2019 GGRA Draft Plan
Executive Summary

Maryland
Department of
the Environment

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)

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[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 $MMtCO_2e$).

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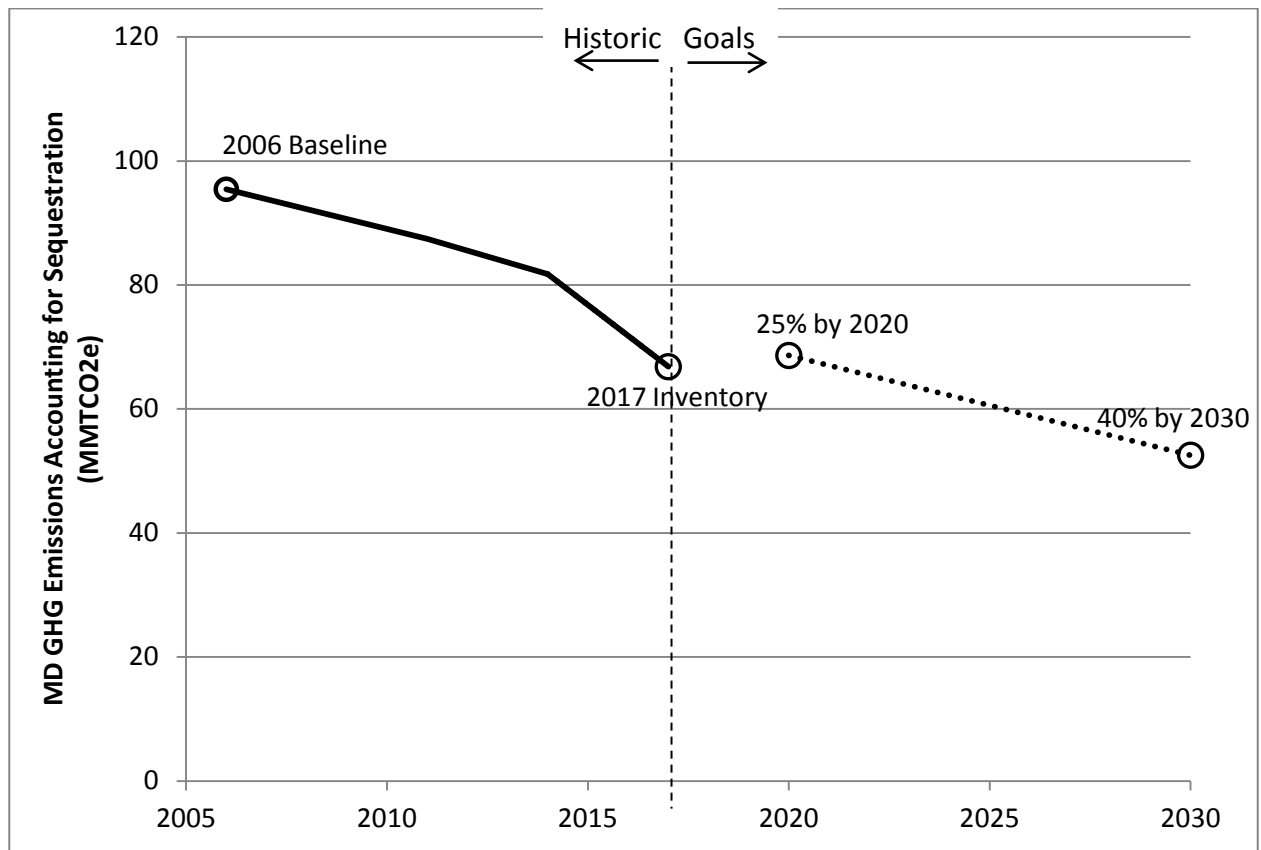
Figure ES-1. Historic decrease in Maryland's GHG emissions compared to GGRA goals.

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$_2$e was stored in Maryland forest biomass and agricultural soils in 2017. This leads to net emissions of 66.77 MMtCO$_2$e 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%.

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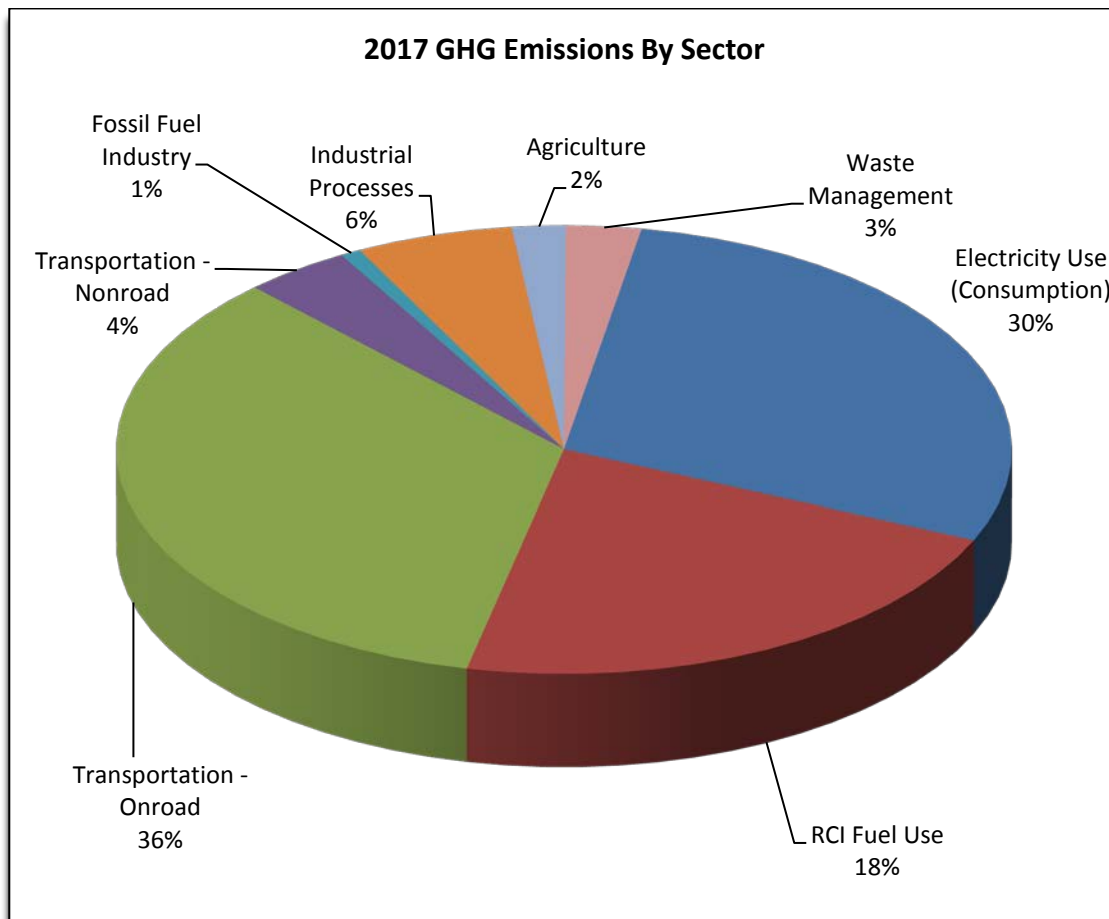
Figure ES-2. Maryland's 2017 Gross GHG Emissions by Sector.

The GGRA of 2016 requires that the state must reduce emissions by 42.89 MMtCO$_2$e (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$_2$e (42.89 MMtCO$_2$e 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$_2$e 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.
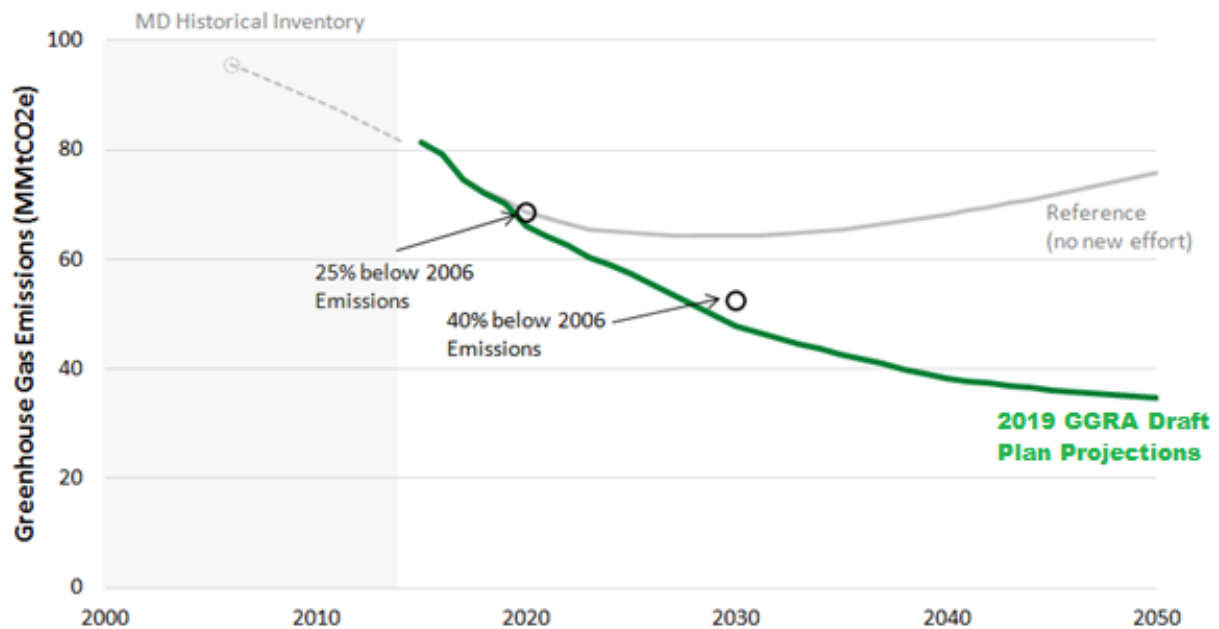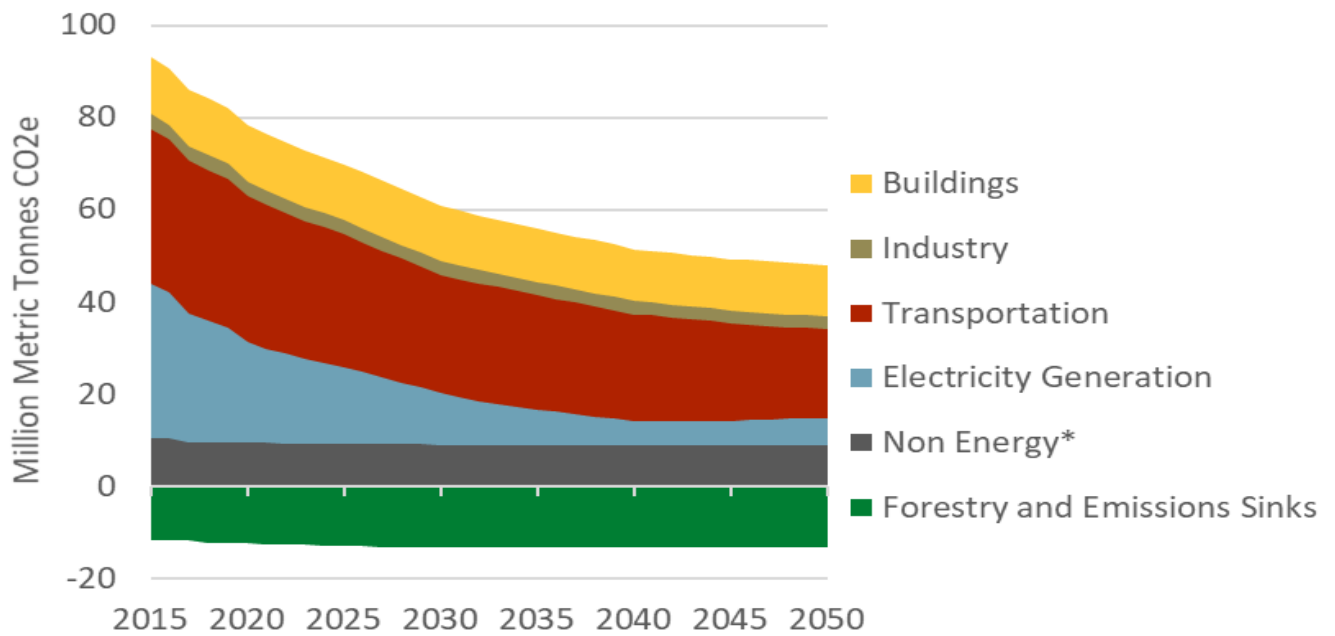
Figure ES-3. *2019 GGRA Draft Plan* Emission Reduction Projections.

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.
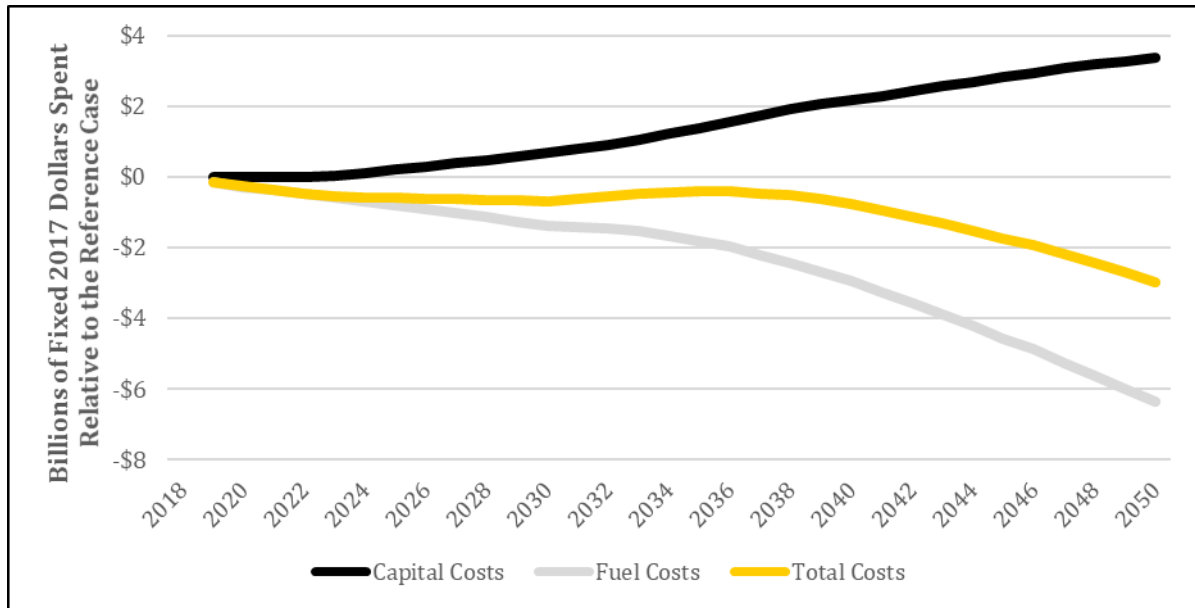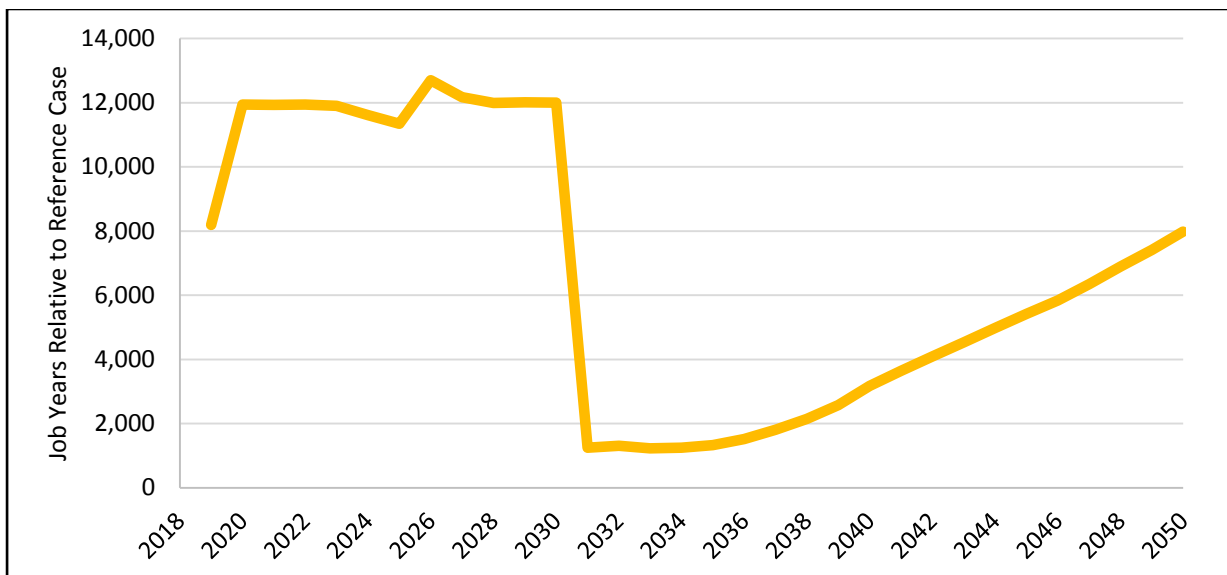
Sources: E3, MDE, RESI

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.
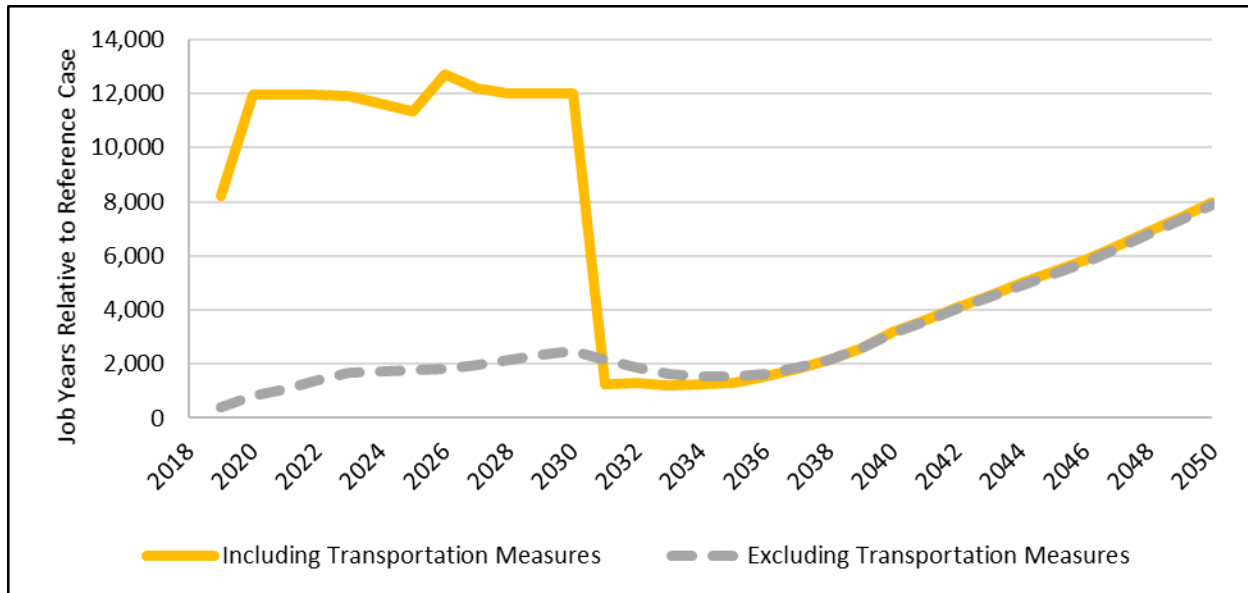

Sources: E3, MDE, REMI PI+, RESI

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.

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