



**Maryland**  
Department of  
the Environment

# 2030 GGRA Plan Executive Summary

## ES.1 The Greenhouse Gas Emissions Reduction Act – Reauthorization of 2016 and Maryland Climate Goals

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 greenhouse gas (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 the Maryland Department of the Environment (MDE) to develop a statewide GHG reduction plan (2030 GGRA Plan). The GGRA 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.

In its 2020 Annual Report,<sup>1</sup> the Maryland Commission on Climate Change (MCCC)<sup>2</sup> recommended that Maryland update the GGRA of 2016 and adopt a more ambitious reduction goal of 50% reduction from 2006 levels by 2030 and recognize the finding by the Intergovernmental Panel on Climate Change (IPCC) that developed nations will need to reduce emissions to net zero as early as 2045. The 2030 GGRA Plan treats the more ambitious 2030 recommendation as a stretch goal and includes a series of measures that will reduce emissions more than required by the goal in current law.

MDE's emissions analysis shows that the 2030 GGRA Plan will come very close to achieving a 50% reduction by 2030 without accounting for some anticipated new federal government policies to reduce emissions. If the incoming federal administration takes action to improve vehicle efficiency, reduce the cost of electric vehicles (EVs), deploy more clean and renewable electricity, and invest in energy efficiency and electrification, Maryland will be able to achieve a 50% reduction in GHG emissions by 2030. Future iterations of the *GGRA Plan* will continue to identify additional measures to reduce GHG emissions as new technologies become available.

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

<sup>1</sup> <https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/MCCCAnnualReport2020.pdf>

<sup>2</sup> <https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Pages/index.aspx>

**Table ES-1. GGRA of 2016 Requirements.**

Maryland shall reduce statewide GHG emissions by 40% from 2006 levels by 2030.
MDE must: <ul style="list-style-type: none"> <li>• Submit a proposed draft plan that reduces statewide GHG emissions by 40% from 2006 levels by 2030;</li> <li>• Make the proposed draft plan for public comment; and</li> <li>• Convene a series of public workshops to provide interested parties with an opportunity to comment on the proposed draft plan.</li> </ul>
Maryland must adopt a final plan that reduces statewide GHG emissions by 40% from 2006 levels by 2030 by 2019. The plan must: <ul style="list-style-type: none"> <li>• Include adopted regulations that implement all plan measures for which State agencies have existing statutory authority;</li> <li>• Include a summary of any new legislative authority needed to fully implement the plans, and a timeline for seeking legislative authority;</li> <li>• Ensure no net loss of existing manufacturing jobs; and</li> <li>• 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.</li> </ul>
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% 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 2030 GGRA 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 2030 GGRA 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.**

**Table ES-2. 2030 GGRA Plan Economic, Employment, Public Health, and Climate Benefits.**

	Through 2030	Through 2050
<b>Average Job Impact<sup>1</sup></b>	+ 6,186 jobs	+ 6,823 jobs
<b>MD GDP Impact<sup>2</sup></b>	+ \$5.3 billion	+ \$14.7 billion
<b>Personal Income Impact<sup>2</sup></b>	+ \$4.5 billion	+ \$16.1 billion
<b>Avoided Mortality<sup>2</sup></b>	+ \$0.9 to \$2.1 billion	+ \$7.5 to \$17 billion
<b>Climate Benefit<sup>2</sup></b>	+ \$3.12 billion	+ \$27.9 billion

<sup>1</sup>Average number of job-years created or sustained each year.

<sup>2</sup>2018 Dollars, Cumulative, Net Present Value using 3% discount rate. Climate benefit evaluated using Federal Social Cost of Carbon (2015)

## ES.2 Climate Change and the Cost of Inaction in Maryland

With 3,100 miles of shoreline, Maryland is one of the most vulnerable parts of the U.S. to the effects of sea level rise associated with climate change. Rising sea levels and increased storm intensity could have devastating and far-reaching impacts on the Atlantic coast and the Chesapeake Bay ecosystem that affect the environmental, recreational and economic benefits enjoyed by Maryland and its visitors. Although Maryland's coastal areas may be considered particularly vulnerable, all areas of the state are at risk. In general, climate change alters the severity, frequency or distribution of existing issues that are impacted either directly or indirectly by temperature and precipitation. This includes, but is not limited to:

- Impacts on coastal, bay, and inland water quality parameters that may change the viable uses of surface water, such as for irrigation, recreation, or human consumption;
- More frequent disruptions to urban and coastal infrastructure in Maryland caused by extreme weather events and sea level rise that may indirectly impact the economy of the region by restricting the flow of goods and affecting days worked;
- Common stressors experienced among ecosystems, agriculture, fisheries, 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;
- Human health issues, including those affected by impacts on food and water supply, air quality and extreme weather events; and
- A higher probability of negative outcomes for disadvantaged communities and individuals inherently more sensitive or with a reduced adaptive capacity for responding to the impacts of climate change.

Detailed discussion of the latest scientific findings on the impacts of climate change is included in Chapter 1.

## ES.3 Environmental and Climate Justice

Environmental justice EJ is an ethical mandate that seeks equal protection from environmental and public health hazards for all people regardless of race, income, culture and social class. Additionally, EJ means that no group of people, including racial, ethnic or socioeconomic groups should bear a disproportionate share of the negative environmental consequences resulting from industrial, land-use planning and zoning, municipal and commercial operations or the execution of federal, state, local and municipal programs and policies. EJ requires the development, implementation, and enforcement of environmental laws, regulations, and policies that ensure that no single community will bear a disproportionate share of the negative environmental conditions or pollution. This may include industrial operations, land-use planning and zoning, or municipal and commercial operations, such as through Title V permits issued by environmental regulatory agencies.

Climate change poses a significant threat to vulnerable communities with little adaptive capacity. Furthermore, disadvantaged communities are disproportionately impacted by pollution, often stemming from previous policy and planning decisions. The state must ensure that equity and EJ are key principles of climate policies moving into 2021. Maryland must also ensure that residents and businesses across all communities have ample opportunity to shape and comment on climate policy, direct resources from climate programs like the Regional Greenhouse Gas Initiative (RGGI) to help disadvantaged communities address climate change and benefit from the transition to clean energy, and to repair damage to communities from previous policies.

“Climate justice” is a term that acknowledges climate change can have differing social, economic, public health, and other adverse impacts on disadvantaged populations. Climate justice begins with recognizing that key groups bear disproportionate climate change impacts. Climate impacts can exacerbate inequitable social conditions.

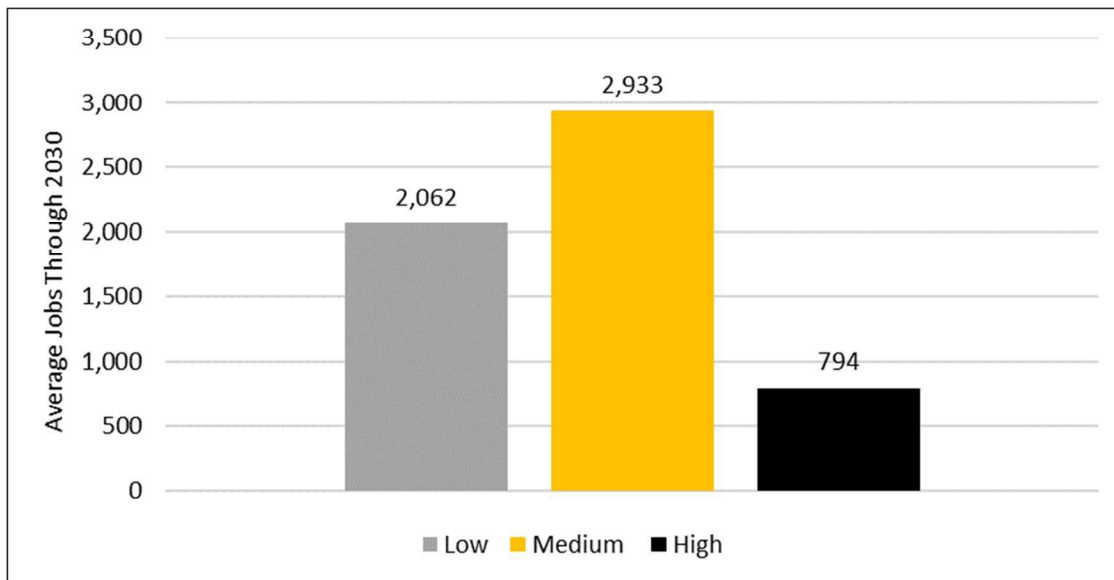
Achieving environmental and climate justice will require multidisciplinary collaboration among various stakeholders, including communities, businesses, public health and education experts, air quality scientists, meteorologists, engineers and community planners, and federal, state and, local regulatory agencies. Climate justice principles may include:

- Supporting the right to economic development and employment opportunities;
- Sharing benefits and burdens equitably;
- Ensuring decisions are participatory, transparent, and accountable;
- Supporting education for climate stewardship; and
- Using effective partnerships.

Necessary steps and opportunities to achieve environmental and climate justice are included throughout the 2030 GGRA Plan, and considerations of how each measure can advance those objectives is considered in the program-by-program discussions in Chapter 3. Some ways in which programs in the 2030 GGRA Plan address environmental and climate justice include:

- Community solar expands the benefits of access to renewable energy to individuals who do not own land or rooftop space, allowing them to enjoy the benefits of solar power generation, while the Community Solar Low to Moderate Income (LMI) Power Purchase Agreement (PPA) grant provides funding to offer community solar subscriptions with deep discounts below the utility's standard offer service rates for LMI households.
- The Maryland Department of Housing and Community Development (DHCD) provides financing from the EmPOWER Maryland Program for projects that reduce energy costs and address critical health and safety issues for residents and limited income families.
- Under RGGI, more than half of all funds collected by Maryland are invested in energy assistance for low-income households, and energy efficiency in LMI homes and communities.
- The Maryland Department of Natural Resources (DNR) has helped to fund tree planting in urban areas, which has been shown to remove air pollutants, reduce the risk of certain health problems, keep urban areas cooler, as well as sequestering carbon dioxide (CO<sub>2</sub>) from the atmosphere.
- The Maryland Department of Planning (MDP) is taking measures to mitigate the impact of saltwater intrusion on agricultural communities on the Eastern Shore, and DNR's Park Equity Tool identifies underserved communities that may benefit from preservation of open space, shoreline enhancement, and other nature-based approaches to risk reduction.
- Transportation technologies play a critical role in reducing emissions from the transportation sector which disproportionately impact low-income communities and communities of color. The state has several programs that deploy electric buses and trucks, reducing pollutants that can contribute to health problems in communities while also reducing CO<sub>2</sub> emissions.

The 2030 GGRA Plan aims to achieve Maryland's GHG reduction goals in a way that benefits Maryland's economy and creates jobs, and that shares those benefits broadly. Economic impact analysis by Towson University estimates that the 2030 GGRA Plan will primarily create middle-class jobs.



**Figure ES-1. Employment impacts from the 2030 GGRA Plan through 2030 in the lower, middle, and upper thirds of the income distribution.**

The economic impact analysis also finds that the jobs created by the 2030 GGRA Plan are expected to be broadly spread across Maryland’s geography, and across racial and ethnic groups.

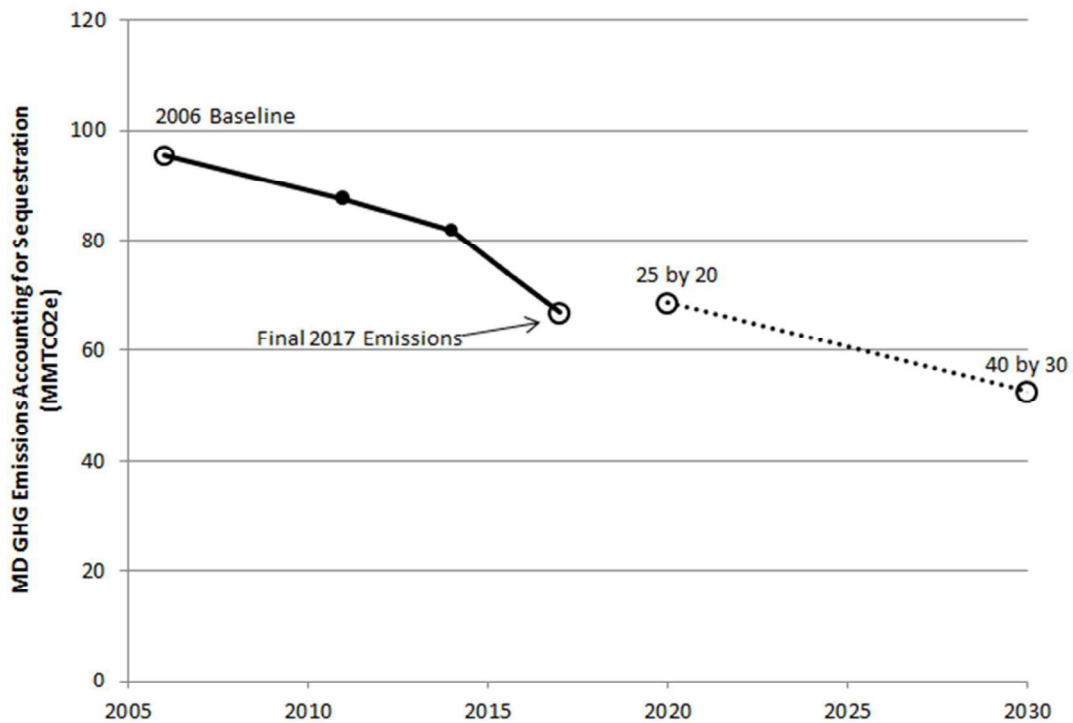
Detailed discussion of environmental and climate justice is included in Chapter 2.

## ES.4 Emissions Reductions and Modeling

Maryland has made significant strides in the reduction of GHG emissions. As illustrated in Figure ES-1, analysis of Maryland’s 2017 GHG emissions<sup>3</sup> show that activities in Maryland accounted for approximately 80.14 million metric tons of gross CO<sub>2</sub> equivalent emissions (MMtCO<sub>2</sub>e) in 2017, an amount equal to about a 25.8% reduction of the state’s total gross GHG emissions in 2006 (108.06 MMtCO<sub>2</sub>e).

That 25.8% reduction in emissions in 2017 is greater than Maryland’s reduction goal for 2020. However, MDE cautions against concluding that the state met its 2020 goal, because emissions from electricity generation and residential and commercial buildings tend to vary year-to-year with the weather as energy demand for heating and cooling homes and buildings is substantially higher during cold winters and hot summers than during mild seasons. Maryland enjoyed particularly mild winter weather and a relatively mild summer, so we saw an especially steep drop in emissions in 2017.

<sup>3</sup> Maryland performs comprehensive greenhouse gas inventories on a 3-year cycle to coincide with the National Emissions Inventory. The most recent inventory year is 2017; MDE will complete the next inventory for 2020 in late 2021 once federal datasets on 2020 energy use are published.



**Figure ES-2. 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 11.79 MMtCO<sub>2</sub>e was stored in Maryland forest biomass and agricultural soils in 2017. This leads to net emissions from all sectors of 68.35 MMtCO<sub>2</sub>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 40%, and buildings 18%.



Figure ES-3. Maryland's 2017 Gross GHG Emissions by Sector.

The GGRA of 2016 requires that the state must reduce emissions by 43.22 MMtCO<sub>2</sub>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 53 MMtCO<sub>2</sub>e (43.22 MMtCO<sub>2</sub>e below the state's net GHG emissions in 2006).<sup>4</sup> The combined emissions reductions of all programs in the 2030 GGRA Plan will yield a total of 52.7 MMtCO<sub>2</sub>e in emissions reductions in 2030, compared to 2006. **This will result in a total reduction of 48.7%, achieving 9.45 MMtCO<sub>2</sub>e of emission reductions more than the 2030 GGRA goal.**

The 2030 GGRA Plan yields greater emissions reductions than the *2019 GGRA Draft Plan* that MDE published in October 2019, thanks to additional reductions in electricity generation, RCI fuel use, transportation, and methane (CH<sub>4</sub>) leakage from the natural gas supply chain.

<sup>4</sup> MDE has updated the Global Warming Potential (GWP) factors used to evaluate the impact of greenhouse gases other than carbon dioxide to reflect the latest available from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report. Prior iterations of GGRA plans, including the *2019 GGRA Draft Plan*, used GWP values from the Second Assessment Report.

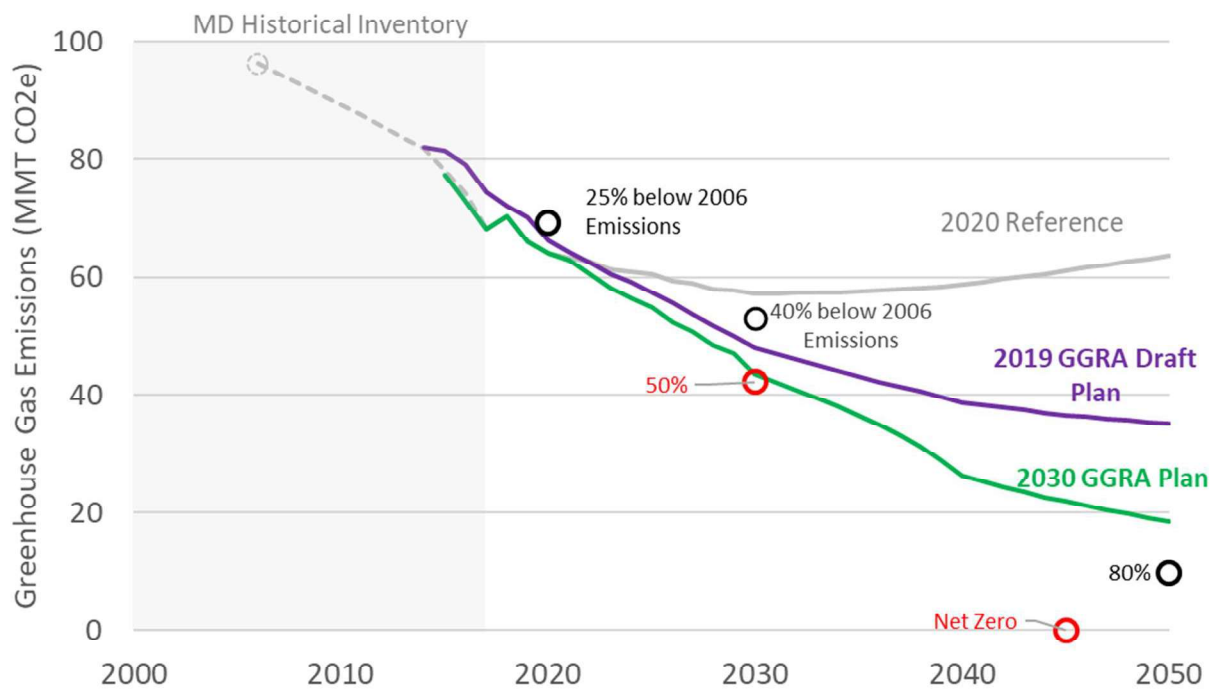


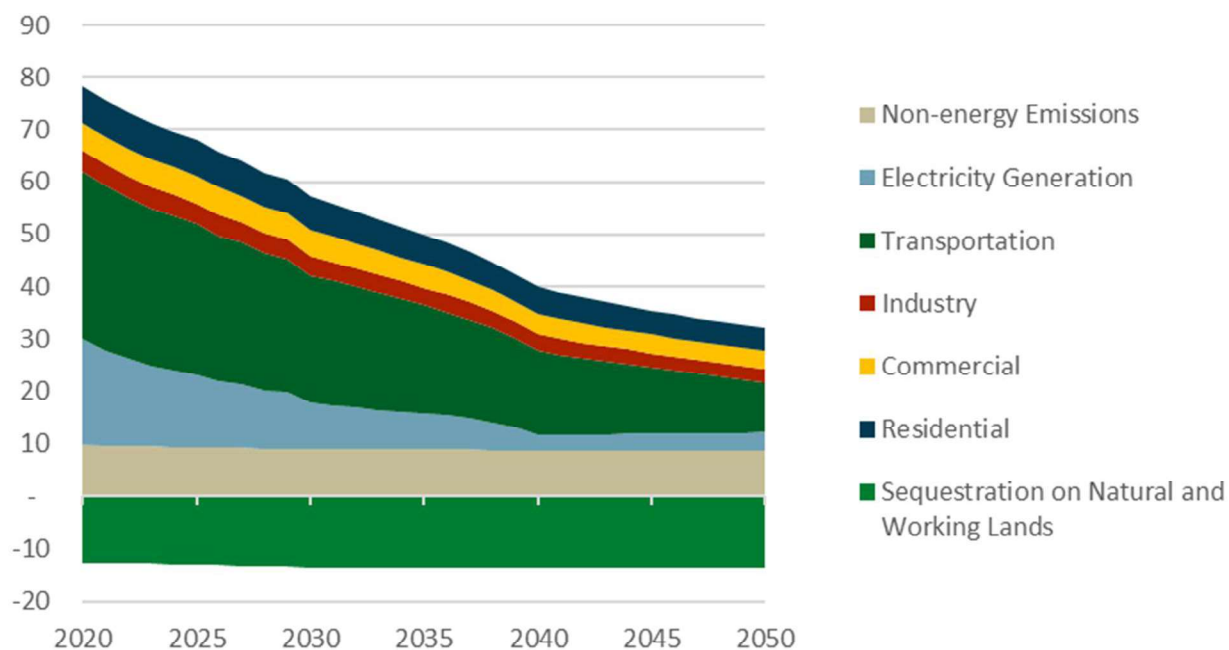
Figure ES-4. 2030 GGRA Plan Emission Reduction Projections.

MDE tasked the Regional Economic Studies Institute at Towson University (RESI) 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 2030 GGRA 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 (the Reference Case), 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 2030 GGRA Plan that will reduce the state’s emissions below its 2030 goal.

The 2030 GGRA Plan programs achieve emissions reductions from across multiple sectors (Figure ES-5). 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-5. Maryland GHG Emissions Projections by Sector under the 2030 GGRA Plan.**  
 \*Non-Energy includes Agriculture, Waste Management, Industrial Processes and Fossil Fuel Industry

MDE, RESI, and E3 will supplement these estimates with sensitivity analyses, where assumptions about federal government programs, consumer behavior, and nuclear energy generation will be varied to reflect more or less difficult environments for achieving the 2030 goal.

Since one of the primary focuses of that supplemental analysis is the impact of changing federal programs, MDE will produce the analysis once a clearer picture of the incoming federal administration’s near-term climate actions emerges.

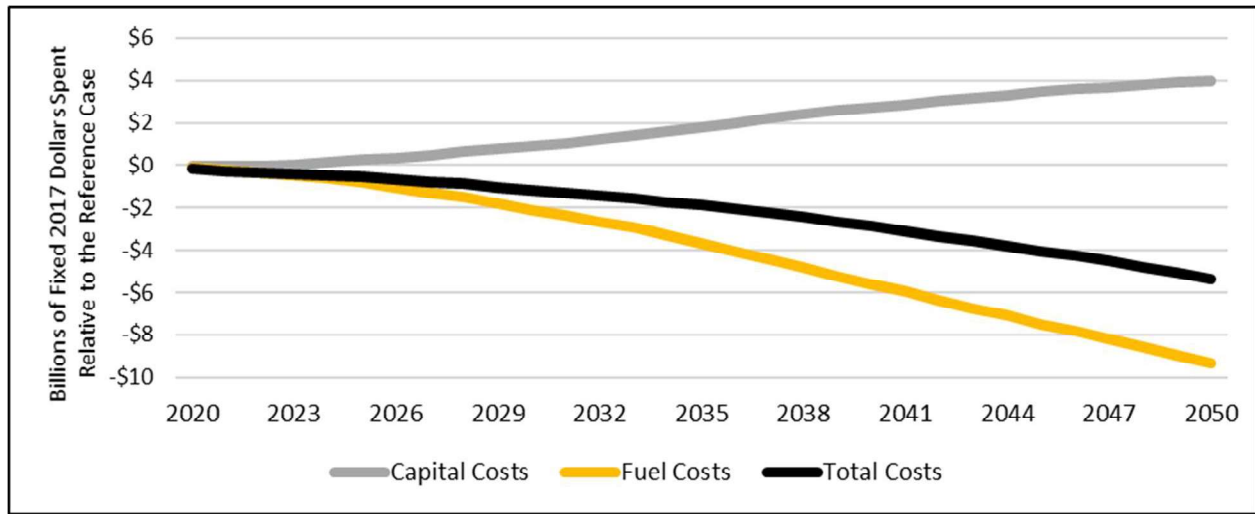
Detailed discussion of GHG emissions analysis is included in Chapter 5.

## ES.5 Economic Benefits

MDE and RESI analyzed the economic impacts of the 2030 GGRA Plan using a dynamic macroeconomic model called REMI PI+, which 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.

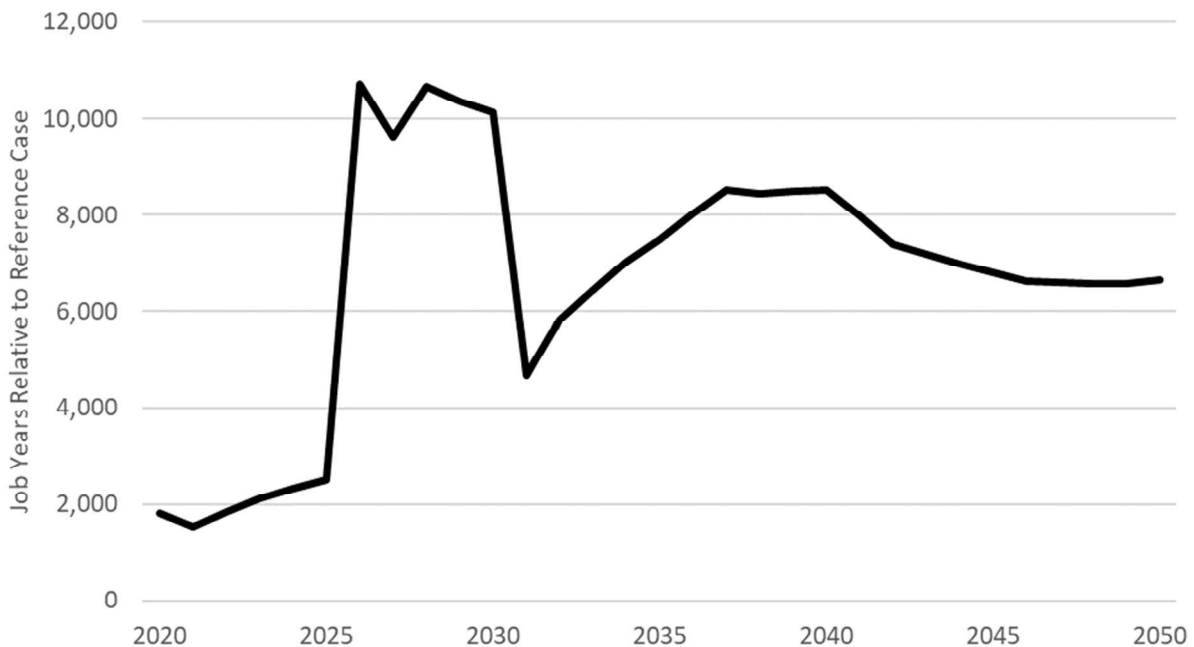


Sources: E3, MDE, RESI

Figure ES-6. Total Costs from 2030 GGRA Plan programs.

Although consumers and businesses are spending more on capital costs (e.g., energy-efficient appliances or new EVs) in the 2030 GGRA Plan (Figure ES-6), fuel savings are greater than this amount every year.

- Spending on transportation infrastructure projects is significant. 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 transit electrification).
- The impacts of infrastructure spending and capital costs can both be seen in Figure ES-7. The GGRA scenario supports an average of 6,186 jobs each year through 2030 relative to the reference case.

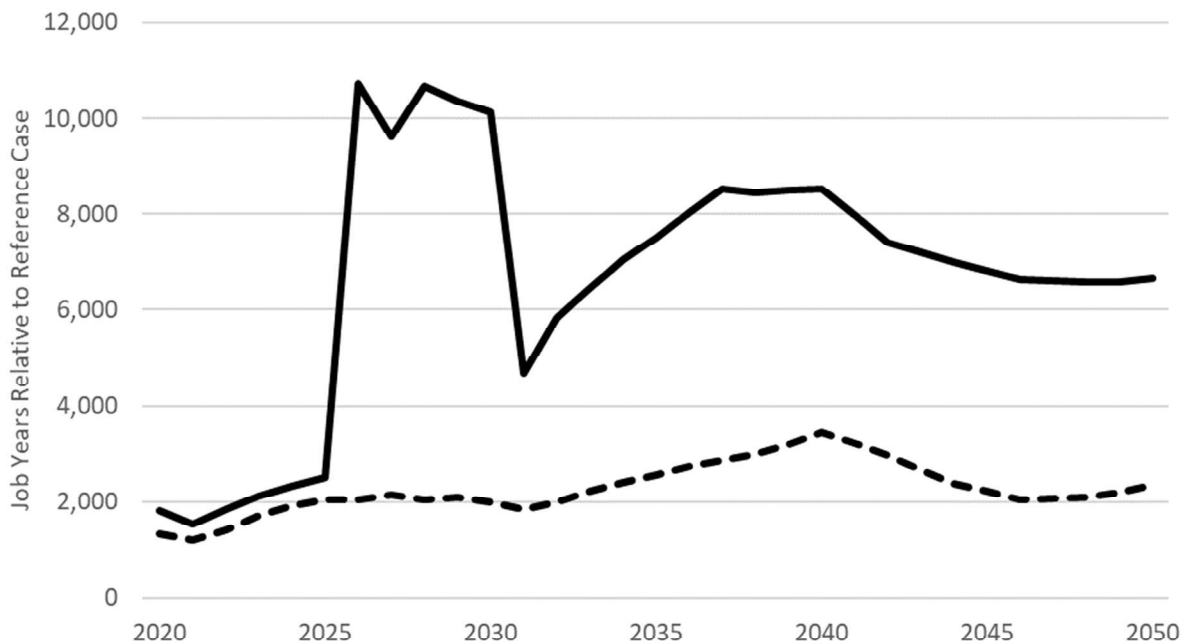


Sources: E3, MDE, REMI PI+, RESI

Figure ES-7. 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 relative to the reference case.

To visualize the impact of spending by the Maryland Department of Transportation (MDOT) on transportation infrastructure on the economic impact results for the GGRA scenario, Figure ES-8 below shows employment impacts with and without this spending.



**Figure ES-8. Employment in GGRA Scenario with Transportation Capital Investments (solid line) and without (dashed line) Relative to the Reference Case.**

On average through 2030, transportation infrastructure measures support 4,374 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 the 2030 GGRA Plan.

After 2030, the positive impacts through 2050 are being driven by two primary factors. First, while capital costs are generally higher than the *2019 GGRA Draft Plan*, fuel savings are substantially higher in the 2030 GGRA Plan. This leads to an acceleration in job growth. Second, after 2030 there is significant build-out in the in-state solar industry. This build-out is associated with an increase in jobs in the later years as Maryland invests in locally produced electricity generation.

Detailed discussion of economic impact analysis is included in Chapter 5.

## ES.6 Federal Action and Inaction

The 2030 GGRA Plan draws upon existing policies at the federal, state, and local level, and puts forward new programs to achieve Maryland’s GHG reduction goals.

The state plan does not rely on additional federal action to meet Maryland’s existing goals. However, federal action is absolutely necessary to address the challenge of climate change in the United States and globally, and to meet more ambitious Maryland goals posed by the MCCC. Maryland and fellow leadership states in the U.S. Climate Alliance, RGGI, and other collaborations have made great progress by advancing GHG reduction policies in the absence of much federal action, but there are limits to what states can accomplish without the federal government as a partner.

Achieving 50% or greater reduction in GHG emissions by 2030 and achieving net-zero GHG emissions by 2045 will require new technologies and substantial investment in energy systems that cross state lines. Federal action on clean

electricity can reduce emissions from power plants outside of Maryland that supply electricity into Maryland. Federal action on vehicle efficiency and EV incentives can reduce emissions from Maryland vehicles and from vehicles passing through Maryland. Federal action on building efficiency can deploy new technologies. New technologies to capture and store carbon, and to produce and use green hydrogen and other clean and renewable fuels will require investments in technology development and new interstate infrastructure systems.

Maryland will continue its nation-leading work<sup>5</sup> to reduce GHG emissions and grow its economy, and to work with other states to deploy solutions at greater scale. Maryland looks forward to partnering with the new federal administration as it renews the federal government's commitment to reducing GHGs and addressing climate change and environmental injustice.

## ES.7 Adaptation and Resiliency

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.<sup>6</sup> Over the past 10 years (2010-2020), Maryland has experienced 10 weather-related events warranting Presidential Disaster declarations, including five coastal flood events.<sup>7</sup> In Maryland, climate change risks include increased frequency, duration and intensity of events such as drought, storms, flooding, and forest fires; more heat-related stress; the spread of existing or new vector-borne diseases; changes to public health challenges as a result of climate-driven stressors, and increased erosion and inundation of low-lying areas along the state's shoreline and coast. These impacts will influence the interactions and management of our resources now and into the future.

Maryland has been implementing climate adaptation efforts for more than a decade. In 2008, the Adaptation and Resiliency Working Group (ARWG), a working group of the MCCC, published Phase I: Comprehensive Strategy to Reduce Maryland's Vulnerability to Climate Change,<sup>8</sup> which focused on sea level rise and coastal storms. In 2011 the second phase strategy was published, focused on societal, economic and ecological resilience.<sup>9</sup> These strategies together laid out recommendations on adaptation efforts that address changes in precipitation patterns and increased temperature as well as the likely impacts to human health, agriculture, forest and terrestrial ecosystems, bay and aquatic environments, water resources, and population growth and infrastructure.

Climate adaptation is also a key component of Maryland's Chesapeake Bay restoration efforts. Maryland has participated in the Chesapeake Bay Agreement since its inception in 1983, and has remained an engaged leader and member, working together with neighboring states to address all issues impacting the Bay. Maryland has signed and agreed to all subsequent goals and agreements since the initial program in 1983, including the 2014 Chesapeake Bay Watershed Agreement,<sup>10</sup> which included climate resilience as one of its main goals.

Adaptation refers to action to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities.<sup>11</sup> Climate change adaptation is an extremely complex process with no single means of response. As stressed in a recent report by the National Academies,<sup>12</sup> climate change adaptation must be a highly integrated process that occurs on a continuum, across all levels of government, involving many internal and external

<sup>5</sup> <https://www.wri.org/blog/2020/07/decoupling-emissions-gdp-us>

<sup>6</sup> Chesapeake Bay Foundation. What is Climate Change? (2020) <https://www.cbf.org/issues/climate-change/>

<sup>7</sup> FEMA All Disasters Database. (2020) <https://www.fema.gov/disasters/disaster-declarations>

<sup>8</sup> Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change Phase I: Sea-level rise and coastal storms (2008) [https://dnr.maryland.gov/ccs/Publication/Comprehensive\\_Strategy.pdf](https://dnr.maryland.gov/ccs/Publication/Comprehensive_Strategy.pdf)

<sup>9</sup> Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change Phase II: Building societal, economic and ecological resilience (2011) [https://climatechange.maryland.gov/wp-content/uploads/sites/16/2014/12/ian\\_report\\_2991.pdf](https://climatechange.maryland.gov/wp-content/uploads/sites/16/2014/12/ian_report_2991.pdf)

<sup>10</sup> Chesapeake Bay Watershed Agreement (2020) [chesapeakebay.net/documents/FINAL\\_Ches\\_Bay\\_Watershed\\_Agreement.withsignatures-HIres.pdf](https://www.chesapeakebay.net/documents/FINAL_Ches_Bay_Watershed_Agreement.withsignatures-HIres.pdf)

<sup>11</sup> Bierbaum, R., A. Lee, J. Smith, M. Blair, L. M. Carter, F. S. Chapin, III, P. Fleming, S. Ruffo, S. McNeeley, M. Stults, L. Verduzco, and E. Seyller, 2014: Ch. 28: Adaptation. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 670-706. doi:10.7930/J07HIGGT.

<sup>12</sup> National Research Council. 2010. Adapting to the Impacts of Climate Change. National Academies Press, Washington, DC

partners and individual actions, and often evolves at different spatial and temporal scales. Maryland recognizes the need to include robust adaptation and resiliency efforts alongside the aggressive GHG mitigation measures put in place to effectively address and protect the state from climate change impacts. These actions are increasingly dependent on one another, and any program or policy to mitigate the effects of climate change will complement steps to reduce the state's risk to those impacts. Mitigation without adaptation, or vice versa, could render Maryland, its people, and resources vulnerable to harm from impacts of climate change.

Adaptation aims to enhance the resilience of natural and human-based systems across multiple sectors, including bay and aquatic environments, agriculture, human health, water resources, population growth and infrastructure, forest and terrestrial ecosystems and our coastal zone. Maryland does not work in isolation on these efforts and relies on diverse partnerships at the local, state, and federal levels. Since the MCCC's inception, the ARWG has served as the state's leader on adaptation and resiliency. The ARWG develops comprehensive strategies to reduce Maryland's climate change vulnerability, serves as a resource to state and local governments for tools and planning resources and provides a platform for collaboration. In addition to the ARWG, Maryland's participation in multi-jurisdictional compacts such as the Chesapeake Bay Program (CBP) is essential to the state's success in the adaptation arena. The CBP's Climate Resiliency Work Group (CRWG) leads and monitors work being done in accordance with the climate resiliency goal of the 2014 Chesapeake Bay Watershed Agreement. The ARWG, CBP, and CRWG memberships include representatives across state government agencies, institutes of higher education, and non-governmental organizations. Working across and between compacts like the CRWG and the ARWG ensures Maryland relies upon a large, diverse, and committed group of organizations and individuals implementing climate adaptation efforts across the state, protecting Maryland's societal, economic, and ecological resources for years to come.

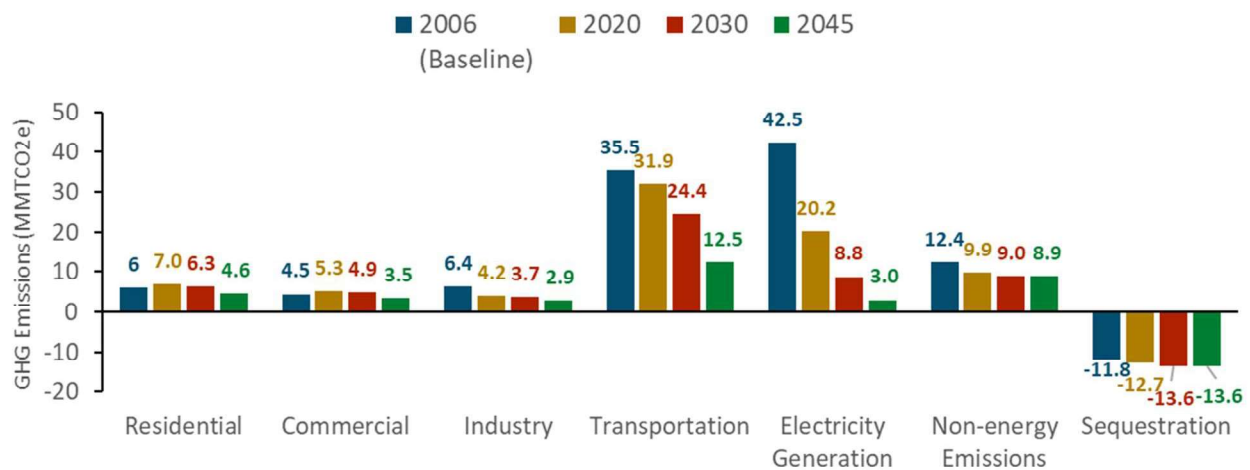
Detailed discussion of adaptation and resiliency is included in Chapter 7.

## ES.8 Getting to Net Zero

The GGRA of 2016 requires that the 2030 GGRA Plan be developed in recognition of the need for developed nations to reduce GHG emissions between 80% and 95% from 1990 levels by 2050. In its 2020 Annual Report, the MCCC recommended that Maryland adopt a more ambitious long-term goal of achieving net zero GHG emissions as early as 2045.

The 2030 GGRA Plan acts as an important step toward 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 2030 GGRA Plan includes several additional "what if" scenarios to estimate the future impact of various 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 several potential measures and technologies that the state could deploy after 2030 to achieve deeper reductions by 2045 and 2050.



**Figure ES-9. Maryland GHG emissions (MMtCO<sub>2</sub>e) by sector in 2006, 2020, 2030, and 2045 in the 2030 GGRA Plan.**

With the measures advanced in the 2030 GGRA Plan, Maryland will substantially reduce emissions from buildings, transportation, and electricity generation, while improving the rate at which its forests and farms are removing CO<sub>2</sub> from the atmosphere (Figure ES-9). Thanks to the clean electricity programs in the 2030 GGRA Plan, Maryland achieves 100% clean electricity by 2040, largely eliminating emissions from its power plants; the residual electricity sector emissions are attributable to power plants outside of Maryland that supply electricity consumed in Maryland, and over which the State of Maryland has limited influence. Without further action in the 2030s, by 2045 Maryland continues to emit approximately 22 MMtCO<sub>2</sub>e more than it sequesters. The remaining emissions come from Maryland’s buildings, vehicles, industrial facilities, waste management systems, and fossil fuel infrastructure.

Securing the additional reductions beyond 2030 necessary to achieve net-zero by 2045 will require deploying new and emerging zero-emissions technologies in buildings and non-road transportation applications, zero-carbon and renewable liquid and gaseous fuels for combustion uses that cannot be electrified, carbon capture and storage systems for industrial processes that emit CO<sub>2</sub> regardless of energy source, and greater long-term efforts to sequester CO<sub>2</sub> using both natural systems and potentially direct air capture systems. Many of those outcomes cannot be achieved without action by the federal government to support research and development, and commercialization of emerging technologies.

The 2030 GGRA Plan proposes a set of measures that are available and economically beneficial today, and that achieve reductions beyond the GGRA of 2016’s 2030 goal, and make substantial progress toward more ambitious goals recommended by the MCCC. 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.9 Sectors and Programs

The 2030 GGRA Plan utilizes various strategies, programs, and initiatives that the state is developing and implementing to meet the GHG 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 sectors, 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 2030 GGRA Plan extend from the suite of programs developed for previous GGRA plans, specifically the state's 25% by 2020 Plan and the *2019 GGRA Draft 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, they are at least partly due to mild weather in 2017, so continued progress is necessary to ensure we maintain and sustain reductions beyond 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.

## Electricity Generation

Now Maryland's second-largest source of GHG emissions, the electricity generation sector includes emissions from Maryland's fossil fuel-burning power plants, as well as estimates of the emissions associated with electricity generated outside of Maryland, but used in the state (Imported Power).

The electricity generation strategy in the 2030 GGRA Plan is designed to achieve **100% Clean and Renewable Electricity by 2040** by both deploying energy through the existing Renewable Portfolio Standard (RPS) and the proposed Clean and Renewable Energy Standard (CARES), and by capping and reducing emissions through RGGI.

Achieving 100% clean electricity is an essential part of the economy-wide decarbonization and electrification strategy, as it will not only reduce emissions from Maryland power plants, but also provide carbon-free energy to decarbonize the buildings and transportation sectors by replacing fossil-powered systems with electric systems that run on increasingly clean and renewable electricity.

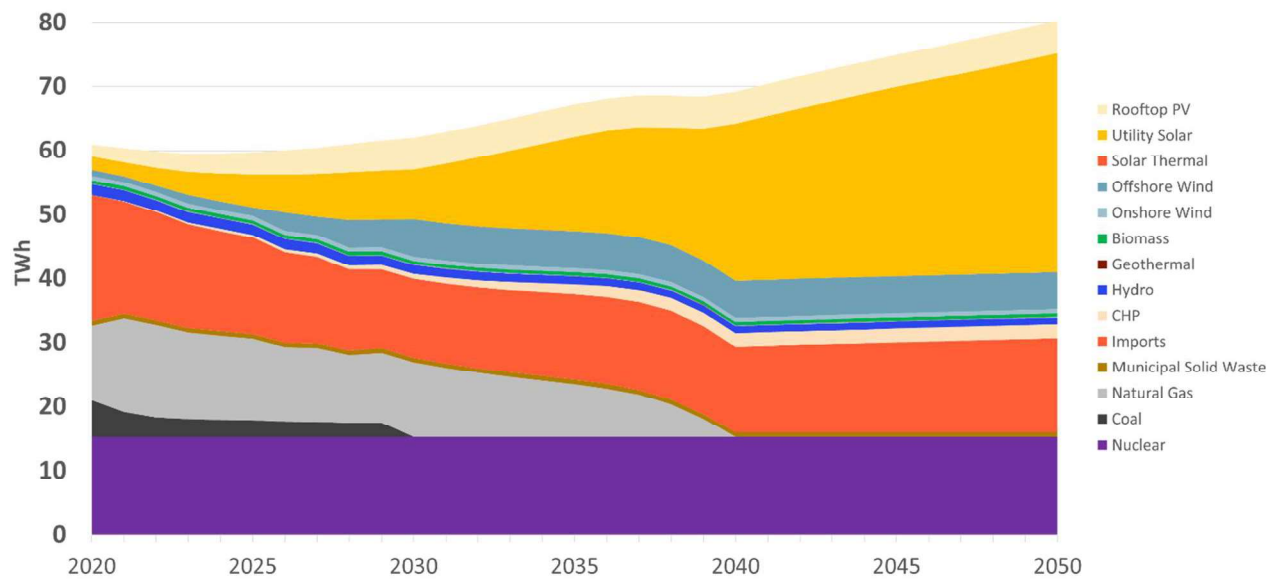
### Deploying Clean and Renewable Energy through the RPS and CARES

Maryland's RPS requires Maryland electric utilities to purchase increasingly large proportions of Maryland's electricity from renewable energy sources like solar, wind, hydropower, and qualifying biomass. The current RPS goal is for 50% of Maryland's electricity to come from renewable sources by 2030 through substantial increases in solar power and deployment of new offshore wind energy off the Atlantic coast.

The proposed CARES would build upon the existing RPS to achieve 100% clean electricity by 2040. It would rely on both renewable energy and additional zero- and low-carbon electricity sources to meet that goal where most cost-effective, including:

- Additional Maryland solar power beyond the current RPS requirements;
- New efficient Combined Heat and Power (CHP) systems in Maryland buildings;
- New nuclear power; and
- Natural gas or qualifying biomass power plants with carbon capture and storage (CCS).

Analyses by MDE and Resources for the Future (RFF) estimate that the CARES program would result in substantial increases in Maryland solar power and efficient CHP systems under current projections of resource costs. Should other eligible clean energy sources become less expensive, the CARES program would deploy the most cost-effective mix of resources to meet the 100% clean electricity goal.



**Figure ES.10. Maryland electricity mix through 2050 in the 2030 GGRA Plan.** Fossil power plants without carbon capture and storage technology (gray colors) are eliminated by 2040 and replaced with clean and renewable energy. “Imports” reflects electricity generated outside of Maryland but consumed in Maryland. Analysis assumes no carbon capture or new nuclear facilities available before 2030.

### **Capping and Reducing Fossil Energy through RGGI**

RGGI is a collaborative program among Eastern states to reduce CO<sub>2</sub> emissions from power plants through a regional cap-and-invest program. Maryland has participated in RGGI since its inception 12 years ago. Through RGGI, the participating states have cut power plant emissions in half while enjoying billions of dollars of economic benefit and creating thousands of jobs.<sup>13</sup>

Thanks to its success, RGGI has grown substantially in recent years, with New Jersey renewing its participation in the program in 2020, Virginia joining in 2021, and Pennsylvania proposing to begin participation in 2022.

RGGI sets a binding cap on CO<sub>2</sub> emissions from power plants in the region that reduces every year. To achieve the 100% clean electricity by 2040 goal, the 2030 GGRA Plan proposes to reduce the RGGI cap to zero by 2040, with cost controls. Maryland will bring that goal into the upcoming 2021 Program Review, where the RGGI participating states convene to establish the program’s future goals. Combined with the RPS and proposed CARES program, that would eliminate CO<sub>2</sub> from Maryland power plants and substantially reduce emissions from the power plants in nearby states that supply electricity into Maryland.

### **Beneficial Siting of Renewable Energy Resources**

Building sufficient renewable electricity capacity to meet Maryland’s climate change goals will require careful balancing of land-use impacts, particularly from solar energy. The 2030 GGRA Plan incorporates the recommendations of Governor Hogan’s Task Force on Renewable Energy Development and Siting that identified several opportunities to prioritize renewable energy development in preferable locations, including degraded lands, building rooftops, and parking lot canopies.<sup>14</sup>

### **Offshore Wind MOU - SMART-POWER**

<sup>13</sup> <https://www.rggiprojectseries.org/>

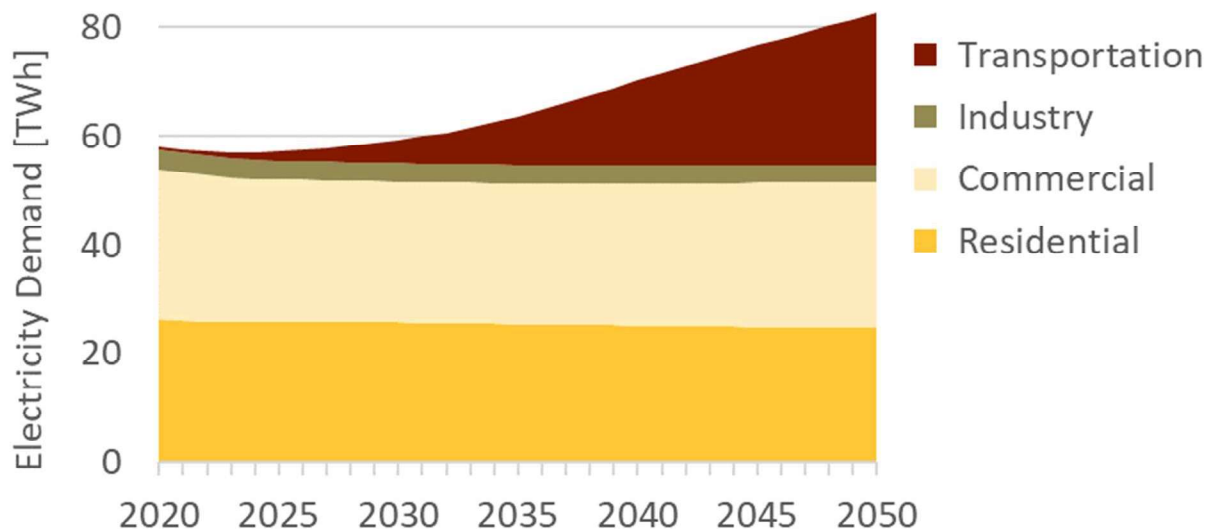
<sup>14</sup> <https://governor.maryland.gov/energy-task-force/>



Maryland also continues to work with its regional partners, and most recently Maryland joined North Carolina and Virginia in launching the Southeast and Mid-Atlantic Regional Transformative Partnership for Offshore Wind Energy Resources (SMART-POWER). This tri-state collaborative effort to promote the Southeast and mid-Atlantic United States as a hub for offshore wind and industry. Under this initiative the three states agree to cooperatively promote, develop and expand the offshore wind industries, estimated to support up to 86,000 jobs and \$57 billion in investment by 2030.

### **Managing a Clean and Electrified Energy System**

A 100% clean electricity system will enable decarbonization and electrification of the transportation and building sectors, as EVs and electric heating systems use carbon-free energy sources. However, Maryland will have to deploy new and emerging technologies and practices to accommodate the increased electricity demand and balance an electrical grid that uses substantial amounts of intermittent renewable energy.



**Figure ES-11. Electricity use by sector under the 2030 GGRA Plan.** Increased demand from building electrification is offset by energy efficiency, but additional load from EVs increases total Maryland electricity consumption beginning in the late 2020s.

Building upon the Maryland Public Service Commission’s (PSC) grid modernization process (PC-44), Maryland will deploy battery storage, flexible demand management, and other solutions to integrate higher levels of clean and renewable energy, and satisfy increasing demand for electricity, particularly to charge EVs.

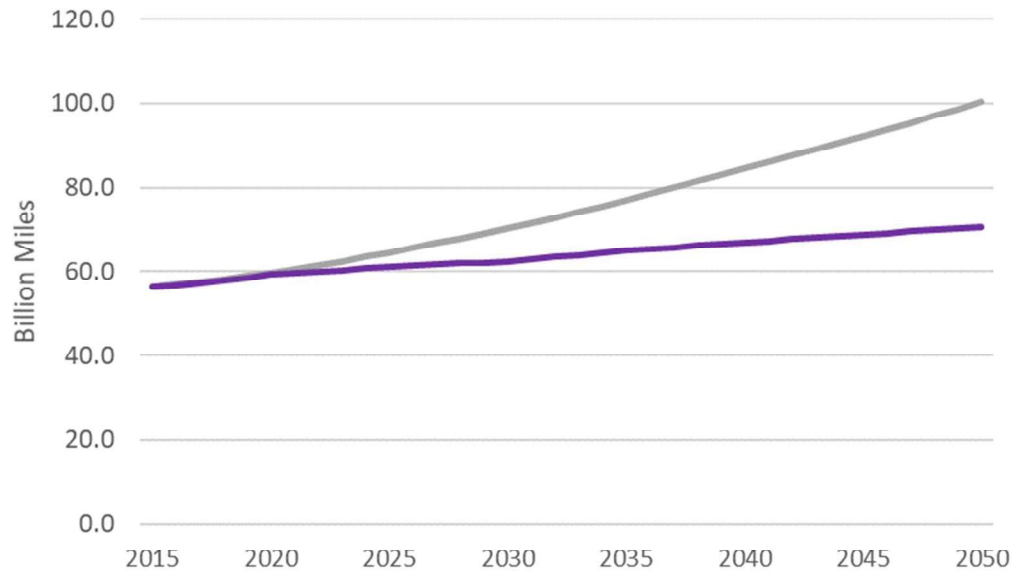
Maryland does have time to plan for and deploy those solutions. Increased electricity demand will take decades to accumulate because of the long lifetime of vehicles and building heating systems that will be electrified at the end of their useful life, and most of the additional demand will likely come from EVs whose charging can be timed to help balance generation and load on the electrical grid.

### **Transportation**

The transportation sector is the largest source of GHG emissions in Maryland. Most of those emissions come from light-duty passenger cars and trucks, followed by heavy duty trucks. The transportation strategy in the 2030 GGRA Plan is to provide Marylanders with reliable clean transportation alternatives to driving single occupancy vehicles, while accelerating deployments of electric and other zero emissions vehicles (ZEVs) that are powered by increasingly clean Maryland electricity.

## **Promoting Reliable Clean Transportation Options**

Reducing miles traveled on Maryland’s roads reduces GHG emissions, saves fuel, and relieves congestion on busy roadways. The 2030 GGRA Plan will reduce vehicle miles traveled (VMT) by continuing and expanding investments in public transit systems, intercity systems like the Maryland Area Regional Commuter (MARC) train, and bike and pedestrian infrastructure, while achieving the Smart Growth program’s compact development goal.



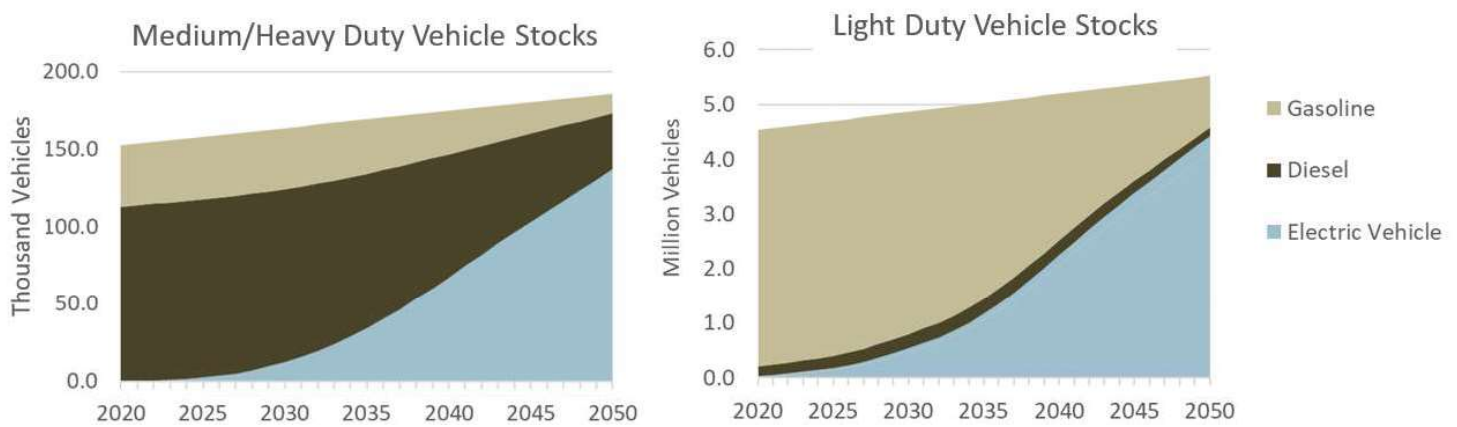
**Figure ES-12. Miles traveled on Maryland roads under the 2030 GGRA Plan (purple line) versus without the investments in the 2030 GGRA Plan (gray line).**

## **Deploying ZEVs**

EVs and plug-in hybrid vehicles that use electricity instead of gasoline or diesel substantially reduce GHG emissions and other pollutants that harm air quality and public health. As Maryland’s electricity system continues to decarbonize, the pollution benefits of EVs will become even greater.

The 2030 GGRA Plan builds upon Maryland’s early action to deploy ZEVs through the Maryland Clean Cars Program’s ZEV mandate regulation that requires car manufacturers to sell ZEVs into Maryland and other participating states, the EV excise tax credit that provides rebates to purchasers of EVs, and the EV charging infrastructure deployments coordinated by the Zero Emissions Electric Vehicles Infrastructure Council (ZEEVIC).

The 2030 GGRA Plan will accelerate deployment of EVs across all on-road vehicle classes and complement existing market forces. Maryland recently signed a Memorandum of Understanding with 13 other jurisdictions to electrify medium and heavy-duty trucks, with the goal of achieving a 30% sales share of ZEV medium and heavy-duty vehicles by 2030, and 100% ZEV sales by 2050. Maryland and the other signatory states are developing action plans to achieve those goals in 2021.



**Figure ES-13. Maryland's stock of medium and heavy-duty vehicles (left) and light-duty cars and trucks (right).**

Maryland also works with other states in the Transportation and Climate Initiative (TCI), a regional effort aimed at developing a potential cap-and-invest program to apply the successful RGGI model to transportation emissions. A few of the TCI jurisdictions are moving to implement the program, which would provide additional funding to advance cleaner transportation programs like those in the 2030 GGRA Plan, including investments in clean transportation infrastructure, electric trucks and buses, electric cars, and other projects.

### **Leading by Example: Maryland State Government Vehicles and Transit Buses**

Maryland state agencies' vehicle fleets include nearly 4,000 light-duty vehicles that can be converted to ZEV by 2030, given adequate funding for charging infrastructure at state facilities and for higher vehicle purchase prices. The Maryland Department of General Services (DGS) is coordinating a *State Innovation Plan* to deploy the necessary infrastructure to electrify those vehicles. In addition, the MDOT Maryland Transit Administration is establishing contracts and building charging infrastructure to convert half of Maryland's transit buses to ZEV by 2030.

### **Residential and Commercial Buildings**

Combustion of fossil fuel in buildings is a substantial source of emissions in Maryland. Most of this energy use is for space and water heating. The 2030 GGRA Plan reduces emissions from energy use in residential and commercial buildings by prioritizing energy efficiency to counteract increases in use that would otherwise occur from growth in Maryland's economy, and by converting fossil fuel heating systems to efficient electric heat pumps that are powered by increasingly clean and renewable Maryland electricity.

### **Reducing Energy Use Through Energy Efficiency**

Originally established in 2008, EmPOWER Maryland is a nation-leading energy efficiency program that has dramatically reduced energy use and emissions in Maryland. EmPOWER has established annual energy savings requirements for Maryland electric utilities through 2023. The 2030 GGRA Plan proposes that the EmPOWER program continue to invest in energy efficiency beyond 2023.

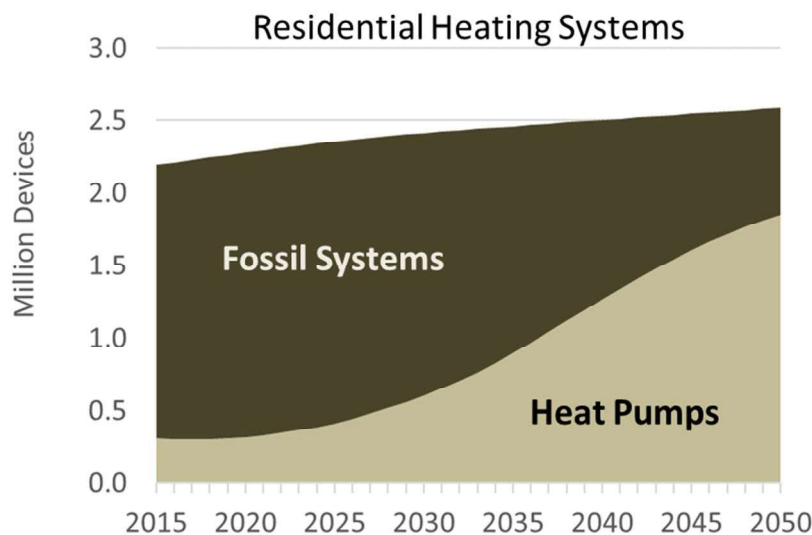
Beyond direct investments through EmPOWER Maryland, the 2030 GGRA Plan includes several measures to continue to improve efficiency in Maryland's buildings. Continuing to achieve the Smart Growth program's compact development goal saves energy through more efficient homes and businesses. Adoption of new building codes at the state and local level will continuously drive efficiency in new buildings and advance building technologies. And investments in state buildings coordinated under a 2019 Executive Order issued by Governor Hogan will reduce energy use in state facilities by at least 10% by 2030.

## **Beneficial Electrification of Building Heating Systems**

Many homes and businesses in Maryland are already heated by heat pumps, which use electricity to move heat from outside air (air source heat pumps) or the ground (ground source heat pumps) into buildings. These heating systems are much more efficient than furnaces or boilers that burn natural gas, heating oil, or propane for heat, and electricity is a lower carbon source for energy than those other fuels. The result is that homes heated by heat pumps are responsible for fewer GHG emissions than those heated by fossil systems. As Maryland's electricity system continues to decarbonize, the pollution benefits of heat pumps will continue to grow. However, converting fossil fuel systems to electric systems costs more than replacing systems like-for-like when they need to be replaced, and in some cases heat pump systems may cost more to operate than systems that burn natural gas.

In its 2020 Annual Report, MCCC identified initial steps Maryland can take to increase the use of efficient electric heat pumps to heat homes and businesses, while launching a Building Energy Transition Plan process for 2021. Those steps include reforming the EmPOWER Maryland program to pursue a portfolio of mutually reinforcing goals, including GHG reductions, energy savings, net customer benefits, and reaching underserved customers. Broadening the goals of the EmPOWER program and removing existing barriers to fuel switching would allow Maryland to provide funding for homeowners and building managers to replace fossil fuel burning furnaces and boilers with efficient electric heat pumps when those systems need to be replaced and it is cost effective to do so.

The MCCC's plan will identify more specific measures and goals to decarbonize the building sector. In the meantime, the 2030 GGRA Plan incorporates estimates of the emissions reductions from converting fossil fuel burning systems to efficient heat pumps that are powered by increasingly clean and renewable Maryland electricity.



**Figure ES-14. Composition of residential heating systems in Maryland in the 2030 GGRA Plan.** Thanks to incentives for heat pumps, increasingly large shares of fossil systems are replaced by heat pumps when they reach the end of their useful life. Heat pump use in commercial buildings projected to be lower.

## **Carbon Sequestration on Natural and Working Lands**

In addition to reducing GHG emissions from sources throughout Maryland, the 2030 GGRA Plan includes measures to pull more CO<sub>2</sub> out of the atmosphere through improved management of Maryland's forests and farms. Forests store large amounts of carbon both above ground and in the soil, and soil conservation practices on farms can increase long-term carbon storage in farm soils.

## **Improved Forest Management and Tree Planting**

Maryland's forests play an important role in mitigating GHG emissions and actions are being taken by the state to enhance this conservation practice.. Enrolling previously unmanaged forests into sustainable 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. Increasing forest management has economic benefits and results in additional availability of renewable biomass for energy production. The 2030 goals for managing Maryland forests are to provide sustainable forest management on 38,000 acres of private land annually, ensure greater than 50% of state-owned forest lands will continue to be third-party certified as sustainably managed, support forest markets that keep land in forest use, and provide sustainable management for multiple benefits on other state lands where possible. In addition to managing existing forests many new trees are planted in the state every single year. These plantings expand the state's forest cover and stores of carbon by regenerating or establishing healthy, functional canopies and forests utilizing practices such as soil preparation, erosion control and supplemental planting. By 2030, the goal is to achieve the afforestation or reforestation of 68,530 acres in Maryland, including planting 4.6 million trees. The 2030 GGRA Plan also includes planting 2.65 million urban trees, for a total of 7.25 million trees planted by 2030.

## **Maryland Healthy Soils Initiative**

In addition to reducing nutrient and sediment flows into the Chesapeake Bay and its tributaries, many of the agronomic and conservation practices already 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 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 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 also intends to use this information to explore the options for the metrics and tools that will be used to quantify soil carbon as well as provide incentives to encourage the widespread implementation of climate-friendly soil practices. Existing programs, too, are being examined and expanded to find ways to capitalize on co-benefits for both air and water quality, and carbon sequestration that build upon Maryland's nationally-recognized progressive farming practices and programs.

## **Short-Lived and Super-Pollutant Greenhouse Gases**

While the bulk of Maryland GHG emissions are CO<sub>2</sub> from combusting fossil fuels, substantial amounts of climate-warming pollution come from emissions of methane from the natural gas system, agriculture and waste management, and from other pollutants like hydrofluorocarbons (HFCs). The 2030 GGRA Plan includes targeted measures and regulations to identify and mitigate those emissions sources.

## **Eliminating Super-Polluting HFCs**

HFCs are chemicals used as propellants and refrigerants in a variety of products, air conditioning and refrigeration systems that are extremely potent GHGs when released into the atmosphere.

After efforts to limit fugitive emissions of HFCs stalled at the federal level, several states began their own initiatives to phase out certain highly potent HFCs - some with the climate forcing effect of approximately 1,400 pounds of CO<sub>2</sub>. **MDE finalized regulations in 2020 that will phase out the use of certain HFCs in multiple end-uses, such as foam products and certain refrigeration equipment in retail establishments such as supermarkets.** The phase out of HFCs will require the use of alternatives with much lower GHG emissions.

## **Catching and Eliminating Methane Leaks**

Methane, the primary constituent of natural gas, is a short-lived but potent GHG that leaks from the natural gas delivery system. The 2030 GGRA Plan includes measures to catch and eliminate those leaks, including regulations MDE finalized in 2020 that require leak detection and repair measures in the transmission system, and replacement of old and leaky pipes throughout the utility distribution systems.

Detailed discussion of each of the dozens of GHG reduction measures in the 2030 GGRA Plan is included in Chapter 3.

## **ES.10 Conclusions**

**The 2030 GGRA Plan is both ambitious and achievable and includes dozens of important large and small initiatives to reduce GHG emissions in Maryland.** When fully implemented, the 2030 GGRA 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 2030 GGRA Plan will position the state to achieve more ambitious goals recommended by the MCCC, including a 50% reduction in GHG emissions by 2030, and net zero emissions by 2045. **While the economic and environmental effects of the COVID-19 pandemic are still uncertain, the state's focus on combating climate change and reducing GHG remains on track.**