of the CPP and strongly supported this rule proposed by the previous Administration. Maryland, through MDE, opposed the repeal of the CPP, unless the Plan was going to be replaced with a policy as effective and enforceable as the Regional Greenhouse Gas Initiative (RGGI).

The Affordable Clean Energy (ACE) Rule

Maryland is challenging this EPA final rule. Maryland, through MDE, joined a lawsuit with 28 other states and cities opposing the EPA's final action related to the repeal of the CPP and finalization of the ACE rule. MDE opposed the ACE Rule because ACE is not as effective and enforceable as RGGI. Maryland supports state flexibility; however, the rule did not set a minimum standard for states to reduce GHGs. Therefore, it is unclear whether implementation of the rule would accomplish any emissions reductions.

The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule

The SAFE rule, as proposed, would to roll back existing federal light-duty vehicle GHG emission standards for model years (MYs) 2021 through 2025, and revoke California's waiver to adopt stricter vehicle emission standards than the federal government and other state's ability to follow the stricter California standards.

Maryland, through MDE, submitted multiple letters and official comments opposing the proposed rule. Maryland recommended that EPA and NHTSA withdraw it, retain the existing federal standards under the unified national program, and collaborate closely with California, other state and local air agencies, auto manufacturers and other stakeholders to find an approach that can provide the flexibility that industry seeks and, at the same time, ensures the critically important emission reductions that states, like Maryland, need to achieve and/or maintain clean air and public health goals are kept in place.

The federal government has indicated it will be finalizing this rulemaking in several steps. It has not yet finalized the proposal on rolling back existing federal light-duty vehicle GHG emission standards for model years (MYs) 2021 through 2025. Sections of the proposal related to California's and other states authority for stricter GHG emission standards are discussed below.

Federal Efforts to Revoke GHG Standards for Vehicles that are More Stringent than Federal Standards

Maryland, through MDE, joined 23 other states and two cities in a lawsuit opposing a final rule by the EPA and the National Highway Traffic Safety Administration (NHTSA) entitled "The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule Part One: One National Program". In the action, EPA announced its decision to withdraw California's waiver to adopt stricter vehicle emission standards than the federal government and NHTSA finalized regulations that declare that the federal Energy Policy and Conservation Act (EPCA) preempts state laws that regulate GHG emissions from new passenger cars and light trucks. The NHTSA regulation targets by name the GHG emission and zero-emission vehicle standards promulgated by the State of California and adopted by twelve other states, including Maryland. EPA's final decision to revoke the waiver for the California standards relies on the NHTSA regulation as a basis for revocation of the waiver.

Methane Emissions from New Sources in the Oil and Gas Industry

Maryland, through MDE, and thirteen other states filed a motion to intervene in a lawsuit against EPA's actions to halt regulation of leaks of GHG emissions and other harmful air pollutants from new sources in the oil and gas industry. EPA asked that this lawsuit be held by the court due to EPA's related action on the proposed rulemaking discussed below.

MDE submitted written comments opposing EPA's proposed rule on amendments to the methane new source performance standards for the oil and natural gas sector. EPA proposed to reduce the monitoring frequency of fugitive emissions at compressor stations and to extend the allotted time for owners and/or operators of compressor stations to repair fugitive emission components. Additionally, EPA sought comment on extending the time period for owners and/or operators of well sites or compressor stations to conduct an initial monitoring survey and reoccurring leak inspections. MDE strongly opposed these proposed amendments. The EPA has not yet finalized this proposal.

Methane Emissions from Existing Sources in the Oil and Gas Industry

Maryland and 14 other states filed a lawsuit against the EPA for failing to perform a legal duty to control emissions of methane from existing oil and gas operations. Specifically, the suit charges that the EPA has violated the CAA by 'unreasonably delaying' its mandatory obligation under the Act to control methane emissions from these operations.

Methane Emissions from New and Existing Landfills

A coalition of eight states, including Maryland, filed a lawsuit against the EPA over its failure to implement and enforce a critical landfill methane regulation. The regulation would reduce landfill emissions of volatile organic compounds, hazardous air pollutants, CO_2, and methane. It went into effect on October 28, 2016, but the EPA has not implemented or enforced it. EPA proposed a new rule on this topic that would delay the compliance date for states to file a plan.

The U.S. Climate Alliance

Governor Hogan sent a letter to the Executive Director of the U.S. Climate Alliance expressing Maryland's commitment to join the Alliance. The Governor highlighted Maryland's clean air and GHG reduction progress and cited the need for balanced action in states and the need for multistate and international leadership on climate change.

The U.S, Climate Alliance now includes 25 states and was initiated when the federal government withdrew from the Paris Climate Accord.

Hydrofluorocarbon Regulation/Federal Rules Stalled

In partnership with other USCA states, Maryland, through Governor Hogan and MDE, is i pursuing measures in 2019 to phase out the use of hydrofluorocarbons (HFCs), GHGs that are significantly more potent than CO_2. States are taking action to phase out HFCs due to the uncertainty of EPA's plans for the federal regulations governing HFCs.

Maryland is currently drafting the HFC regulations with plans adopt a final rule by fall 2020. HFCs are critical to the States short-term and long-term emission reduction goals as they are highly potent SLCPs.

The Mercury and Air Toxics Standard (MATS)

Maryland, through MDE, joined with 20 other states and 5 other localities opposing EPA's proposed "National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-Fired Electric Utility Steam Generating Units—Reconsideration of Supplemental Finding and Residual Risk and Technology Review." Specifically, this challenge addresses EPA's proposed action to revise its 2016 supplemental finding, which required EPA to take costs into account when evaluating whether it is "appropriate" to regulate coal- and oil-fired power plants under section 112 of the Clean Air Act. EPA proposed to change course in spite of the MATS Rule's proven public health benefits (such as reductions in fine particulate matter), States and Local Governments' reliance on the Rule, and over objection of the electric power sector, which has made significant investments to comply with the Rule.

The MATS Rule generates significant GHG co-benefits.

Maryland's Section 126 Petition and Corresponding Litigation

Maryland submitted a petition to EPA under Section 126 of the Clean Air Act. The petition asked EPA to require 19 power plants in five upwind states (Indiana, Kentucky, Ohio, Pennsylvania and West Virginia) to run their already installed air pollution controls to reduce emissions. The petition includes data that shows that these power plants have stopped running their pollution controls effectively and the increased emissions significantly affect the quality of the air that Marylanders breathe. Maryland is asking these plants to do what Maryland's largest coal-fired power plants are already required to do under regulations implemented in 2015 through Governor Hogan and MDE.

EPA denied Maryland's petition. Maryland, through MDE, sued EPA in the D.C. Circuit Court of Appeals asking the court to review the final action of the EPA on Maryland's 126 petition. Delaware and Environmental NGOs also filed suit over EPA's denial of Maryland's 126 petition and denial of similar petitions filed by Delaware. The court consolidated those cases with Maryland's case. This lawsuit is in active litigation.

The petition could have a significant impact on reducing emissions at the specified power plants in the five states upwind of Maryland. The petition is driven primarily by the need to reduce nitrogen oxide emissions to address ground level ozone, but it will also reduce GHG emissions and have significant climate change co-benefits.

EPA's Cross State Air Pollution Rule (CSAPR) Close-Out

Maryland, through MDE, joined five other states and one city on a lawsuit opposing EPA's final CSAPR Close-Out Rule. MDE strongly disagrees with EPA that the CSAPR Close-Out, which relies on the CSAPR Update partial remedy, now fully addresses 20 states' interstate ozone transport obligations under the 2008 ozone standard.

This issue is driven primarily by the need to reduce nitrogen oxide and volatile organic compound emissions across the East to address ground-level ozone. It will also generate significant GHG reduction co-benefits.

EPA Denial of Eight State 176A Petition

Maryland, along with seven other states, sued EPA under the Clean Air Act sec. 176A to ensure upwind states adequately control the pollution that blows into Maryland and other downwind states. Specifically, the suit challenged the EPA's denial of a petition that Maryland and several other states filed in late 2013 for the Agency to help level the playing field by adding nine new states to the Ozone Transport Commission. Unfortunately, the D.C. Circuit held in favor of EPA's denial of the petition.

The petition would have required more aggressive controls on power plants and mobile sources in the nine new states and generated significant GHG co-benefits.

8.5 Modeling and Goals

Modeling and longer-term goals are heavily dependent on Maryland's past and current GGRA Plans. This section will be updated upon stakeholder review of the *2019 GGRA Draft Plan* and finalized in the *2019 GGRA Plan*.

Maryland's planners can't predict the future; but that shouldn't prevent them from setting science based goals and developing a plan to meet those goals. Mitigating and adapting to climate change requires that planners and policy-makers consider various sources of uncertainty in plan development.

Maryland used the best available tools and information to identify strategies to meet the 40 by 30 goal. Maryland evaluated several policy scenarios amid significant sources of uncertainty. The policy scenario approach provides a framework to develop a draft plan that is adaptive and flexible. The "what-if" scenarios in each respective policy scenario answered many short-term and long-term questions, and indicated how emissions and the economy would respond to various strategies in 2030 and beyond - when uncertainty increases.

Full descriptions of each modeling scenario, including the one representing the *2019 GGRA Draft Plan*, can be found in Chapter 5. MDE and its modeling partners specifically designed one scenario, "Policy Scenario 2," to meet a long-term goal of 80 percent reduction below 2006 levels by 2050 (Fig. 8.5-1).[162]

[162] Though the GGRA of 2016 requires that Maryland's plans be developed in recognition of the need to reduce emissions by at least 80% below 1990 levels by 2050, Maryland does not have a 1990 GHG inventory, so MDE used the 2006 baseline in its exploration of long-term goals.

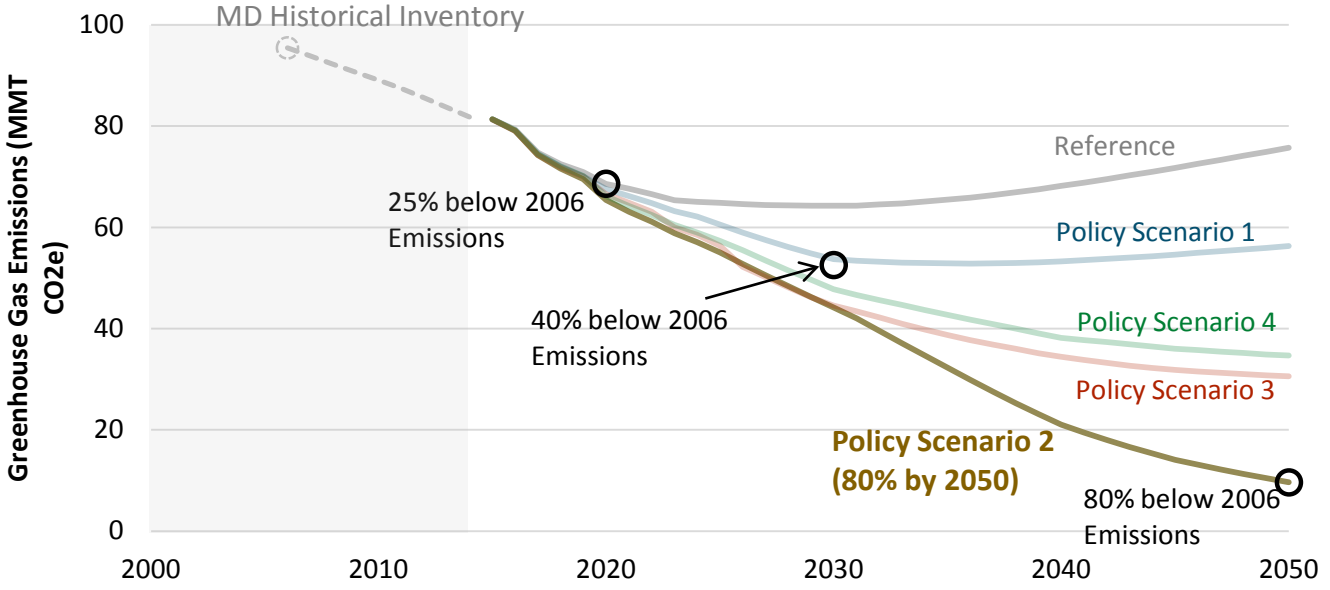

Figure 8.5-1: Maryland Net GHG Emissions in modeling scenarios. Policy Scenario 2 achieves 80 percent reduction by 2050

The measures that achieved deeper long-term reductions in Policy Scenario 2 beyond those already included in the *2019 GGRA Draft Plan* include:

- More rapid electrification of light-duty vehicles, achieving 50 percent of new sales by 2030 and 100 percent by 2050;
- Electrification of heavy-duty vehicles, with 40 percent of heavy-duty on-road vehicle sales being either ZEV or diesel hybrid by 2030 and 95 percent by 2050;
- Electrification of non-road vehicles, including 50 percent of construction vehicles by 2050;
- 100 percent adoption of high-efficiency electric and natural gas building appliances by 2030 and beyond;
- Wide-scale electrification of building heating systems, with 95 percent of all system sales being heat pumps in 2050 (including when replacing natural gas furnaces and boilers); and
- Transition to advanced biofuels blended into remaining diesel and natural gas uses, with 63 percent of diesel replaced by renewable diesel by 2050, and 25 percent of natural gas replaced by biomethane by 2050.

These measures, combined with those already in the *2019 GGRA Draft Plan*, reduce Maryland's emissions to 80 percent below 2006 levels by 2050. While MDE has identified these as important measures to monitor and pursue in the future, the *2019 GGRA Draft Plan* does not include them as measures to achieve the 2030 goal, because they are either more ambitious in the near-term than seems feasible (e.g. higher near-term light-duty EV sales), or because they rely on technologies that are not yet proven (e.g. electric heavy-duty vehicles).

Additionally, since many of these long-term measures represent new technologies that have not been deployed at scale, their current cost is relatively high, and their long-term cost is very uncertain. That drives some negative economic impact after 2030 in MDE's analysis (Fig. 8.5-2).

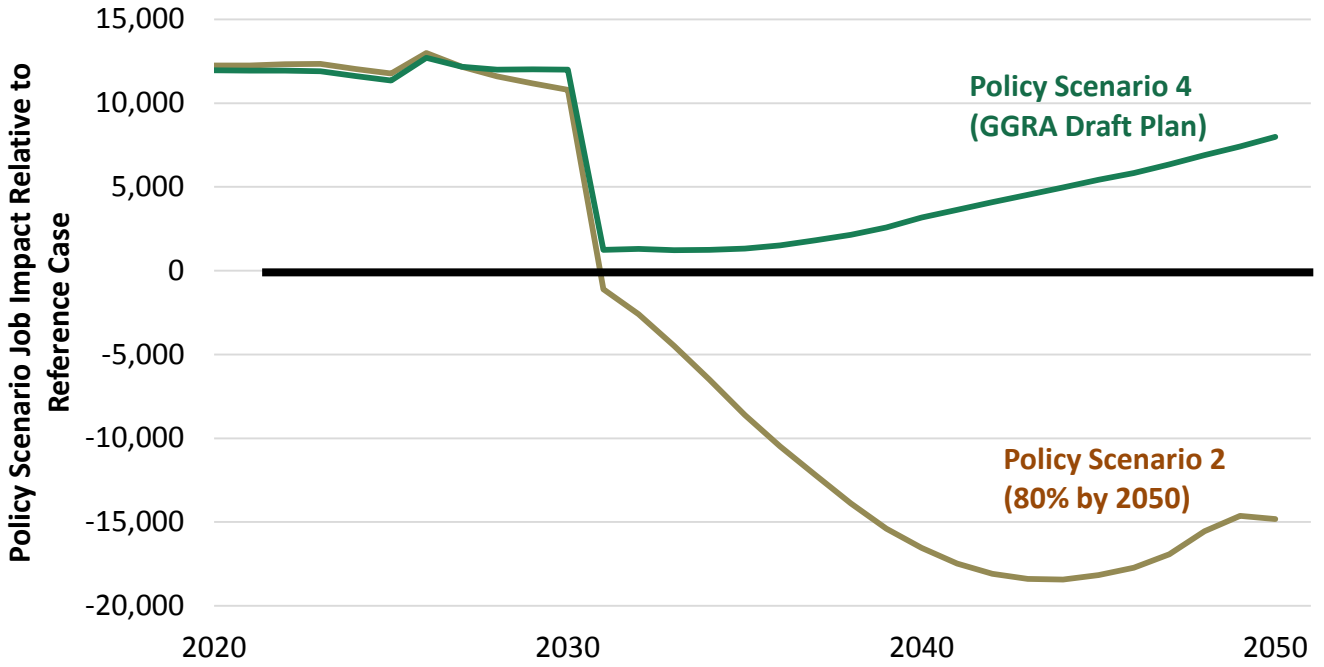

Figure 8.5-2: Employment impacts of the measures in the *2019 GGRA Draft Plan* (green line) and in Policy Scenario 2 (brown line), which included long-term measures to reduce emissions by 80 percent by 2050.

These results do not mean that those measures will not be cost-effective or economically beneficial when the time comes, and as the relevant technologies mature. These results only mean that future technology development is very uncertain, so decisions on what technologies to deploy after 2030 should be re-evaluated as those technologies mature, and as their costs come down.

The *2019 GGRA Draft Plan* proposes a set of measures that are available and economically beneficial today, and that meet the state's 2030 goal. It identifies a number of future measures that should be monitored as technologies mature, and deployed accordingly if they become viable later on, to ensure that Maryland continues to reduce its GHG emissions beyond 2030.

Maryland Department of the Environment

Chapter 9

Adaptation and Resiliency

9.1 Introduction

Climate change will affect Maryland in a variety of ways, and in some places the impacts are already being felt. Impacts now and into the future may 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 or shifts in public health challenges due to climate-driven stressors; 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 their frequency, intensity, extent, and magnitude.

Even as the State moves forward with actions that will reduce greenhouse gases (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. Increasingly these actions are no longer independent from one another 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 Academies[163], 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. Maryland is taking action to address a wide range of climate impacts to sectors such as bay and aquatic environments, agriculture, human health, water resources, population growth and infrastructure, forest and terrestrial ecosystems and our coastal zone.

9.2 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. Over the past 10 years, Maryland has experienced seven weather-related events warranting Presidential Disaster declarations, including five coastal flood events. The Scientific and Technical Workgroup of the Maryland Commission on Climate Change (MCCC) updates state sea level rise projections periodically. The Adaptation and Response Working Group (ARWG) partners use these projections to tailor their work and

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

coordination across the state, thus ensuring that actions protect Maryland's future economic well-being, environmental heritage, and public safety in the face of climate change and sea level rise. In addition, the conversation about water is not just limited to our coasts and sea level rise; over the past three years, work has increasingly focused on including inland and precipitation-driven events and water quantity. This theme will continue into the coming years.

Climate change also 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 15 to 30 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.

Maryland's Climate Action Plan includes two climate change adaptation strategies that guide overall 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.

The strategies provide the basis for guiding and prioritizing State-level activities and for identifying annual ARWG efforts with respect to both climate science and adaptation action and policy over the near and longer terms.

Between 2015 and 2018, the State implemented many high-priority elements of Maryland's Phase I and II Adaptation Strategies and identified new and emerging ones to help accelerate adaptation progress. Chapter 3 of the *2015 Greenhouse Gas Emissions Reduction Act (GGRA) Plan*, the Adaptation Update, provided information about adaptation efforts and annual work plans. Summary highlights of a few adaptation efforts from the past three years are outlined in the section below.

9.3 Adaptation Implementation Updates (2015-2018)

9.3.1 The Maryland Healthy Soils Program

In addition to reducing nutrient and sediment flows into the Chesapeake Bay and its tributaries, many of the agronomic and conservation practices used by Maryland's farmers have the potential to make a significant contribution to the State's climate change goals by sequestering carbon and other GHGs. Convened in August 2016, the Healthy Soils Consortium took on the tasks of a previous carbon advisory group to inventory best management practices, create a carbon and GHG practice menu, and determine the metrics and tools that will be used to measure carbon sequestration. Through this Healthy Soils Initiative and the 2017 Healthy Soils Act, the Maryland Department of Agriculture (MDA) has collaborated with consortium partners to complete a comprehensive scientific literature review to identify those practices that are most effective in building soil carbon stocks and create a menu of Maryland-specific practices. The next steps are to determine the metrics and tools that

will be used to quantify soil carbon, and develop a new incentive program to encourage the further adoption of soil health practices.

9.3.2 Community Resilience Grants/Resiliency through Restoration

The Maryland Department of Natural Resources (DNR) solicited and funded community-based resilience projects in 2017 and 2018 through the Community Resilience Grant Program. The program leverages federal dollars with newly available state "Resiliency through Restoration" capital funding to promote and support comprehensive, holistic planning and implementation projects that address both water quality and quantity. Through these projects, DNR is helping Maryland communities become more resilient to flood risks, and enhance the protection and management of the state's resources including the bay and the ocean. Projects funded in 2017 included risk reduction planning in Cambridge, Hyattsville, and Calvert County and implementation projects in Baltimore City as well as Prince George's, St. Mary's, Somerset, and Dorchester counties. Projects funded in 2018 included risk reduction planning in Annapolis, Laurel, Talbot, Berlin, Charlestown, Hebron, and Cecil County and implementation projects in Anne Arundel, Talbot, and Worcester counties. This work continues a decade-long effort to provide support to local communities to assess risk, plan risk-reduction efforts and implement projects.

9.3.3 Climate and the Phase III Watershed Implementation Plan (WIP)

All Chesapeake Bay states are now required to incorporate climate change into their Chesapeake Bay nutrient reduction WIPs, which include the implementation strategies for achieving the Chesapeake Bay nutrient and sediment total maximum daily loads (TMDLs) required under the federal Clean Water Act. Climate change is expected to make the nutrient reduction goals more challenging. To confront this challenge, members of the Principals' Staff Committee, who represent the Bay-state governors, agreed to a three part climate strategy in March 2018. First, states will include a narrative strategy in their 2019 Phase III WIPs to address climate change. Second, the Chesapeake Bay Program Partnership will sharpen its understanding of the impacts of climate change on the Bay, identify research needs, and refine nutrient and sediment load estimates for each jurisdiction by March 2021. Third, Bay States will account for additional nutrient and sediment loads, as well as improved understanding of the behavior of pollution control practices under climate change conditions, beginning in September 2021. These strategies will be reflected in a Phase III WIP addendum and/or 2022-2023 two-year milestone commitments. The framework of the Phase III WIP is strongly aligned with the overall dual-pronged approach and adaptive management strategies that Maryland is committed to employing, which will be critical to the long-term success of climate and TMDL efforts.

9.3.4 Implementation of Projects to Address Resilience Needs

Through the Chesapeake and Atlantic Coastal Bays Trust Fund, DNR supported a series of bioretention projects in Oxford aimed at reducing local flooding and improving bay water quality. The project integrates two new substantial bioretention areas, and expands and improves existing bioretention areas in order to increase stormwater retention capacity, improve water quality, and increase coastal resiliency for a critical area of the community. Bioretention projects have been identified in federal and state vulnerability studies as a recommended best management practice both for water quality improvement and for tidal flooding resiliency. This project has been designed to allow for the incorporation of additional retention areas as needed in the future and eventually improvements to the critical state road connection through town, allowing the town to continue to address and accommodate long-term sea level rise predictions.

9.3.5 Resiliency and Land Conservation

Recognizing the benefits that nature and natural features provide in buffering communities from climate impacts and the importance of protecting open space for habitat and wildlife into the future, DNR updated its Stateside

Program Open Space scorecard to evaluate potential acquisition properties for their coastal community resilience to climate change benefits. These benefits are provided by areas along the shoreline where natural habitats, such as marshes and coastal forests, have the potential to reduce the impact of coastal hazards to the adjacent coastal communities by dampening waves, stabilizing sediment, and absorbing water. This recent enhancement complements existing land conservation criteria that avoids conserving lands that will be inundated by sea level rise and targets adaptation areas important for wetland migration. The Stateside Program Open Space scorecard provides the ecological, resiliency and management justification that Maryland's Board of Public Works relies upon to approve funding for land conservation.

9.3.6 Coast Smart Council Assessment and Certificate

The Maryland Coast Smart Council created a Coast Smart Assessment and Certificate to help Maryland state agency personnel and others understand and apply the Coast Smart Construction Program guidelines for various phases of their project to prevent or minimize the future impacts of coastal and riverine flooding, storm surge and sea level rise.

9.3.7 Patapsco Valley State Park Resiliency Project

DNR, working with the University of Maryland Center for Disaster Resilience alongside the Maryland Park Service and Patapsco Valley State Park staff in Baltimore County, conducted an assessment of watershed issues driving inland flooding events following flashy and intense precipitation events at the Glen Artney area of the park. The project team is completing watershed or engineering studies, developing management strategies and/or engaging the surrounding community to address the problem to reduce future impacts.

9.3.8 Beneficial Use of Dredged Material

DNR is currently evaluating and developing policies and processes to proactively identify environmentally- and economically-sound beneficial use of dredged material practices to improve coastal resiliency. DNR is developing a mapping tool, "Beneficial Use: Identifying Locations for Dredge (BUILD)," to enable DNR project managers to quickly identify beneficial use opportunities. To enhance BUILD and advance efforts to use dredged material for resilience efforts, DNR has and continues to pursue site suitability models that prioritize placement of dredged material based on societal and environmental coastal resiliency needs and engage in thin-layer placement studies. Regarding thin-layer sediment placement, DNR is a participating investigator in a National Estuarine Research Reserve Science Collaborative Grant aimed and gathering data to inform thin-layer placement as a restoration technique to promote marsh resilience in the face of sea level rise. Through this project, replicated restoration experiments are being conducted at several reserve sites across the nation, with the purpose of examining the effectiveness of thin-layer sediment placement as a marsh adaptation strategy. Novel aspects of the project include the broad distribution of sites, the examination of the effectiveness of thin-layer sediment placement at different marsh elevations, a standardized monitoring protocol, and the incorporation of biochar (carbon material produced through the conversion of biomass in an oxygen limited environment) to improve soils and plant health.

9.3.9 Maryland's Climate Leadership Academy

Maryland's Climate Leadership Academy is the nation's first state-sponsored institution providing continuing education and executive training programs specifically designed for state and local government officials, infrastructure executives and business leaders. The Academy is supporting the work of the MCCC, serving as a tool that establishes a community of climate smart local government and infrastructure leaders. The Academy's programs and planning efforts are informed by an advisory council that includes senior leadership from numerous Maryland state agencies in order to ensure continuity and coordination with the Commission. Through extensive partnerships and guidance from a body of Maryland leaders and nationally recognized experts, the Academy's

programming will be coordinated with universities and community colleges throughout the state, as well as other convening organizations, to deliver training programs statewide. The Academy will advance professional competencies in integrating climate change into decision-making across sectors and occupations, and will help ensure that decision-makers across sectors and Maryland communities are appropriately trained and educated to successfully integrate climate change into their operations and activities.

9.3.10 Installation of Tide Gauges in Somerset and Talbot County

DNR, the Maryland Emergency Management Agency (MEMA), the United States Geological Service (USGS), Somerset and Talbot Counties coordinated the installation of new tide gauges in Crisfield and Claiborne that will become part of the network of gauges throughout the Bay measuring water levels. The two new gauges fill a data gap and will allow for more local and accurate reporting of water levels ongoing and during flood events. The gauges will be maintained by USGS and by the end of 2018 were accessible on the National Weather Service Advanced Hydrologic Prediction Service website.

9.3.11 Maryland Flood Tabletop Exercise

The Maryland Department of the Environment (MDE), DNR and the Federal Emergency Management Agency (FEMA) Region III hosted a one day training in April 2018 to see how state and local partners can work together before, during and after a significant flood event. As part of the workshop a situational manual was developed to accompany the training. There were over 75 participants from state and local jurisdictions and future partnerships may continue to improve collaboration.

9.3.12 Building Risk Communication Training

DNR, the National Oceanic and Atmospheric Administration (NOAA) and the Eastern Shore Land Conservancy hosted a 2-day training in June 2018 with the goal for participants to have a better understanding of how people respond to risk and how to develop new communication skills for discussing hazards in their community. State, local and non-governmental organization partners participated.

9.3.13 State Highway Vulnerability Assessment

The Maryland Department of Transportation (MDOT) is conducting an ongoing Assessment to determine current and future impacts of climate change on the State's transportation network. Data from the vulnerability assessment will be integrated into all aspects of planning, programming and design to ensure resilient and reliable transportation is available for counties to utilize. MDOT's programs focus on an integrated and multimodal approach, leveraging public-private partnerships and ensuring equity to accomplish these goals.

9.3.14 The Maryland Climate Change Health Adaptation Program (MCCHAP)

The Maryland Department of Health (MDH) has begun development of an Environmental Public Health Climate Adaptation Tracker (EPHCAT). The EPHCAT will be an online portal that highlights climate adaptation around the State of Maryland that includes a health adaptation component. The tracker will host relevant information (organization, purpose, outcomes of interest, health component, and timeline) as well as supplemental content information as deemed relevant. It aims to begin filling a gap that exists around awareness of climate and health adaptation work in Maryland and will be populated with the assistance of the MCCC working groups. MCCHAP is expanding the educational and training adaptation program 'Climate Change and Community Health Workers' to include chronic disease management and emergency preparedness. This training program is the result of a

partnership with the University of Maryland Extension. MCCHAP held a round of community health worker (CHW) trainings across the state during the summer/fall of 2018.

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

9.4.1 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: the DNR, MDE, the Maryland Department of Planning (MDP), the Maryland Historical Trust (MHT), the Maryland Department of Housing and Community Development (DHCD), the Maryland Department of Information Technology (DoIT), the Maryland Environmental Service (MES), MEMA, the Maryland Department of Budget and Management (DBM), the Maryland Department of Health and Mental Hygiene (DHMH), MDOT, the Maryland Port Authority (MDOT MPA), the Maryland State Highway Administration (MDOT SHA), MDA, the Maryland Insurance Agency (MIA), the Maryland Energy Administration (MEA), the Maryland Department of General Services (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.

9.4.2 Addressing the challenge that low income and otherwise vulnerable communities will likely be disproportionately impacted by climate change

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.

9.4.3 Assessing the impacts that climate change will likely have on the State's economy, revenues and investment decisions

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 *2012 GGRA Plan*, 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.

9.4.4 Delivering Tools and Assistance for Local Governments

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 Coast Smart, to non-coastal communities to address issues such as the intersection of climate and stormwater, as well as riverine and nuisance flooding.

9.5 State Enhancement Actions

9.5.1 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.

9.5.2 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.

9.6 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 a "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 10

Climate Change Legislation (2015 – 2018)

10.1 Climate Change-Related Legislation (2015 – 2018)

Maryland has historically been at the forefront of states taking action to address both the drivers and consequences of climate change. Beginning with the development of A Sea Level Rise Response Strategy for Maryland in 2000; the passage of the Healthy Air and Clean Cars Acts of 2006 and 2007 respectively; participation in the Regional Greenhouse Gas Initiative (2007-present); creation of the Coast Smart Council in 2014; and reauthorization of the Greenhouse Gas Emissions Reduction Act (GGRA) in 2016 (GGRA of 2016); Maryland has consistently advanced efforts to combat climate change.

Following the 2015 Session, Governor Larry Hogan signed the Maryland Commission on Climate Change (MCCC) Act of 2015 to codify the commission into law. The tasks and responsibilities assigned to the MCCC under the act are generally similar to those under the 2014 Executive Order, including the requirement to report to the Governor and General Assembly each year on the status of the state's efforts to "mitigate the causes, prepare for and adapt to the consequences of climate change, including future plans and recommendations, if any, to be considered by the General Assembly." The MCCC now has representatives from the administration, the legislature, business, nonprofit organizations, academia, and local governments.

On April 4, 2016, Governor Hogan signed the GGRA of 2016 into law, which requires Maryland to reduce statewide greenhouse gas (GHG) emissions by 40 percent from 2006 levels by 2030. The GGRA of 2009 was created based on the recommendations of the MCCC's 2008 Climate Action Plan. The original law required Maryland to achieve a 25 percent reduction in statewide GHG emissions from 2006 levels by 2020. The Maryland Department of the Environment (MDE)'s 2015 GGRA Plan Update, showed that Maryland was on target to not only meet but exceed the emission reduction goal; and that this was being accomplished with an estimated economic benefit between $2.5 and $3.5 billion in increased economic output by 2020 as well as creation and maintenance of between 26,000 and 33,000 new jobs.

Governor Hogan signed legislation in 2017 establishing the Maryland Healthy Soils Program and making Maryland among the first to pass such a state-sponsored initiative in the nation. House Bill 1063, sponsored by Delegate Dana Stein (D-Baltimore County and member of the MCCC), directs the Maryland Department of Agriculture to provide farmers with the research, education, and assistance necessary to improve the health, yield, and profitability of Maryland's soils and increase soil carbon storage capacity on Maryland farms.

The Governor announced Maryland's intention to join the U.S. Climate Alliance following the United States withdrawing from the 2015 Paris Agreement (2018). Subsequently, he signed HB3: Environment - U.S. Climate Alliance – Membership, which codified the decision, requiring the Governor join the Alliance and to report to

certain committees of the General Assembly on any collaborations among Alliance members and any policies or programs that the Alliance has endorsed or undertaken.

A number of bills about the use of electric vehicles (EVs) were passed in recent years, including a 2015 bill to continue the Maryland Electric Vehicle Infrastructure Council until June 2020. The use of specified high occupancy vehicle (HOV) lanes regardless of the number of passengers was extended to EVs in 2016. The Clean Car Act (2017) extended the Electric Vehicle Recharging Equipment Rebate Program and created tax credits for specified qualified plug-in electric drive vehicles.

Recognizing the economic, environmental, fuel diversity, and security benefits of renewable energy resources, Maryland became one of the first states to adopt a Renewable Energy Portfolio Standard (RPS) in 2004. The Legislature intended the RPS law to establish support for the development of renewable electricity generation within Maryland and the Pennsylvania Jersey Maryland Interconnection, LLC region, by requiring that power providers procure Renewable Energy Credits from renewable sources. The Maryland legislature updated the original legislation in 2017, to increase the goal to 25 percent of retail electricity sales by 2020, replacing the 20 percent by 2022 target. This includes a 2.5 percent carve-out specifically for solar energy. The RPS legislation has a clear and direct impact on GHG emissions from the electricity sector, by increasing the percentage of electricity that comes from zero emission generation sources.

Other energy bills have been supported in Annapolis in as well. The State passed and signed into law the Maryland Offshore Wind Energy Act of 2013. This initiative amended the Renewable Portfolio Standard (RPS) to include offshore wind projects located between ten and thirty miles off of Maryland's coast and to provide financial support for projects in the form of Offshore Wind Renewable Energy Credits (OREC). The Law also created an application and review process for offshore wind developers to propose OREC projects tailored for Maryland. The OREC process is coordinated by the Maryland Public Service Commission (PSC).

In 2015, SB 398: Electricity - Community Solar Energy Generating System Program established a pilot program on community solar energy generating systems under the authority of the PSC. Several bills passed in 2016 including HB 1106 Clean Energy Jobs - Renewable Energy Portfolio Standard Revisions, which altered the renewable energy portfolio standard percentage derived from solar energy for specified years and required the Department of Labor, Licensing, and Regulation to study the workforce development training needs for the clean energy industry in the State. The same year, SB 936: Maryland Clean Energy Incentive Act of 2016 extended a specified credit against the State income tax for electricity-producing facilities using specified qualified energy resources and established the Maryland Clean Energy Incentive Tax Credit Reserve Fund.

In 2017, the Governor announced support of a hydraulic fracturing prohibition, which was affirmed by the General Assembly in HB1325 – Oil and Natural Gas - Hydraulic Fracturing - Prohibition. Additionally that year, HB 1414: Renewable Energy Portfolio Standard requiring the Power Plant Research Program to conduct a study on the renewable energy portfolio standard and related matters. SB313/HB410 – Economic Development – Maryland Energy Innovation Institute, sponsored by the administration established the Maryland Energy Innovation Institute as part of the A. James Clark School of Engineering to collaborate with academic institutions on clean energy programs and to attract private investment to clean energy innovation and commercialization in the State.

During the 2018 legislative session, HB1456 – Offshore Drilling Liability Act, established "offshore drilling activity" as an ultrahazardous and abnormally dangerous activity and that a person that causes a spill of "oil" or "gas" while engaged in an offshore drilling activity is strictly liable for damages for any injury, death, or loss to person or property that is caused by the spill.

The Sea Level Rise Inundation and Coastal Flooding - Construction, Adaptation, and Mitigation Act (House Bill 1350 / Senate Bill 1006) also passed in 2018. In addition to making changes to the Maryland Coast Smart Council, over the next two years work will move ahead through State agencies, local jurisdictions and other partners to

establish plans to adapt to saltwater intrusion and nuisance flooding; and, with the Board of Public Works and in conjunction with the Maryland Department of Natural Resources, MDE, and the Maryland Emergency Management Agency, partners will establish criteria to evaluate whether state funds may be used to mitigate hazards associated with sea level rise inundation and coastal flooding.

The legislature also took action to require the General Assembly to enact a law approving any future withdrawal from the Regional Greenhouse Gas Initiative in SB 290: Regional Greenhouse Gas Initiative - Withdrawal.