Maryland Department of the Environment

Appendix G

Economic Impacts

2030 GGRA Plan

Appendix G: Economic Impacts

Commissioned by
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Acronyms and Abbreviations

AVERT — Avoided Emissions and Generation Tool
CARES — Clean and Renewable Energy Standard
CHP — Combined heat and power
CTAM — Carbon Tax Assessment Model
COBRA — CO-Benefits Risk Assessment
E3 — Energy and Environmental Economics, Inc.
EPA — U.S. Environmental Protection Agency
GGRA — Greenhouse Gas Emissions Reduction Act
GSP — Gross state product
HCUP — Healthcare Cost and Utilization Project
MCCC — Maryland Commission on Climate Change
MDE — Maryland Department of the Environment
MDOT — Maryland Department of Transportation
MMBTUs — Millions of British Thermal Units
MOU — Memorandum of understanding
MPG — Miles per gallon
MPO Metropolitan Planning Organization
MWG — Mitigation Working Group
NAICS North American Industrial Classification System
NH_3 — Ammonia
NO_X — Nitrogen oxides
$PM_{2.5}$ — Fine particulate matter with a diameter less than 2.5 micrometers
Project Team — RESI and E3
RCCI — Regional Cost Collection Initiative Bill
RESI — Regional Economic Studies Institute
RGGI — Regional Greenhouse Gas Initiative
RPS — Renewable portfolios standard
SO_2 — Sulfur Dioxide
SOC — Standard Occupational Classification
VMT — Vehicle miles traveled
VOCs — Volatile organic compounds

1.1 Executive Summary

The Maryland Department of the Environment (MDE) tasked the Regional Economic Studies Institute (RESI) of Towson University to provide a coherent set of analyses that would inform the development of MDE's proposed plan to reduce statewide greenhouse gas emissions by 40 percent from 2006 levels by 2030. MDE's proposed plan was created to satisfy its obligations under the Greenhouse Gas Emission Reduction Act (GGRA) Reauthorization. To form the Project Team, RESI contracted with Energy and Environmental Economics, LLC (E3) to model changes in emissions arising from various policy bundles under consideration. The results of the emissions modeling, conducted using the PATHWAYS model, are discussed in Chapter 6 of this report. This emissions modeling, along with estimates of program costs from state agencies, formed the base of the economic modeling, which is contained in this chapter. RESI completed the economic modeling using the REMI Model.[1]

The REMI model is a high-end dynamic modeling tool used by various federal and state government agencies in economic policy analysis. The REMI model is calibrated to both the specific demographic features of Maryland as a whole and five distinct regions of the state:

- **Central Maryland**: Baltimore City and Harford, Baltimore, Carroll, Anne Arundel, and Howard Counties;
- **Southern Maryland**: St. Mary's, Charles, and Calvert Counties;
- **Capital Maryland**: Frederick, Montgomery, and Prince George's Counties;
- **Western Maryland**: Garrett, Allegany, and Washington Counties; and
- **Eastern Shore**: Cecil, Kent, Queen Anne's, Talbot, Caroline, Dorchester, Wicomico, Somerset, and Worcester Counties.

Additionally, the Project Team conducted public health modeling to estimate the economic impact associated with improved air quality under each policy scenario.

1.1.1 Criteria for Evaluating the Economic Impact of Policy Scenarios

In addition to satisfying emission requirements through 2030, the policies selected by the State of Maryland to reduce carbon emissions must provide a net benefit to the Maryland economy. To determine whether each policy scenario meets this economic mandate and qualifies as meeting the economic goals of the GGRA, RESI used the following set of indicators:

- Average positive job growth through 2030;
- Positive cumulative personal income growth through 2030 with a 3 percent discount rate; and
- Positive cumulative gross state product (GSP) growth through 2030 with a 3 percent discount rate.

In addition to these three metrics, the Project Team considered other measures of economic well-being, including:

[1] All analyses were conducted using REMI Version 2.2.

- The impact across different sectors of Maryland's economy, including manufacturing;
- The impact on consumer prices;
- Distributional impacts in terms of income, education and training, and race/ethnicity; and
- The regional distribution of jobs.

Reducing carbon emissions and ensuring net benefits to Maryland's economy are not mutually exclusive goals. The following sections will outline the various policy bundles that the Project Team considered, as well as the results of the analysis.

1.1.2 Overview of the MWG Scenario, Draft GGRA Plan and the Final GGRA Plan

In evaluating policies to reduce carbon emissions in Maryland and achieve the goals set in the GGRA plan, the Project Team evaluated a total of four preliminary policy scenarios. Based on these draft analyses, the Draft GGRA Plan was constructed, a subsequent scenario put forth by the Mitigation Working Group (MWG) was constructed, and the Final GGRA Plan was developed. This section provides an overview of these three newer scenarios.

1.1.2.1 Draft GGRA Plan

The Draft GGRA Plan, published in 2019, assumes a continuation or extension of current policies. For example, EmPOWER goals that are currently in place are extended past the expiration year of 2023. In addition to these extensions, the Draft GGRA Plan layers on additional decarbonization efforts, including:

- A 100 percent Clean and Renewable Energy Standards (CARES) goal by 2040;
- Transit bus electrification and other transportation programs; and
- Forest management and healthy soils initiatives.

The Draft GGRA Plan was constructed both to achieve the emissions requirements laid forth in the GGRA and to provide a blueprint for future efforts to reduce greenhouse gas emissions.

1.1.2.2 MWG Scenario

The MWG Scenario established by the working group of the Maryland Commission on Climate Change in 2020 represents an aggressive bundle of decarbonization policies dictated by the working group. In contrast to the Draft GGRA Plan, the MWG Scenario pursues more aggressive:

- Electrification and efficiency in buildings;
- Sales of both light duty and heavy duty Zero Emissions Vehicles (ZEVs);
- Transit bus electrification and other transportation programs; and
- Forest management, healthy soils, and related practices.

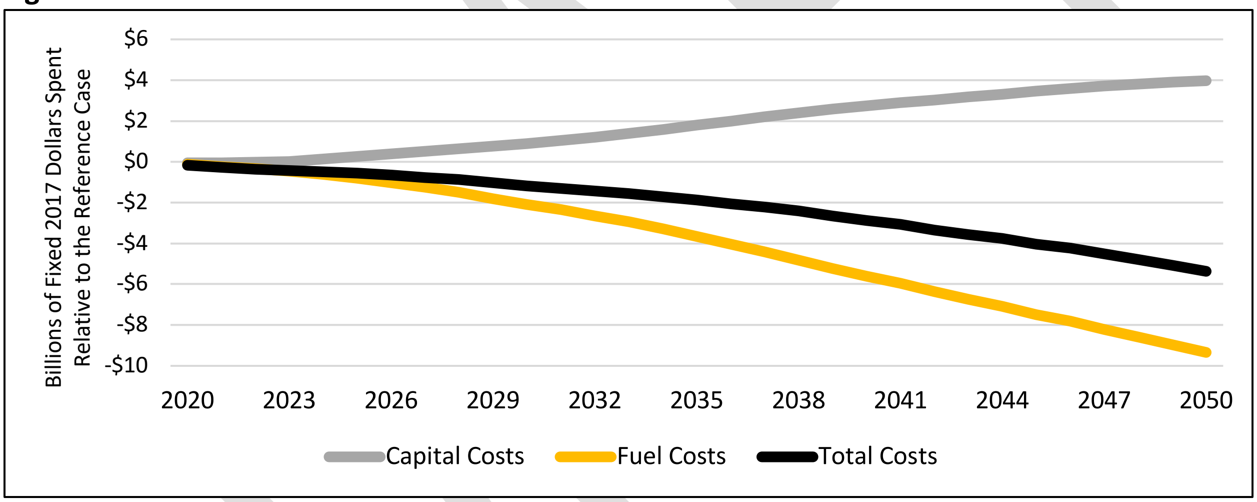
1.1.3 Final GGRA Plan

The Final GGRA Plan represents the plan proposed by MDE to achieve the emissions requirements as specified in the GGRA and provide a blueprint for future efforts to reduce greenhouse gas emissions. The Final GGRA Plan consists of a combination of policies from the MWG Scenario, as well as the Draft GGRA Plan, to determine an economically efficient bundle that yields significant reductions in emissions.

Compared to the MWG Scenario, this plan contains marginally less aggressive policies in a number of sectors, including electrification and increased efficiency in buildings, transportation (including both light and heavy-duty vehicle sales), and industrial energy use. On the other hand, compared to the Draft GGRA Plan, this plan contains significantly more aggressive measures in all the aforementioned sectors.

The Final GGRA Plan achieves the emissions goals with low levels of spending. As illustrated in Figure 1, for every year in the Final GGRA Plan, fuel savings offset capital expenditures, resulting in a net savings for the Maryland economy.

Figure 1: Total Costs from PATHWAYS in the Final GGRA Plan Relative to the Reference Case



Sources: E3, MDE, RESI

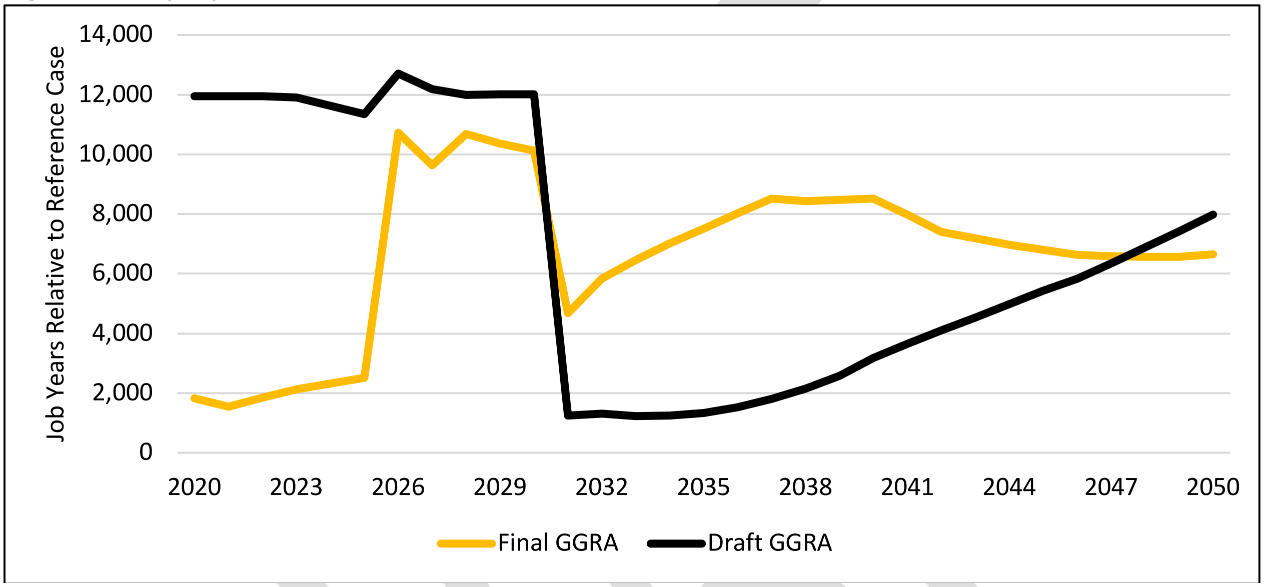
Although consumers and businesses are spending more on capital costs (e.g., new energy-efficient appliances or new electric vehicles) in the Final GGRA Plan than in the reference case, fuel savings exceed this amount every year. This is attributable to two general trends.

1. 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 bus electrification).
2. Total costs are generally the lowest when compared to the Draft GGRA Plan and the MWG Scenario. In both the Draft GGRA Plan and the MWG Scenario, total costs increase

post-2030 before eventually declining. The Final GGRA Plan has a consistent decline in costs through 2050.

The impacts of infrastructure spending and capital costs can both be seen when examining the economic impacts of the Final GGRA Plan. As seen in Figure 2, the Final GGRA Plan supports an average of 5,788 jobs each year through 2030 relative to the reference case.

Figure 2: Employment in the Final and Draft GGRA Plans Relative to the Reference Case

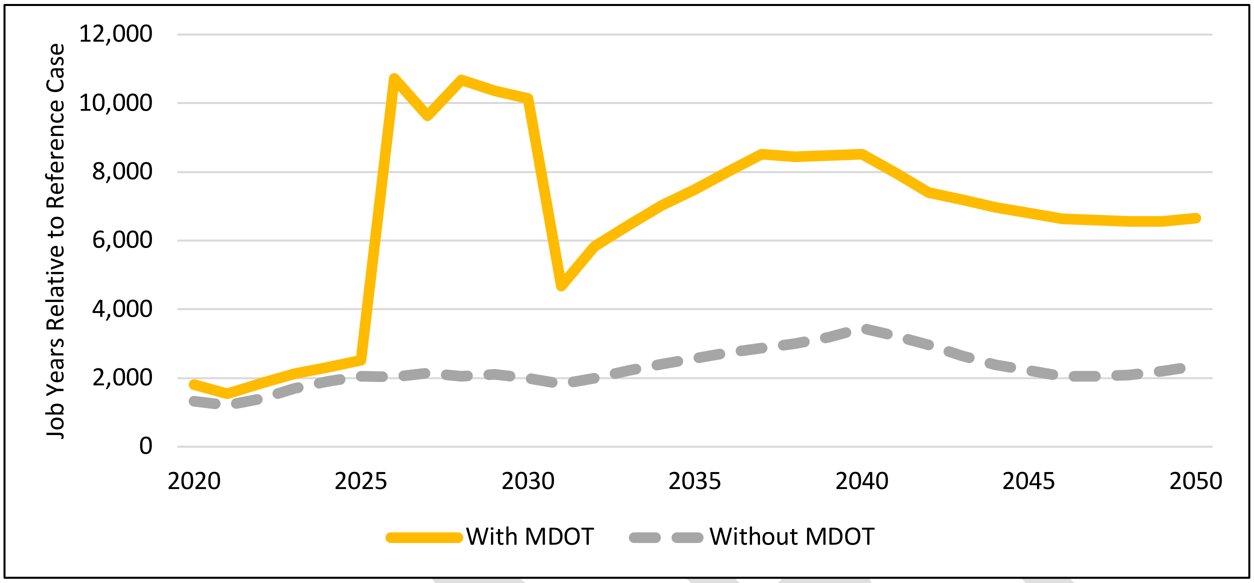


Sources: E3, MDE, REMI, RESI

Through 2030, these employment impacts are driven by transportation infrastructure projects, as seen in other policy scenarios. After 2030, employment impacts remain positive relative to the reference case. As seen above, forecasted employment in the Final GGRA Plan through 2030 is lower than the job gains originally calculated for the Draft GGRA Plan. Since the preparation of the Draft GGRA Plan analysis, MDOT has adopted a new six-year capital budget, called the Consolidated Transportation Program (CTP). This budget includes near-term capital investments that were previously part of the Draft GGRA Plan, but are included in the reference case when calculating the impact of the Final GGRA Plan. This is also true for a number of other policies originally included in the Draft GGRA Plan. The differences in employment between these two plans are primarily due to this change in the reference case, as opposed to an actual change in the total expected number of jobs.

To visualize the impact of transportation infrastructure spending on the economic impact results for the Final GGRA Plan, Figure 3 below shows employment differences for this scenario with and without this spending.

Figure 3: Employment in the Final GGRA Plan With and Without Transportation Spending Relative to the Reference Case



Sources: E3, MDE, REMI, RESI

The impact of transportation spending in the Final GGRA Plan is similar to the impacts in the other three policy scenarios. On average through 2030, transportation infrastructure measures support 3,977 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 Final 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 Draft GGRA Plan, fuel savings are substantially higher in the Final 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.

Figure 4 provides a summary of how each scenario performs in regards to meeting emissions goals (for both 2020 and 2030) as well as the economic goal.

Figure 4: Summary of Policy Scenarios

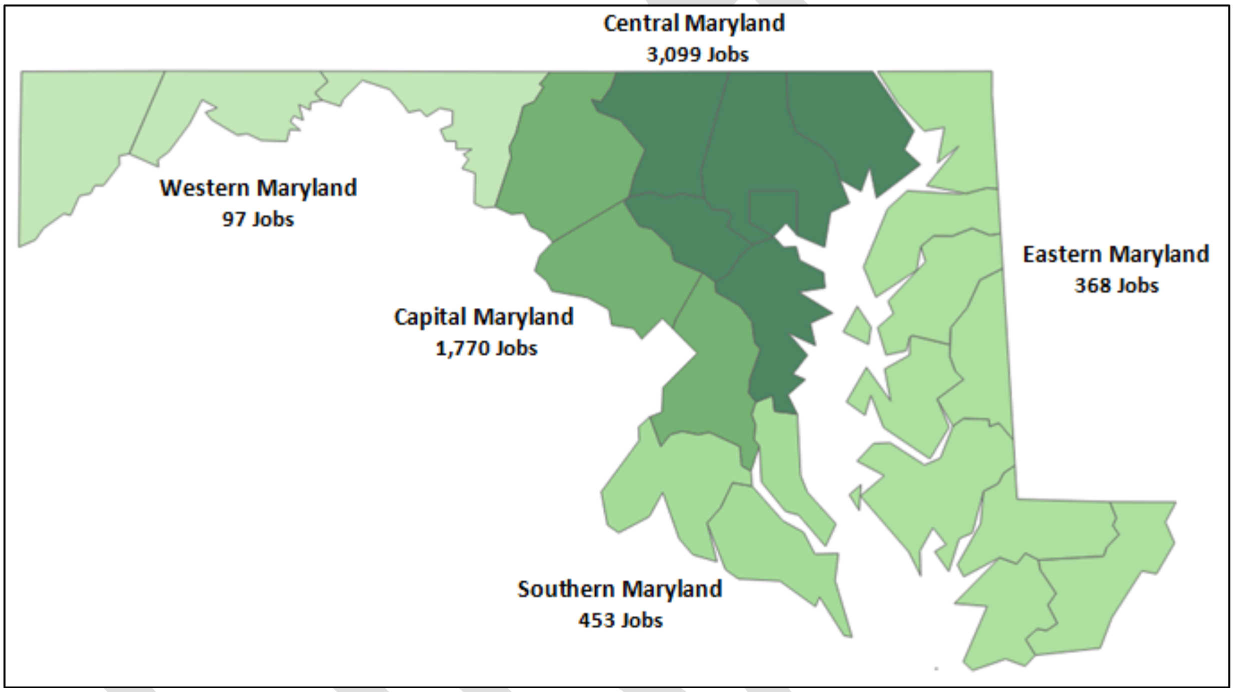
Policy Scenario	Achieve 2020 Emissions Goal?	Achieve 2030 Emissions Goal?	Achieve 2030 Economic Goal?
2019 Draft GGRA Plan	Yes	Yes	Yes
2020 MWG Policy Scenario	Yes	Yes	Yes
2020 Final GGRA Plan	Yes	Yes	Yes

Source: RESI

In sum, all three policy scenarios achieve the 2030 economic goals, as well as the 2020 and 2030 emissions targets. That is, all three policy scenarios exhibit a net positive benefit to the Maryland economy while also reducing emissions by at least 40 percent of 2006 levels by 2030.

In addition, RESI's analysis shows the distributional impacts of the Final GGRA Plan when considered along the lines of geographic region, income level, and race. As shown in Figure 5, all regions of Maryland experience positive job growth relative to the reference case through 2030 for the Final GGRA Plan.

Figure 5: Employment Impacts by Region for Final GGRA Plan

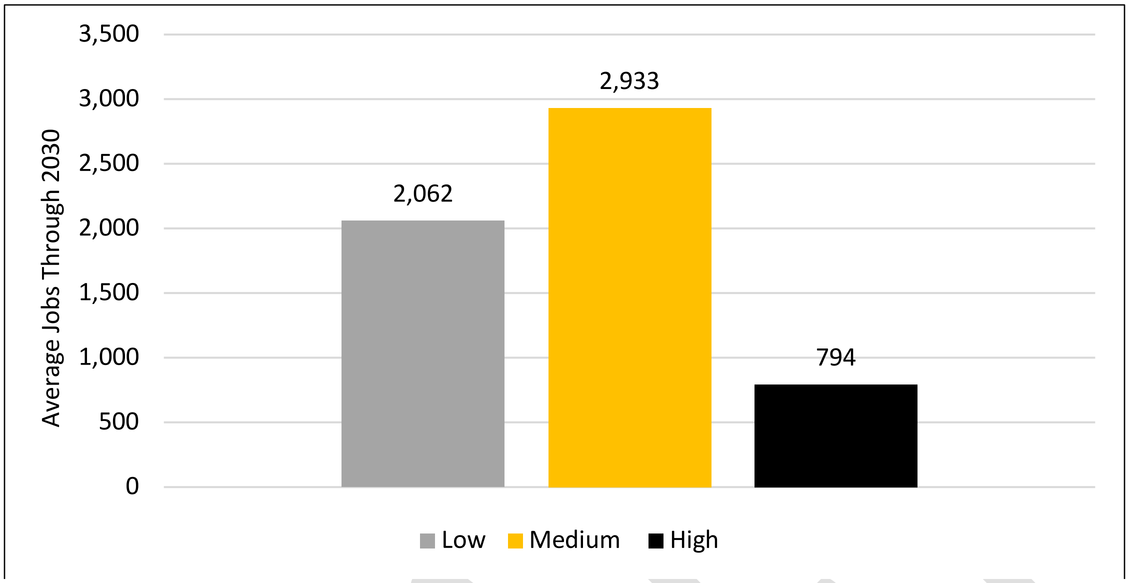


Sources: E3, MDE, REMI, RESI

Under this plan, Central Maryland sustains the largest employment gains of 3,099 jobs. The Capital Maryland region also shows significant employment increases of 1,770 jobs. Central, Eastern, and Southern Maryland have the most significant employment impact when adjusting for population, each gaining a number of annual jobs approximately equal to 0.1 percent of the region's population. Western Maryland adds jobs at only a quarter of that rate.

Employment distribution by wage groups for the Final GGRA Plan are shown in Figure 6 below.

Figure 6: Employment Impacts by Wage Group for Final GGRA Plan

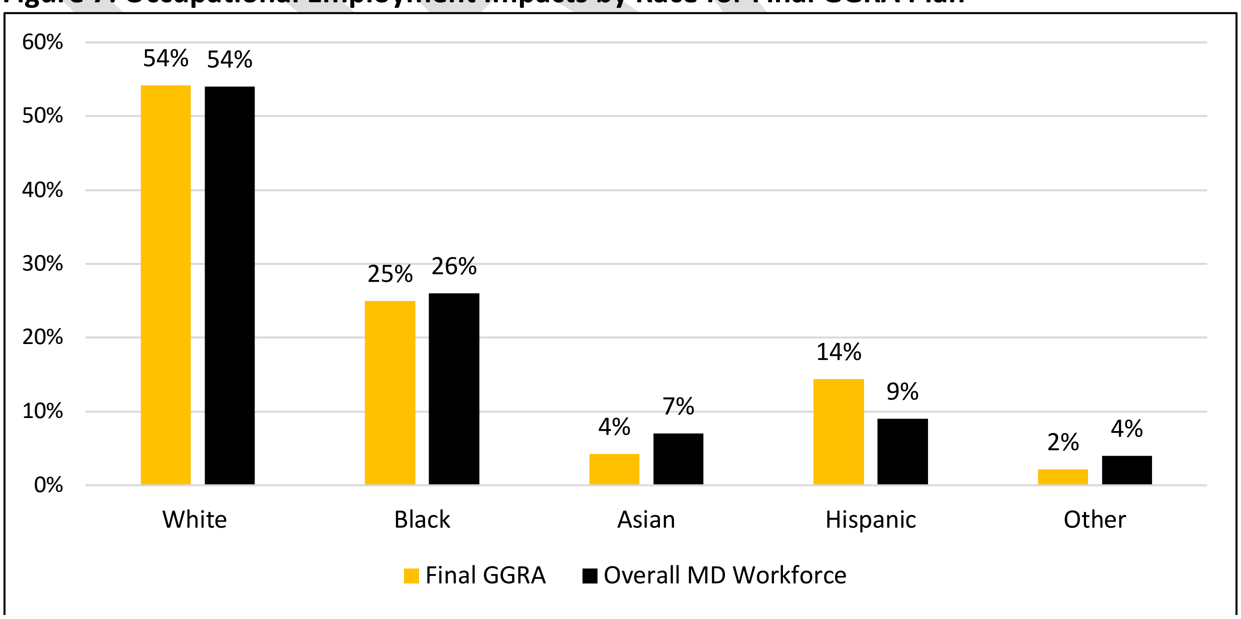


Sources: E3, MDE, REMI, RESI, U.S. BLS

Just over half of the employment impacts under the Final GGRA Plan (2,933 jobs) are found in medium-wage occupations earning between $35,000 and $65,000 annually. A higher number of positions are found in low-wage jobs than high-wage jobs, with more than twice the number of low-wage jobs than in the high-wage category.

Figure 7 shows how employment impacts in the Final GGRA Plan are distributed among racial groups, relative to the state's workforce as a whole.

Figure 7: Occupational Employment Impacts by Race for Final GGRA Plan



Sources: REMI, E3, MDE, MDOT, RESI, U.S. Census

As seen above, employment in the Final GGRA Plan is expected to track closely with the racial breakdown of Maryland's overall workforce, with some differences. Employment for Black and Asian workers is expected to be slightly underrepresented relative to the overall workforce, while Hispanic workers are forecasted to obtain a higher number of jobs relative to their overall representation.

1.2 Introduction

The Maryland Department of the Environment (MDE) tasked the Regional Economic Studies Institute (RESI) of Towson University to provide a coherent set of analyses to inform the development of MDE's proposed plan to reduce statewide greenhouse gas emissions by 40 percent from 2006 levels by 2030. MDE's proposed plan was created to satisfy its obligations under the Greenhouse Gas Emission Reduction Act (GGRA) Reauthorization. To form the Project Team, RESI contracted with Energy and Environmental Economics, LLC (E3) to model changes in emissions arising from various policy bundles under consideration. The results of the emissions modeling, conducted using the PATHWAYS model, are discussed in Chapter 6 of this report. This emissions modeling, along with estimates of program costs from state agencies, for the base of the economic modeling presented in this chapter. RESI conducted the economic modeling using the REMI model. [2]

1.3 Economic Modeling Methodology

As discussed in Chapter 6 of the draft GGRA Plan, the Project Team used the PATHWAYS model to estimate the impact of each policy scenario on greenhouse gas emissions in Maryland. To estimate the economic impacts of each policy scenario, the Project Team used REMI.[3]

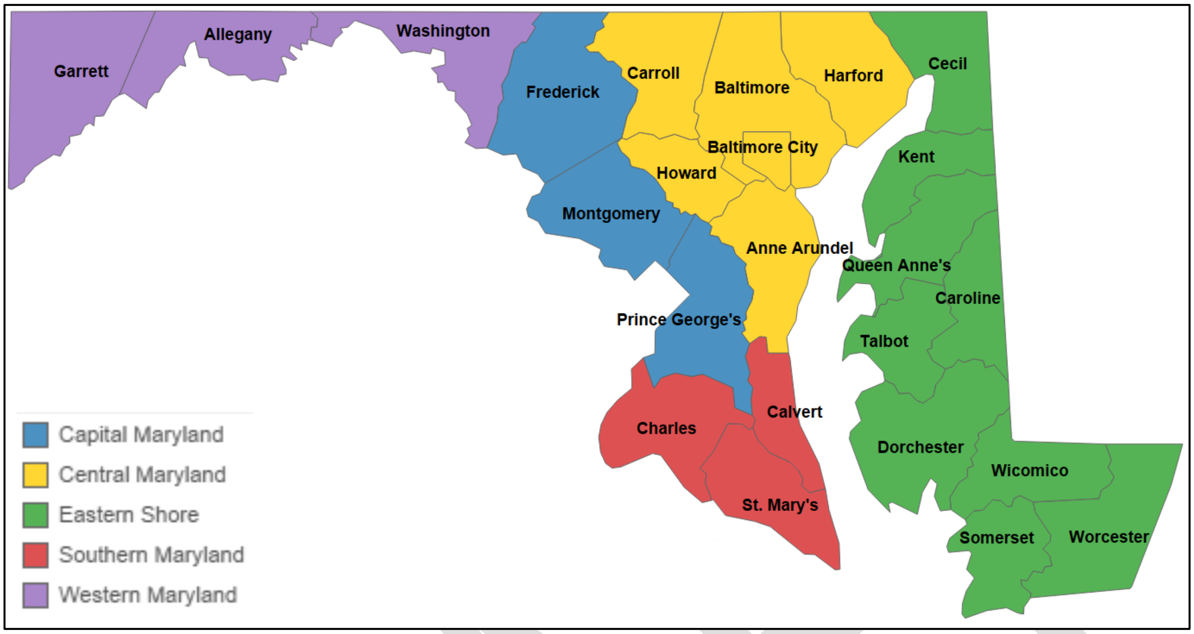
The REMI model is a high-end dynamic modeling tool used by various federal and state government agencies in economic policy analysis. The REMI model is calibrated to both the specific demographic features of Maryland as a whole and five distinct regions of the state:

- **Central Maryland**: Baltimore City and Harford, Baltimore, Carroll, Anne Arundel, and Howard Counties
- **Southern Maryland**: St. Mary's, Charles, and Calvert Counties
- **Capital Maryland**: Frederick, Montgomery, and Prince George's Counties
- **Western Maryland**: Garrett, Allegany, and Washington Counties
- **Eastern Shore**: Cecil, Kent, Queen Anne's, Talbot, Caroline, Dorchester, Wicomico, Somerset, and Worcester Counties

A map of these regions is found in Figure 8.

[2] All analyses were conducted using REMI Version 2.2.

Figure 8: Maryland Counties and Corresponding Region within REMI



Sources: RESI, Tableau

REMI contains a baseline model of the economy for each of the five regions within Maryland. When a scenario is evaluated, REMI calculates the direct impact of the economic event (for example, the sales made to a new business), as well as secondary effects (e.g., the new business' payments to vendors and the money spent in the local economy by workers in the new business). The effects of these effects on the baseline REMI forecast are estimated, allowing researchers to see both the impacts on their own but also in the context of the state's economy. Unlike simpler economic impact analysis models, such as IMPLAN, REMI is a dynamic model. This means that the model also considers economic and demographic shifts between regions (within Maryland and across state lines) in response to the economic scenario.
For example, if a new business opens in Maryland, some workers may move from Virginia or Delaware to be closer to their new employer. The dynamic nature of REMI is important for this analysis, as proposed polices to reduce carbon emissions will lead to changes in consumer prices, salaries, and government spending priorities. Additionally, REMI has a time component, which makes it especially useful in evaluating the long-term impact of policies in the future.

1.3.1 Translating PATHWAYS Output to REMI Input

To ensure that estimates of economic impacts and emissions impacts for each policy scenario were consistent, the Project Team first modeled each policy scenario within PATHWAYS. In addition to calculating changes in emissions for each policy scenario, PATHWAYS also calculates changes in costs for four main sectors of the economy:

1. Residential,
2. Commercial,
3. Industrial, and
4. Transportation.

Across these four sectors, PATHWAYS estimates capital costs associated with 35 distinct subsectors, such as commercial air conditioning, residential clothes washing, transportation light duty automobiles, and residential water heating. Additionally, PATHWAYS produces fuel consumption and fuel cost estimates for a total of 45 different subsectors, such as residential electricity, commercial solar, transportation diesel, and industrial natural gas.

To calculate the economic impact of each policy scenario, the Project Team first translated cost estimates from PATHWAYS into inputs appropriate for REMI. Each cost estimate from PATHWAYS is associated with at least one transfer of funds from one entity to another. For example, if a policy scenario results in increased purchases of residential washing machines, several positive impacts are felt in the economy, including:

- Retail stores experience higher sales, and
- Manufacturers of washing machines experience increased demand and higher sales.

These impacts would generally be associated with job gains, as increased sales may allow stores and manufacturers to hire additional workers. However, in this example, when consumers purchase additional washing machines there are also negative effects on the economy. If consumers spend more of their income on washing machines, they will have less income available to spend on all other goods and services. If consumers forego eating out in order to balance their budget, the economy could experience job losses at restaurants. In other words, it is important to consider not just economic benefits accruing from a given policy, but also the opportunity cost of the new spending.

Therefore, each cost from PATHWAYS produces two inputs for the REMI model: once as a change in spending patterns or production costs from the group bearing the cost of the new policy and once as a change in demand to the industry and group providing the particular good.

Within REMI, there are several ways of modeling the benefits to any given industry. Using the previous example, economic benefits to appliance manufacturers can be modeled through methods such as increased employment in the industry, increased sales, or an increase in consumer/business demand. For this analysis, benefits are generally modeled as a change in consumer/business demand. One advantage of this method is that REMI allows for some portion of the new demand to be satisfied by producers outside of Maryland, which allows for more conservative and accurate estimates than assuming all new production occurs in state.[4]

In addition to modeling benefits, the team also modeled the economic costs associated with each policy, beginning with PATHWAYS output. PATHWAYS categorizes costs as capital costs and fuel costs, both of which correspond to input variables within REMI. An increase in costs increases businesses' production costs, making it more expensive to produce goods in Maryland

[4] When using consumer/business demand, the percent of new demand estimated to be satisfied by in-state sources is estimated to be the same as the percent of local demand satisfied by Maryland producers. For example, if 30 percent of current automobile manufacturing demand is satisfied by in-state sources, 30 percent of all new automobile manufacturing would be satisfied by in-state producers.

as opposed to other states where businesses would not need to invest in the same technologies.

For capital costs and fuel costs impacting households, the Project Team changed REMI's baseline estimates of household spending patterns. For example, if a policy led to consumers spending $30 less on gasoline, the team adjusted household demand for gasoline spending down by $30, and then allowed consumers to spend the $30 on all other goods and services.

1.3.2 Modeling Policy Costs Not Captured Within PATHWAYS

Although the economic impact modeling relied on PATHWAYS output to be consistent with the emissions modeling, not all policies could be explicitly modeled within PATHWAYS. Economic data from PATHWAYS were incomplete because the model was limited to generating cost estimates for items that have a physical stock (e.g., automobiles, appliances, HVAC systems) or that were related to fuels (e.g., electricity, natural gas, diesel). Many policies included investment decisions and benefits not associated with a physical stock.

For example, many policies implemented by the Maryland Department of Transportation (MDOT) would correspond with reduced vehicle miles traveled—and thus emissions—but not a change in the stock of automobiles. Emissions reductions from these policies were still calculated, even though no costs were captured within PATHWAYS. If no cost data were entered separately into REMI, emissions reductions would be achieved for free. Therefore, it was important to capture many changes by state agencies separately instead of relying on PATHWAYS data alone.

One of the largest sources of data to be modeled separately was spending data from MDOT. MDOT data represented a range of different policies across the various policy scenarios, including:

- Public transportation projects,
- Transportation demand management,
- Additional toll roads, and
- More efficient busses.

MDOT policies are modeled within REMI as an increase in the demand for the industry most closely associated with the policy. For example, public transportation projects were generally modeled as an increase in the demand for construction, while updates to the transit bus fleet were modeled as an increase in demand for motor vehicle manufacturing. By increasing the baseline demand values with REMI, REMI assumed some production would be satisfied by out-of-state sources. Note that for the Final GGRA Plan, there was a methodology update regarding MDOT costs post-2030. Instead of assuming no new investment, a linear average of the transportation program line items was used as a proxy for future transportation investments.

Generally, funding for future MDOT projects will come from three broad sources:

- Federal government,

- State government, and
- Private investment.

Funding from the federal government and from private sources was treated as funding that would not be allocated to Maryland otherwise. That is, if the federal government would not provide grant funding to complete a given Maryland project, the team assumed those grant funds would go to another state. Therefore, projects funded by the federal government and private investors represent a positive shock to Maryland's economy.

However, much of the funding needed for transportation projects would originate with the State budget. For these projects, MDOT did not specify the funding source(s) to support the new initiatives. To avoid making broad judgements about which state services would need to be reduced or eliminated to pay for an increase in transportation budgets, the Project Team estimated that state income taxes would change each year by the amount necessary to cover the cost of each project. In instances where spending decreases, particularly due to fuel savings, the team modeled a decrease in state income taxes equal to the savings.[5]

1.3.3 Updating the REMI Baseline

REMI evaluates policy changes in the context of current and forecasted economic conditions, referred to as the standard regional control. Changes to the REMI standard regional control will impact how policies are evaluated in the model. Similarly, policy scenarios within PATHWAYS are evaluated relative to a reference emissions scenario, as described in more detail in Chapter 6. For consistency across models, the REMI standard regional control was adjusted to better align with the reference case in the PATHWAYS model.

The reference case within PATHWAYS assumes the implementation of a variety of policies that are not fully accounted for in REMI's standard regional control. For example, the reference case accounts for Maryland's most recent EmPOWER goals between 2015 and 2023, the most current projections regarding rooftop solar, current renewable portfolio standards (RPS), and changes to the Regional Greenhouse Gas Initiative (RGGI).

Therefore, the Project Team created a new regional control model within REMI that accounts for all policies included in the PATHWAYS reference case. To do so, RESI followed the methodology outlined in Section 1.3.1, increasing capital costs and fuel costs across different sectors of the state economy to more accurately reflect the economy. Once established within REMI, all policy scenarios were run against this new control, rather than the standard regional control.

[5] An alternative approach to the one taken by the Project Team would consist of modeling an increase in demand for the most relevant industry (e.g., construction) and a decrease in general state spending. However, modeling this approach within REMI led to decreases in the employment of teachers and law enforcement personnel. Losses in these occupations are not expected, given the nature of employment contracts for these occupations.

1.3.4 Custom Industries Within REMI

One shortcoming of the REMI model used in this analysis is that all firms producing electric power are aggregated into a single utilities sector. That is, power generated from renewable sources such as wind is modeled identically to power generated from fossil fuels such as coal. This aggregation structure can lead to unintuitive indirect impacts. With the baseline model, an increase in sales of wind energy would be treated the same as an increase in sales of coal power. Because REMI uses one set of economic multipliers to estimate how utility firms spend their revenues on support products and services, an increase in revenue for a wind plant would lead to an increase in purchases of coal or petroleum products within the model.

Therefore, the Project Team separated electric power generation into three categories:

1. Wind electric power generation,
2. Solar electric power generation, and
3. General electric power generation.

General electric power generation uses the same multipliers as the baseline electric power generation sector within REMI. To create the other two custom industries, the Project Team customized REMI using industry multipliers from IMPLAN, another input-output economic modeling software.

To populate the REMI output multipliers, RESI mapped IMPLAN industry classifications to REMI sectors. Because IMPLAN uses a more granular set of industry codes than REMI, some IMPLAN industries were combined. The results were then input into REMI as custom industries.

The solar and wind power generation industries look substantially different than the general electric power generation industry, as illustrated in Figure 9. These industries have a higher value-added component at 0.82 and 0.90, for solar and wind respectively, compared to the base utilities industry, which has a value-added component of 0.79. Because much of the value-added component is due to earnings, on average, it can be expected that jobs in the base utilities industry will be lower paying than those in the solar and wind industries. In terms of intermediate demand, the base utilities industry relies heavily on fossil fuel-intensive industries, such as oil and gas extraction, petroleum and coal products manufacturing, and mining (except oil and gas). Solar and wind, on the other hand, rely more heavily on services (both professional and support services), construction, and real estate.

Figure 9: Top Five Intermediate Demand Industries for Utilities and the Solar and Wind Custom Industries

	Intermediate Demand Industry	Multiplier
Base Utilities	Oil and gas extraction	0.046
	Petroleum and coal products manufacturing	0.033
	Professional, scientific, and technical services	0.019
	Mining (except oil and gas)	0.013
	Scenic and sightseeing transportation; Support activities for transportation	0.012
Solar Power Generation	Professional, scientific, and technical services	0.035
	Scenic and sightseeing transportation; Support activities for transportation	0.019
	Construction	0.016
	Administrative and support services	0.015
	Real estate	0.010
Wind Power Generation	Professional, scientific, and technical services	0.019
	Scenic and sightseeing transportation; Support activities for transportation	0.010
	Construction	0.009
	Administrative and support services	0.008
	Real estate	0.006

Source: REMI, RESI

1.3.5 Estimating Health Impacts

Health impacts and their subsequent economic effects were also evaluated by the Project Team. A reduction in carbon emissions corresponds with increased air quality, leading to a number of health benefits for Maryland residents. These include reduced hospital visits, fewer days missed of work, improved quality of life, and decreased mortality. To estimate these effects, the Project Team used the U.S. Environmental Protection Agency's (EPA) CO-Benefits Risk Assessment (COBRA) model to measure the impacts of reduced emissions on health. The COBRA model is intended to assist state and local governments that are estimating the costs and benefits of clean energy policies. Originally developed by Abt Associates in 2002, and most recently updated in 2017, COBRA is designed to "estimate the economic value of the health benefits associated with clean energy policies and programs," so these values can be weighed against the economic costs of a proposed policy.[6,7]

[6] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 3, accessed August 9, 2018, https://www.epa.gov/sites/production/files/2018-05/documents/cobra_user_manual_may2018_508.pdf.
[7] "CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool," U.S. Environment Protection Agency, accessed August 9, 2018, https://www.epa.gov/statelocalenergy/co-benefits-risk-assessment-cobra-health-impacts-screening-and-mapping-tool.

COBRA utilizes emission estimates for five different forms of air pollution: fine particulate matter ($PM_{2.5}$), sulfur dioxide (SO_2), nitrogen oxides (NO_X), ammonia (NH_3), and volatile organic compounds (VOCs).[8,9] Baseline emission estimates are included for both 2017 and 2025, allowing users to change emissions in either year.[10] Once the emission estimates for the policy are determined, the user can then input any corresponding emission increases or decreases from the baseline into the model. These changes can be input as either percentage changes from the baseline or as a specific quantity of emissions in tons.

To model health impacts through 2050, emission changes from each policy scenario were run for five different years: 2017, 2025, 2030, 2040, and 2050. Since COBRA only contains pre-made baseline emissions for 2017 and 2025, the baseline was increased to adapt for increased emission reductions in the later years of the model.[11]

Except for emissions from electric utilities, all COBRA inputs were derived from PATHWAYS. Final fuel demand (measured in millions of British Thermal Units, or MMBTU) for every sector was calculated as the difference in emissions between the reference scenario and the policy scenario under consideration. The formula for estimating changes in emissions varied by sector.

For example, outside of electric utilities, gasoline and diesel use (particularly in vehicles) makes up the largest portion of emission changes in the policy scenarios. To determine emissions for gasoline and diesel fuels, the change in MMBTUs provided by PATHWAYS was converted into gallons of fuel using conversion rates provided by the U.S. Energy Information Administration.[12] These gallons of fuel were converted into miles traveled using average mileage of 30 miles per gallon (mpg) for gasoline vehicles and 10 mpg for diesel. Finally, miles were converted into emissions using emissions factors prepared for the Project Team by MDE's Mobile Sources Control Program.[13]

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[8] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 18.

[9] According to the U.S. Environmental Protection Agency, fine particulate matter, or $PM_{2.5}$, typically has a diameter of 2.5 micrometers or less.

[10] COBRA also contains the ability to import a custom emissions baseline for any other year, however this functionality was not used for this analysis.

[11] The baseline emissions were increased using a multiplier on the 2025 baseline so that proportional emissions between counties in Maryland would be preserved. Test runs using various COBRA baselines revealed that the size of the baseline does not have an effect on health impacts as long as proportional emissions between counties remains constant.

[12] "British Thermal Units (BTU)," U.S. Energy Information Administration, accessed January 20, 2019, https://www.eia.gov/energyexplained/index.php?page=about_btu.

[13] Private correspondence with MDE, September 24, 2018.

Emissions for natural gas sectors were calculated using emissions factors for greenhouse gases published by the EPA.[14] These EPA figures allow for a direct conversion from MMBTUs as modeled by PATHWAYS into tons of emissions for $PM_{2.5}$, NO_x, SO_2, and VOCs. The EPA's emissions factors also allow for differentiation in NO_X emissions between commercial/industrial and residential natural gas furnaces.

Certain policy scenarios model the introduction and subsequent increase in use of biogas as a fuel source in Maryland. Emissions created through using biogas are calculated using emissions factors made available by the California Air Resources Board.[15] These factors are directly used to calculate emissions for $PM_{2.5}$, NO_x, SO_2, and VOCs.

Emission changes due to shifting fuel sources in electric utilities are calculated by first using the EPA's Avoided Emissions and Generation Tool (AVERT) modeling program to estimate the change in emissions for each pollutant.[16] Additionally, AVERT is used to estimate emissions reductions resulting from increased generation of wind and solar energy. These emission shifts are then entered into COBRA.

COBRA output consists of various impacts, including:

- Changes in mortality and infant mortality;
- Changes in instances of non-fatal heart attacks;
- Changes in hospital admissions for asthma, chronic lung disease, and all other respiratory issues; and
- Changes in days of work missed due to sickness or days of work with inhibited productivity.

All outputs from COBRA were translated into inputs appropriate for use in REMI. Health impact figures output by COBRA are represented in the COBRA model through an increase in the survival rate, the cost of hospitalization, an increase in the amenity value, a change in productivity, and increased consumer income.[17]
In the REMI model, changes to adult mortality and infant mortality are represented through a change in the survival rate, which represents the percentage of a given population expected to die in a single year. To determine the change in the survival rate, RESI compared the decreased mortality from the COBRA model to the population size of each Maryland region. An

[14] U.S. Environment Protection Agency, "Natural Gas Combustion," 6, accessed January 20, 2019, https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s04.pdf.
[15] Marc Carreras-Sospedra and Robert Williams, "Assessment of the Emissions and Energy Impacts of Biomass and Biogas Use in California," University of California and California Biomass Collaborative (January 14, 2015): 63 accessed January 20, 2019, https://www.arb.ca.gov/research/rsc/1-30-15/item6dfr11-307.pdf.
[16] "Avoided Emissions Factors Generated from AVERT," U.S. Environment Protection Agency, accessed January 20, 2019, https://www.epa.gov/statelocalenergy/avoided-emission-factors-generated-avert.
[17] The amenity value measures non-economic improvements to quality of life in a region, which has an effect on migration patterns.

adjustment to the COBRA output was also required to accurately adjust the survival rate for each year.

While most health impacts in COBRA are limited to occurrences within a single year, impacts on premature mortality are determined using a 20-year lag structure. For any change in premature deaths resulting from a single year of emissions, 30 percent of those deaths are assumed to occur in the first year, 50 percent occurs evenly from years two to five after the emissions year, and the final 20 percent occurs over years six to twenty.[18] Mortality changes for each year in the COBRA model were adjusted so that the REMI input reflected the change in mortality that occurs within a given year, rather than the change in mortality caused by a single year of emissions.

Six of the health impacts measured by COBRA involve admittance or visitation to a hospital. To determine the cost of hospitalization for these issues, RESI relied on health data from HCUPnet, an online system which uses data from the Healthcare Cost and Utilization Project (HCUP). Using HCUPnet, RESI obtained average hospital charges in Maryland for each of the relevant conditions.[19] For each reduced incidence of hospital admittance in the COBRA model, RESI decreased medical revenue in the REMI model by an amount equal to the average hospital charge for that condition, reallocating the revenue to consumers, government, and private insurance in proportion to their contribution to the medical bill based on payer data also provided by HCUPnet.[20]

In many cases, a health incident involving hospital admission will result in an absence from work and decreased productivity. COBRA additionally measures missed work days and restricted activity days not directly resulting from one of the other measured health impacts.[21] RESI utilized HCUPnet data to determine the average length of stay for each of the hospital admissions. The productivity gained from a reduction in missed work days was input into REMI as an equivalent increase in employment. RESI calculated the increase in employment by measuring the total reduction in missed work days against the number of active working days in a calendar year.[22]
The change to the amenity value is based on four additional health impacts in the COBRA model: acute bronchitis, upper respiratory symptoms, lower respiratory symptoms, and asthma exacerbation. [23] Since these impacts do not involve hospital admission or missed work days,

[18] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," F-6.
[19] "HCUPnet, Healthcare Cost and Utilization Project," Agency for Healthcare Research and Quality, accessed August 15, 2018, https://hcupnet.ahrq.gov/.
[20] Revenue was reallocated in the REMI model to insurance carriers, federal, state, and local government, and consumer spending.
[21] For RESI's model, a single restricted activity day is treated as 0.5 missed work days.
[22] Active working days exclude weekends and non-working holidays.
[23] The amenity value in REMI is a "willingness-to-pay" measure representing quality in life. For example, if a state A has cleaner air and water than state B, state A will have a higher amenity value. This higher amenity value means state A will have higher immigration rates with economic indicators changing through that avenue.

they are reflected in the REMI model using a change in the amenity value for each region. The values entered into the model were taken directly from COBRA's valuation of each of the four health impacts.

1.3.7 Criteria for Evaluating the Economic Impact of Policy Scenarios

In addition to satisfying emission requirements through 2030, the policies selected by the State of Maryland to reduce carbon emissions must provide a net benefit to the Maryland economy. To determine whether each policy scenario meets this mandate and qualifies as meeting the economic goals of the GGRA, the Project Team used the following set of indicators:

- Average positive job growth through 2030;
- Positive cumulative personal income growth through 2030 with a 3 percent discount rate; and
- Positive cumulative gross state product (GSP) growth through 2030 with a 3 percent discount rate.[24]

In addition to these three metrics, the team considered other measures of economic well-being, including:

- The impact across different sectors of Maryland's economy, including manufacturing;
- The impact on consumer prices;
- Distributional impacts in terms of income, education and training, and race/ethnicity; and
- The regional distribution of jobs.

Reducing carbon emissions and ensuring net benefits to Maryland's economy are not mutually exclusive goals. The following sections will outline the various policy bundles that the Project Team considered, as well as the results of the economic impact analysis; emissions results are presented in Chapter 1.6 of this report.

1.4 Draft GGRA Plan Results

There are multiple avenues through which policies to reduce Maryland's carbon emissions may impact the state's economy. For example, the construction and installation of solar panels and windmills on the Eastern Shore or construction of additional public transportation infrastructure in Montgomery County would boost employment. On the other hand, if policies lead to more expensive electricity costs for consumers and businesses, overall employment growth may be hampered.

This section provides an overview of the Draft GGRA Plan. The results of this policy are then examined. For more detail on individual assumptions and policies in all policy scenarios, please see Appendix A.

[24] GSP is the sum of consumption, investment, government expenditures, and net exports from the state.

1.4.1 Draft GGRA Plan Overview

The Draft GGRA Plan assumes a continuation or extension of current policies. For example, EmPOWER goals of reduced energy consumption currently in place are extended past the expiration year of 2023. In addition to these extensions, the Draft GGRA Plan layers on additional decarbonization efforts, including:

- A 100 percent Clean and Renewable Energy Standards (CARES) goal by 2040;
- Transit bus electrification and other transportation programs; and
- Forest management and healthy soils initiatives.

The Draft GGRA Plan was constructed both to achieve the emissions requirements laid forth in the GGRA and provide a blueprint for future efforts to reduce greenhouse gas emissions.

The following sections contain the economic results of the Draft GGRA Plan.

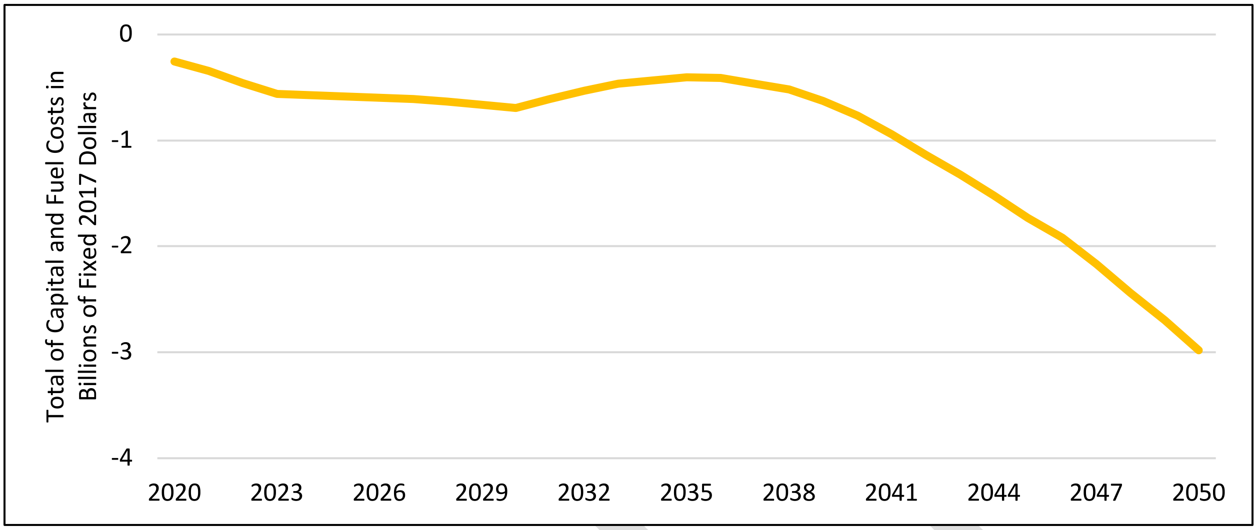
1.4.2 Spending and Electricity Demand in the Draft GGRA Plan

Within this policy scenario, there are two broadly competing forces: capital costs and fuel savings. Generally, the price of fuel increases across policy scenarios, as relatively cheap but carbon-intensive fuels are replaced by more expensive alternatives. To offset rising prices and comply with new regulations, consumers and businesses make investments in new technologies. The hope is that the initial cost of these investments will be outweighed by future fuel savings.

For example, if a consumer purchases an electric vehicle, that purchase may be considered cost effective if fuel savings outweigh the initial purchase premium above a gasoline-powered car. However, if fuel savings are not enough to compensate for the initial capital expenditure, the vehicle is not considered cost effective.

PATHWAYS data can broadly illustrate this effect. Ideally, savings on fuel will outweigh the cost of switching to more energy-efficient technologies, and the total cost for this policy scenario will be lower than in the reference case. As seen below in Figure 10, total costs for the Draft GGRA Plan remain lower than the reference case through 2030, with costs reducing to an even greater degree through 2050.

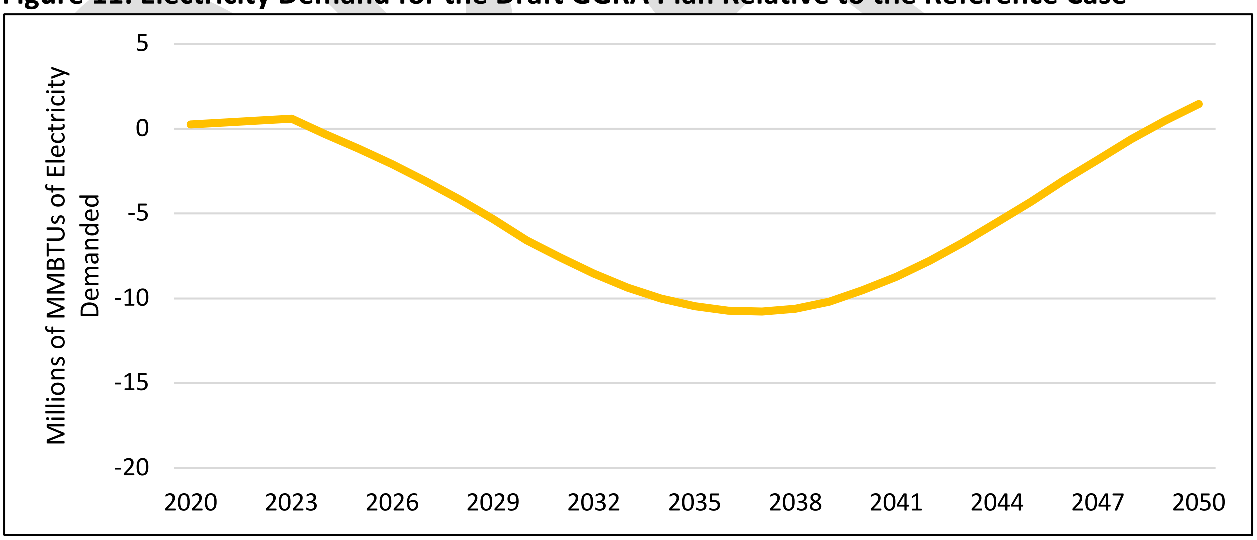
Figure 10: Total Costs for the Draft GGRA Plan Relative to the Reference Case



Sources: E3, MDE, RESI

In the Draft GGRA Plan, electricity demand remains low compared to the reference case, as seen in Figure 11. When viewed in conjunction with Figure 10, as total costs increase, electricity demand tends to decrease. As consumers and businesses invest in energy efficient appliances, this lowers the electricity demanded in the middle years. In the later years, as more of the economy (including the transportation sector) transitions away from fossil fuels and towards renewable electricity generation, demand rises again.

Figure 11: Electricity Demand for the Draft GGRA Plan Relative to the Reference Case



Sources: E3, MDE, RESI

1.4.3 Employment

To meet the economic goals as described in Section 1.3.7, policy scenarios must achieve positive job growth, on average, through 2030. This section presents a description of the measures used to analyze employment results, as well as detailed employment results for the Draft GGRA Plan.

1.4.3.1 Measures of Employment

In addition to the total employment trends, the following aspects will also be addressed for each policy scenario:

- Sensitivity analyses,
- Regional distribution of job impacts,
- Employment impacts by industry,
- Employment impacts by occupation,
- Employment impacts by job zone,
- Employment impacts by income levels, and
- Employment impacts from improved health outcomes.

Sensitivity analyses were conducted by evaluating employment impacts both with and without MDOT transportation measures. This was done due to the magnitude of the job impacts that resulted from this MDOT spending, and to provide a range of expected employment effects if funding levels vary from the initial projections.

Employment impacts were evaluated for the five-region Maryland model described in Section 1.3, which includes:

- **Central Maryland**: Baltimore City and Harford, Baltimore, Carroll, Anne Arundel, and Howard Counties;
- **Southern Maryland**: St. Mary's, Charles, and Calvert Counties;
- **Capital Maryland**: Frederick, Montgomery, and Prince George's Counties;
- **Western Maryland**: Garrett, Allegany, and Washington Counties; and
- **Eastern Shore**: Cecil, Kent, Queen Anne's, Talbot, Caroline, Dorchester, Wicomico, Somerset, and Worcester Counties.

Industries were defined using North American Industrial Classification System (NAICS) codes.[25] NAICS categorizes industries into two- through six-digit codes, with two-digit codes representing the broadest industry definitions, and six-digit codes representing specific industries on a more granular level. For employment results shown within this section, jobs were categorized into two-digit NAICS (industry) codes.

Jobs were categorized into professions using the Standard Occupational Classification (SOC) system. Similar to the structure of NAICS codes, this system organizes jobs from broad major

[25] "North American Industry Classification System," U.S. Census Bureau, accessed February 14, 2019, https://www.census.gov/eos/www/naics/.

groups to more detailed occupations.[26] For employment results shown within this section, occupations were categorized into major SOC groups (codes at the two-digit level).

Job zones were developed by O*NET, which categorizes jobs based on their similarities regarding education, related experience, and on-the-job training requirements.[27] These zones range from one through five, with Job Zone 1 requiring little to no preparation (e.g., dishwashers), and Job Zone 5 requiring many years of preparation (e.g., attorneys). Employment effects within this section are classified as follows.

- Job Zone 1: Some occupations may require a high school diploma or equivalent, and training would be expected to take several days to several months.
- Job Zone 2: Most occupations require a high school diploma or equivalent, and training would be expected to take several months to a year.
- Job Zone 3: Occupations typically require some additional education, such as vocational school or an associate degree, with training expected to take one to two years.
- Job Zone 4: Often require a bachelor's degree, with several years of training expected.
- Job Zone 5: Most occupations require an advanced degree, such as a master's degree or Ph. D., and may require additional training for specialization following degree attainment.[28]

The jobs supported by each policy scenario were further examined based on wage group. Each occupation was categorized into one of three groups based on median earnings for Maryland. These groups were categorized based on the following annual wages:

- Low-wage jobs: less than $35,000;
- Medium-wage jobs: between $35,000 and $65,000; and
- High-wage jobs: more than $65,000.[29]

Improved health outcomes affect employment through numerous avenues. First, because mortality is reduced due to cleaner air, the population survival rate increases. This subsequently causes the number of available workers in the labor pool to rise. Second, a reduction in morbidity will increase the labor productivity of workers as fewer sick days are taken. Third, while hospitals will receive less revenue from treating fewer patients, this money will be cycled back to consumers, insurance companies, and federal and state governments. The net employment effects depend upon on the structure of the economy and magnitude of the medical expenditures. Employment effects shown in this section consider each of these components when generating a net impact.

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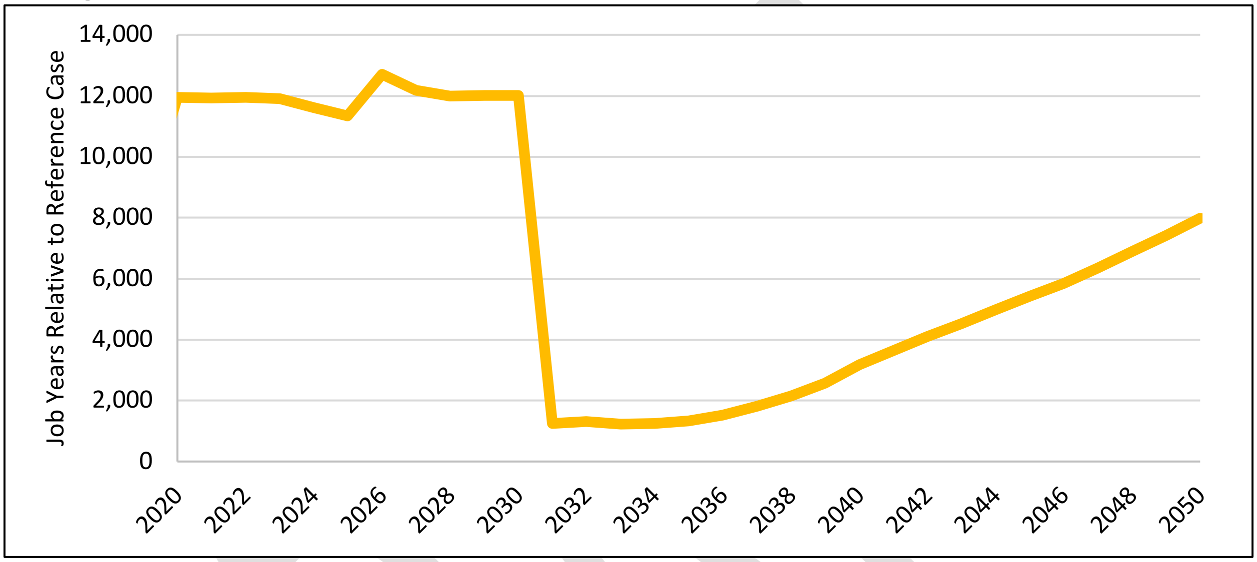
[26] "Standard Occupational Classification," U.S. Bureau of Labor Statistics, accessed February 14, 2019, https://www.bls.gov/soc/home.htm.
[27] "O*NET OnLine Help: Job Zones," O*NET OnLine, accessed February 13, 2019, https://www.onetonline.org/help/online/zones.
[28] "O*NET OnLine Help: Job Zones," O*NET OnLine.
[29] Wage categories were selected which roughly categorize Maryland's workforce into three equal groups. Therefore, if jobs are distributed equally across income levels, we would expect to see an equal number of jobs in all three groups.

1.4.3.2 Employment in the Draft GGRA Plan

The Draft GGRA Plan achieves the economic goal of positive job growth through 2030. Figure 12 shows how employment levels vary over time in response to the Draft GGRA Plan. On average, the Plan supports 11,963 jobs each year through 2030 relative to the reference case.

Figure 12: Employment by Year for Draft GGRA Plan with Transportation Measures 2020 Through 2050

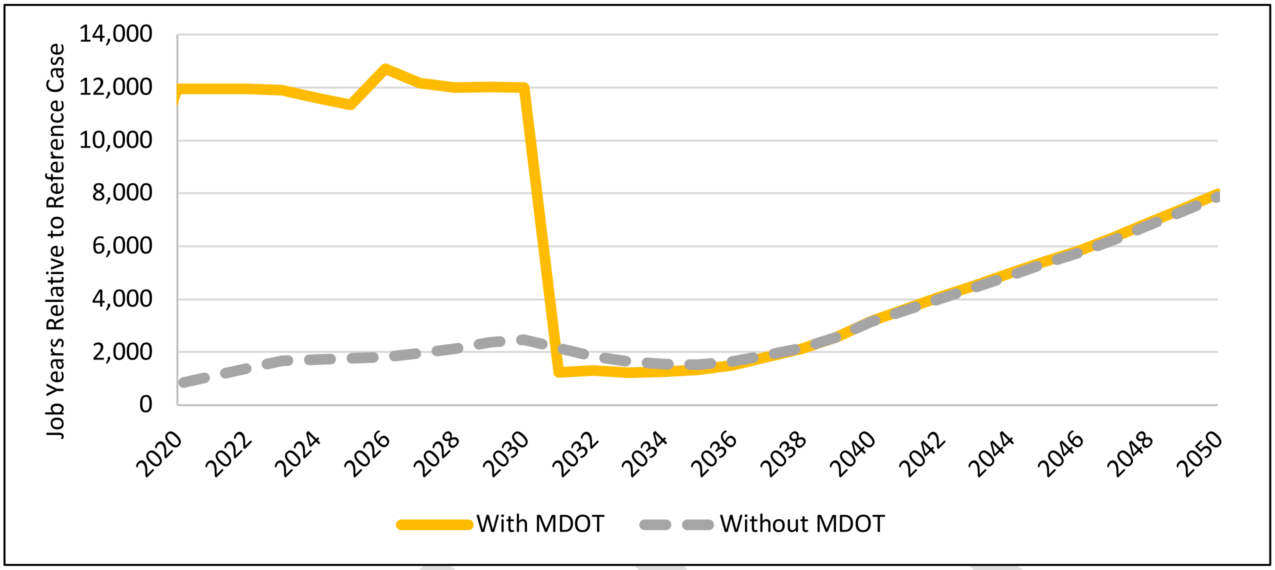


Sources: REMI, E3, MDE, MDOT, RESI

In the short term, employment gains are relatively high, due to spending on a variety of infrastructure projects, including new funding for Metropolitan Planning Organization (MPO) plans and programs. Many of these infrastructure projects are set to be completed by 2030, corresponding with the decrease in job growth seen at this time. After 2030, job growth relative to the reference case slows and approaches zero. Even so, employment under the Draft GGRA Plan is greater than employment in the reference case. During this time, capital expenditures significantly outweigh reductions in energy consumption. One reason for this is the extension of EmPOWER, which begins in 2024 and extends through 2050. Additionally, new sales of zero emission vehicles in the later years of the study period are captured as increased capital costs. The fuel savings from these policies is seen in later years. After 2045, fuel savings outweigh capital costs and lead to higher growth relative to the reference case.

Another driver behind the employment patterns seen in Figure 12 is the increase of in-state renewable energy production. As Maryland's energy mix shifts from out-of-state fossil fuel and towards in-state wind and solar generation, new jobs are created in Maryland.

Figure 13: Employment with and without Transportation Measures in Draft GGRA Plan



Sources: E3, MDE, MDOT, RESI

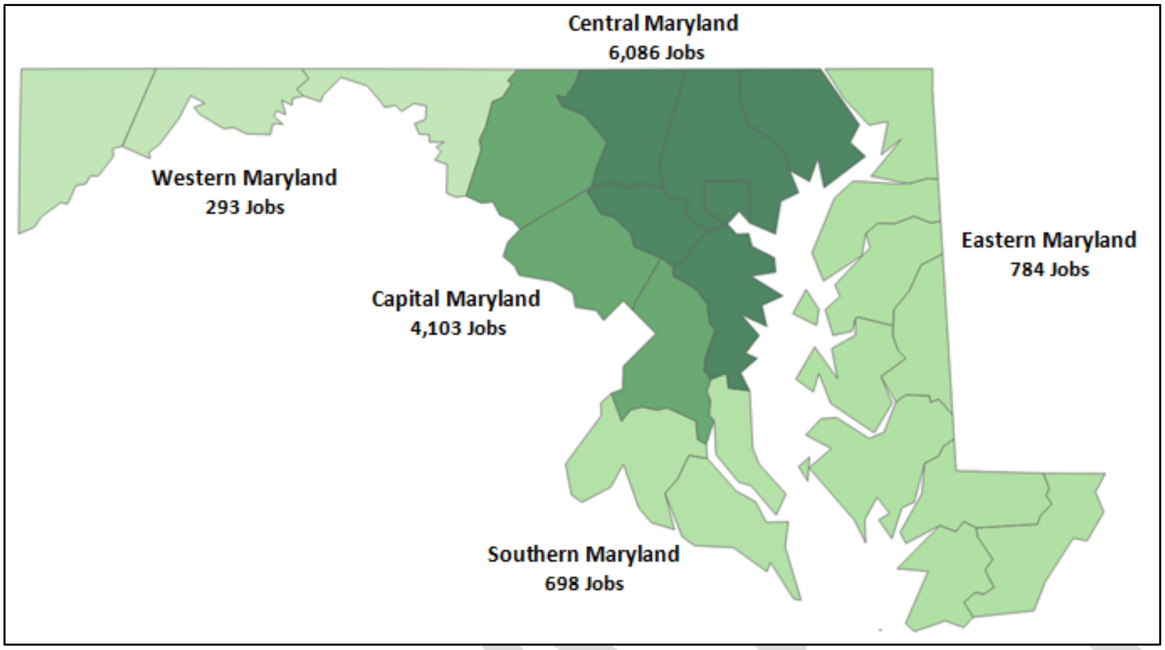
Although transportation spending in the near term constitutes a large percentage of the employment impacts, Figure 13 shows that job growth is dominantly positive relevant to the reference case, even after removing transportation spending from the model. Transportation spending in the Draft GGRA Plan consists of two main phases as seen in the graph below as the difference between the “with MDOT” line and “without MDOT” line.

The majority of spending and associated jobs impacts occurs prior to 2025. A number of smaller projects extend through 2030, representing the smaller, yet significant difference between the employment estimates with and without MDOT measures. On average through 2030, the scenario without MDOT spending supports 10,215 fewer jobs annually compared to the scenario with MDOT spending, though both scenarios increase employment levels over the reference case.

As with each policy scenario evaluated, these employment effects will not be uniformly distributed across the various regions of the state. Each region of Maryland has a unique local economy that will respond differently to the policies outlined in each scenario, based on the composition of industries within the area. For example, Capital Maryland, which is heavily reliant on the on government and services industries, would be impacted differently by policies primarily affecting these industries than the Eastern Shore, where farming and natural resources industries are dominant.

As shown in Figure 14, no region within the state experiences job losses on average through 2030, relative to the reference case. Central Maryland has the largest gains with 6,086 jobs while the smallest gain of 293 jobs occurs in Western Maryland.

Figure 14: Average Annual Employment Impacts by Region for the Draft GGRA Plan, 2020 - 2030



Sources: E3, MDE, RESI

Figure 15 outlines the composition of employment gains by industry.

Figure 15: Average Annual Employment by Industry for the Draft GGRA Plan, 2020 - 2030

NAICS	Industry	Average Annual Jobs Through 2030
11	Agriculture, Forestry, Fishing and Hunting	143
21	Mining, Quarrying, and Oil and Gas Extraction	-29
22	Utilities	185
23	Construction	8,746
31-33	Manufacturing	128
42	Wholesale Trade	82
44-45	Retail Trade	-223
48-49	Transportation and Warehousing	98
51	Information	26
52	Finance and Insurance	104
53	Real Estate and Rental and Leasing	163
54	Professional, Scientific, and Technical Services	317
55	Management of Companies and Enterprises	20
56	Administrative and Support and Waste Management and Remediation Services	219
61	Educational Services	65

62	Health Care and Social Assistance	585
71	Arts, Entertainment, and Recreation	44
72	Accommodation and Food Services	309
81	Other Services (except Public Administration)	275
92	Public Administration	707
Total		**11,964**

Sources: E3, MDE, REMI, RESI, U.S. Census

As detailed above, the vast majority of these jobs—8,746 of the 11,964 total jobs—are estimated to be in the construction industry, which is likely reflective of the transportation infrastructure projects. Conversely, Retail Trade posts the largest decline of -223 jobs, followed by a small loss of 29 jobs in Mining, Quarrying, and Oil and Gas Extraction. A significant proportion of retail job losses are likely attributed to projected declines in gas station use, as consumers shift from gasoline-fuel vehicles to electric and hybrid vehicles. Notably, however, these impacts may be lessened if gas stations shift with market demand to repurpose as charging stations. The REMI model assumes a relatively consistent structure of the Maryland economy over time and would not account for these dynamic or innovative industry changes.

Figure 16 below shows the distribution of employment impacts by occupation. Please note that the total average number of jobs may not match the industry total due to rounding.

Figure 16: Employment by Occupation for Draft GGRA Plan

SOC Code	SOC Description	Average Jobs Through 2030
11	Management Occupations	721
13	Business and Financial Operations Occupations	473
15	Computer and Mathematical Occupations	123
17	Architecture and Engineering Occupations	170
19	Life, Physical, and Social Science Occupations	35
21	Community and Social Service Occupations	68
23	Legal Occupations	37
25	Education, Training, and Library Occupations	306
27	Arts, Design, Entertainment, Sports, and Media Occupations	51
29	Healthcare Practitioners and Technical Occupations	225
31	Healthcare Support Occupations	131
33	Protective Service Occupations	109
35	Food Preparation and Serving Related Occupations	296
37	Building and Grounds Cleaning and Maintenance Occupations	190
39	Personal Care and Service Occupations	231
41	Sales and Related Occupations	210

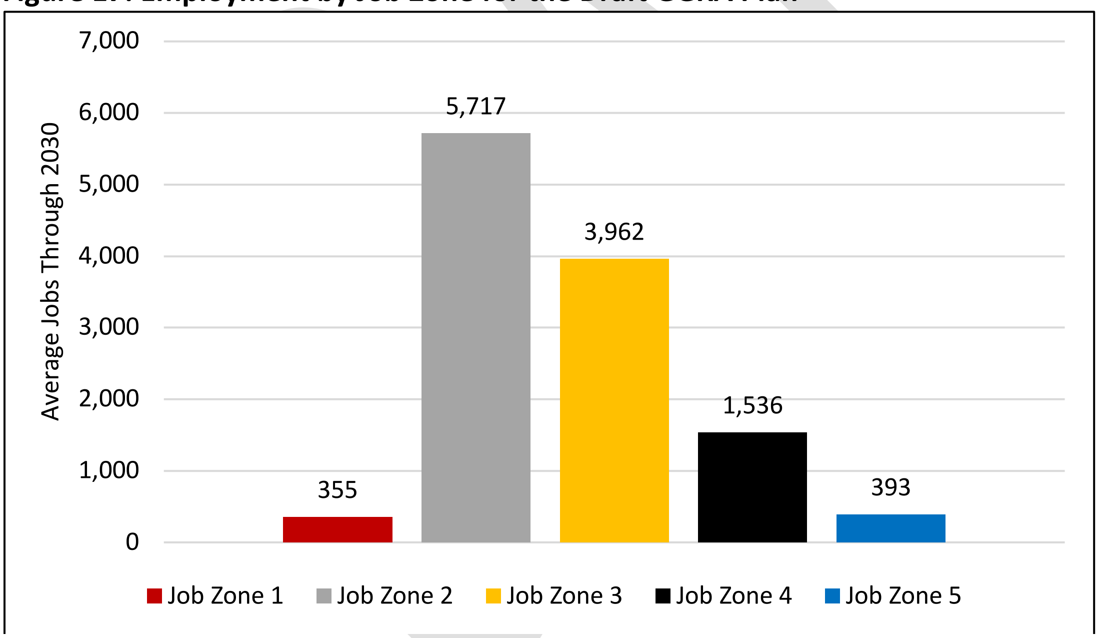
43	Office and Administrative Support Occupations	1,237
45	Farming, Fishing, and Forestry Occupations	82
47	Construction and Extraction Occupations	5,520
49	Installation, Maintenance, and Repair Occupations	964
51	Production Occupations	297
53	Transportation and Material Moving Occupations	488
Total		**11,963**

Sources: E3, MDE, REMI, RESI, U.S. BLS

The greatest employment gains are projected to be in Construction and Extraction Occupations with an estimated 5,520 jobs, and are likely supported by the marked increase in construction activity, in large part, to transportation infrastructure projects. The second-highest increase is shown in Office and Administrative Support Occupations (1,237 jobs), followed by increases in Installation, Maintenance, and Repair Occupations (964) and Management Occupations (721).

Figure 17 below shows the distribution of employment changes by job zone, as previously defined in Section 1.4.3.1.

Figure 17: Employment by Job Zone for the Draft GGRA Plan

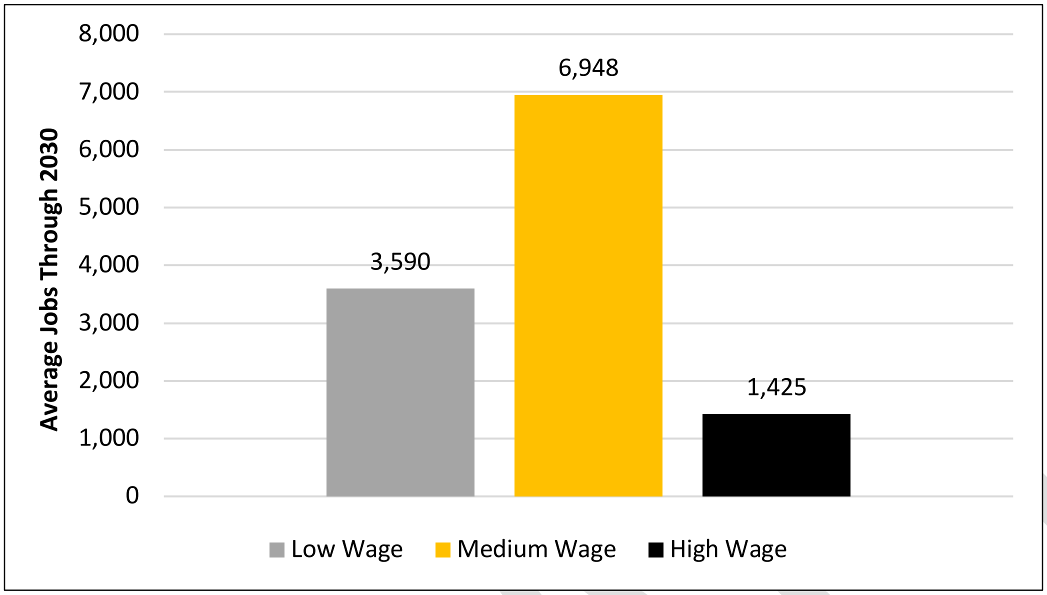


Sources: E3, MDE, O*Net, REMI, RESI

Simulations for the Draft GGRA Plan indicate robust job growth for occupations in Job Zones 2 and 3, where jobs typically require modest preparation and a high school diploma (Job Zone 2), or an associate degree or vocational training (Job Zone 3). This is beneficial in that retraining and educational needs are expected to be relatively less extensive and time consuming. No negative impacts are seen in any job zone under the Draft GGRA Plan, with the smallest annual increases represented in Job Zones 1 and 5.

Figure 18 illustrates employment results by wage group, as previously outlined in Section 1.4.3.1.

Figure 18: Employment by Wage Group for Draft GGRA Plan

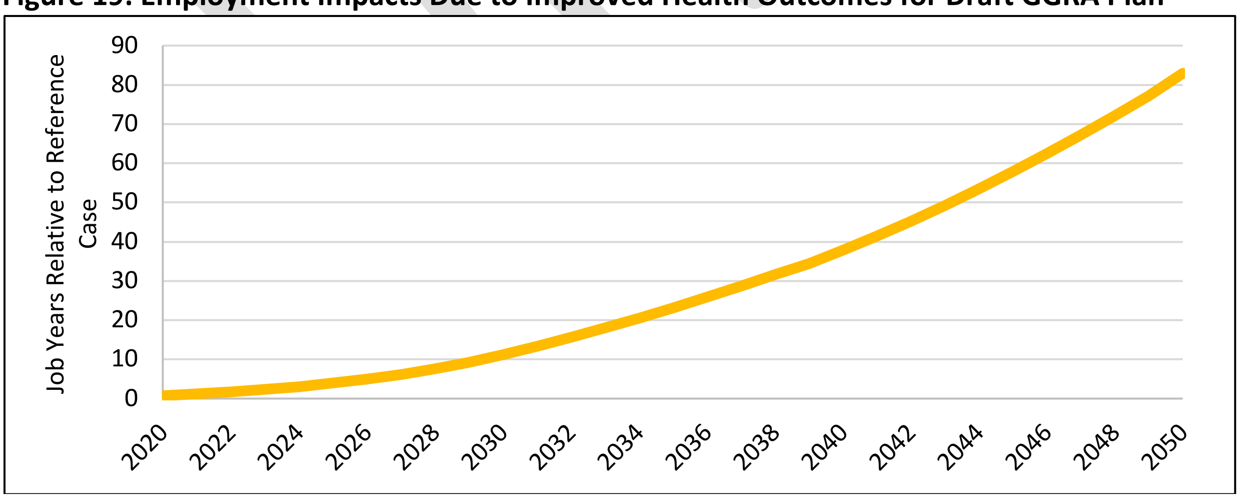


Sources: E3, MDE, REMI, RESI, U.S. BLS

Over half of the employment impacts under the Draft GGRA Plan, 6,948 jobs, are found in medium-wage occupations earning between $35,000 and $65,000 annually. This is followed by an annual average of 3,590 jobs in the low wage category. Under this plan, high-wage positions experience the smallest impact.

Figure 19 details the expected employment impacts resulting from changes in health outcomes, as described in Section 1.4.3.1.

Figure 19: Employment Impacts Due to Improved Health Outcomes for Draft GGRA Plan



Sources: E3, MDE, MDOT, RESI, U.S. EPA

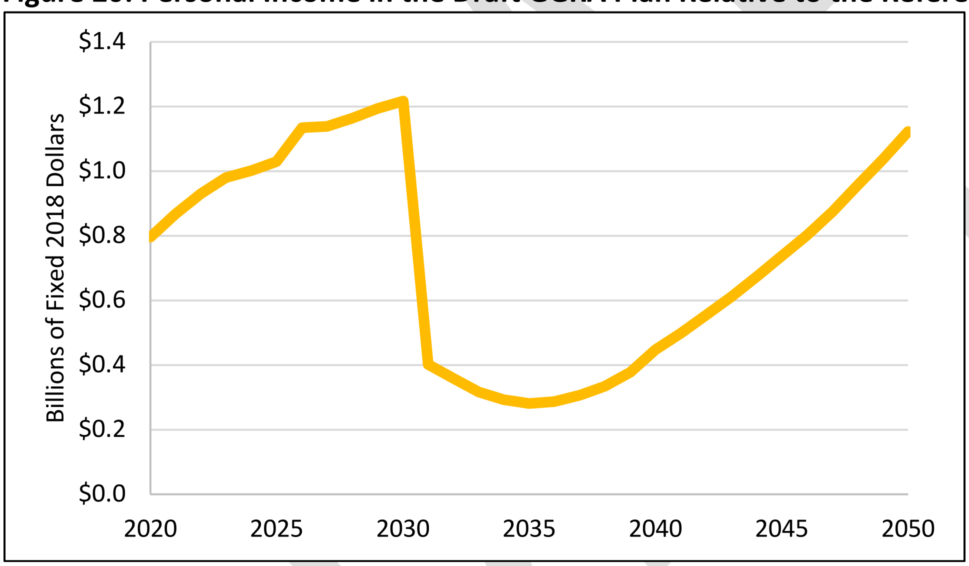
As illustrated above, the number of jobs due to improved health outcomes from the Draft GGRA Plan grows exponentially, averaging approximately 5 jobs per year through 2030 and 29 jobs per year through 2050. By 2050, an estimated 50 jobs will be created as a result of this Plan. This exponential growth is due to the cumulative effects of air pollution reduction. Detailed results for health impacts are found in Appendix C.5.

1.4.4 Personal Income in the Draft GGRA Plan

In addition to employment, it is also important to consider how personal income will be affected. Personal income within REMI is calculated as the sum of the total wages and salaries, supplements to these wages and salaries, property income, and personal current transfer receipts. Of these, wages and salaries represent the majority of personal income in Maryland.

The Draft GGRA Plan posts an increase averaging $1.0 billion between 2020 and 2030. The Draft GGRA Plan also shows a decline after 2030 due to the transportation projects, but fuel savings outweigh any capital expenditures in the long run. Even during the decline, personal income remains positive relative to the reference case in every year.

Figure 20: Personal Income in the Draft GGRA Plan Relative to the Reference Case



Sources: REMI, E3, MDE, MDOT, RESI

1.4.5 Gross State Product (GSP) in the Draft GGRA Plan

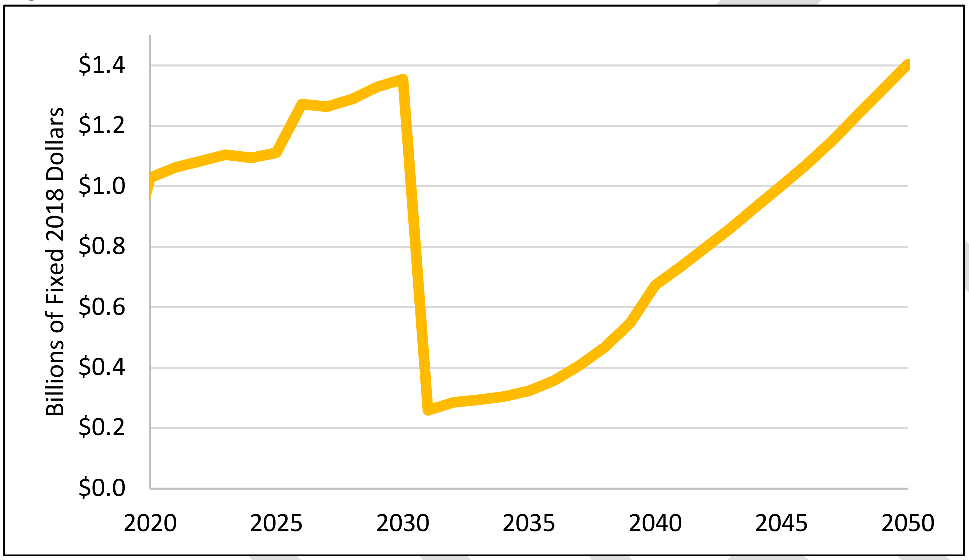
The Project Team also considered impacts to Maryland's economy measured as changes to gross state product (GSP), which is the sum of consumption, investment, government expenditures, and net exports for the state. In 2017, Maryland's GSP totaled nearly $400 billion dollars.[30] The Project Team considered impacts to 2030 as well as between 2030 and 2050. To capture impacts over time, the Project Team measured dollars over time using cumulative net

[30] "Total Gross Domestic Product for Maryland (MDNGSP)," FRED Federal Reserve Bank of St. Louis, last modified November 19, 2018, accessed February 14, 2019, https://fred.stlouisfed.org/series/MDNGSP.

present value, a common way of comparing the return on investment when looking at the financial viability of multiple projects or policies over a period of time.

For this analysis, the Project Team used a discount rate of 3 percent, with contributions to GSP remaining positive through 2030.[31] The Draft GGRA Plan adds an additional $11.2 billion to the state's GSP.

Figure 21: Gross State Product in the Draft GGRA Plan Relative to the Reference Case



Sources: REMI, E3, MDE, MDOT, RESI

Notably, the Draft GGRA Plan is forecasted to continue the positive trend through 2050. That is, Maryland will continue adding more jobs each year through 2050. Figure 21 illustrates the difference in GSP levels between the Draft GGRA Plan and the reference case.

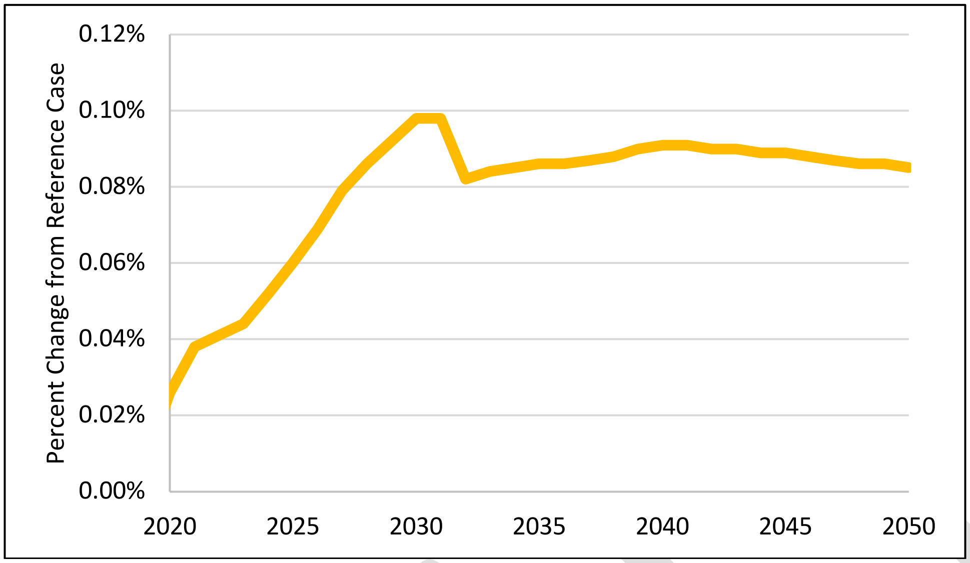
1.4.6 Consumer Prices in the Draft GGRA Plan

The Project Team also considered how the policy scenarios could impact the prices that Maryland residents would pay for goods and services. To do so, price changes were analyzed using the Personal Consumption Expenditure (PCE) Price Index relative to the reference case. The PCE Price Index, similar to the Consumer Price Index (CPI), measures the change in prices for a basket of goods. While the CPI asks consumers directly how much they spend, the PCE Price Index uses sales data from businesses to construct the index.

On average, as illustrated in Figure 22, the Draft GGRA Plan shows price increases through 2030, increasing from 0.06 to 0.08 percent relative to the reference case through 2030 and 2050, respectively.[32]

[31] Figures represent scenarios that include MDOT project spending.
[32] Figures represent scenarios that include MDOT project spending.

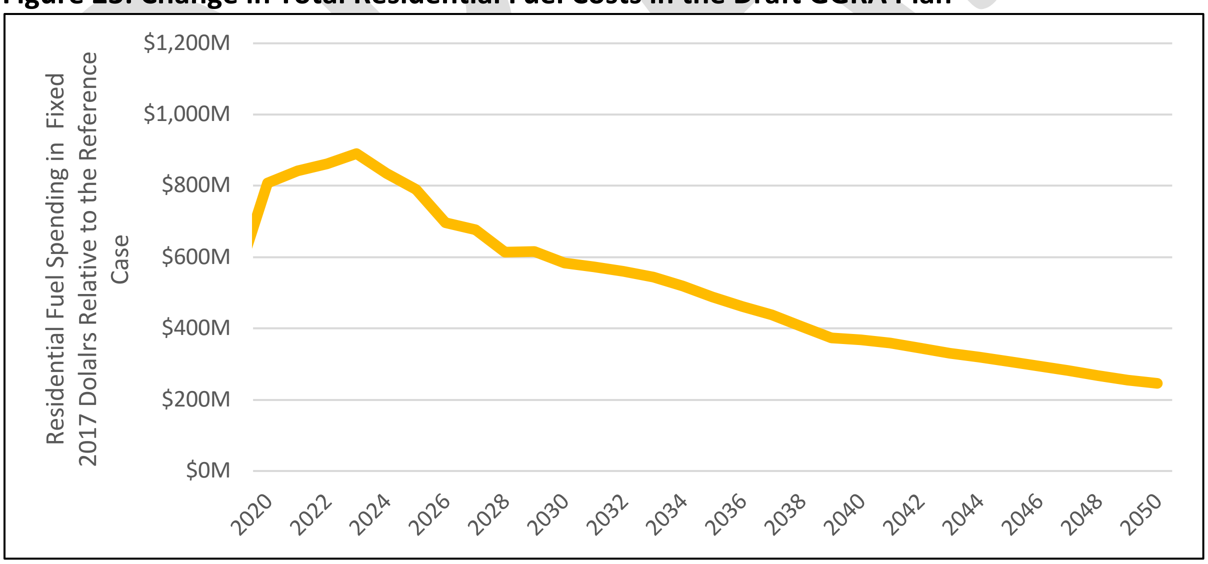
Figure 22: Percent Change in PCE Index in the Draft GGRA Plan Relative to the Reference Case



Sources: REMI, E3, MDE, MDOT, RESI

In addition to considering the impacts on overall consumer prices, the Project Team considered how the policy scenarios could affect the total cost of fuel for residential customers. A number of policies in the Draft GGRA Plan will affect the price and consumption of various fuels, leading to changes in total costs. Figure 23 details the projected change in residential fuel costs until 2050 for the Draft GGRA Plan.

Figure 23: Change in Total Residential Fuel Costs in the Draft GGRA Plan



Source: E3, MDE, REMI, RESI

In 2030, residential spending on non-transportation utilities is higher than the reference case in the Draft GGRA Plan. While this declines by 2050, residential spending in the Draft GGRA Plan remains higher than the reference case. In the GGRA Plan, spending on electricity increases, due to the increased cost of generation, as well as the increased usage of electricity instead of other fuels. Usage of electricity increases as consumers convert to using more energy efficient appliances. Natural gas spending also drops in the Draft GGRA Plan.

1.5 MWG Scenario Results

This section provides an overview of the MWG Scenario. The results of this policy were then examined. For more detail on individual assumptions and policies in all policy scenarios, please see Appendix A.

1.5.1 MWG Scenario Overview

The MWG Scenario consists of policies identified by the Mitigation Working Group (MWG) to achieve deeper emissions reductions. In addition to the continued adoption of the CARES target of 100 percent renewable energy by 2040, as well as meeting 100 percent reductions from the RGGI cap by 2040, these policies target additional sectors of the economy.

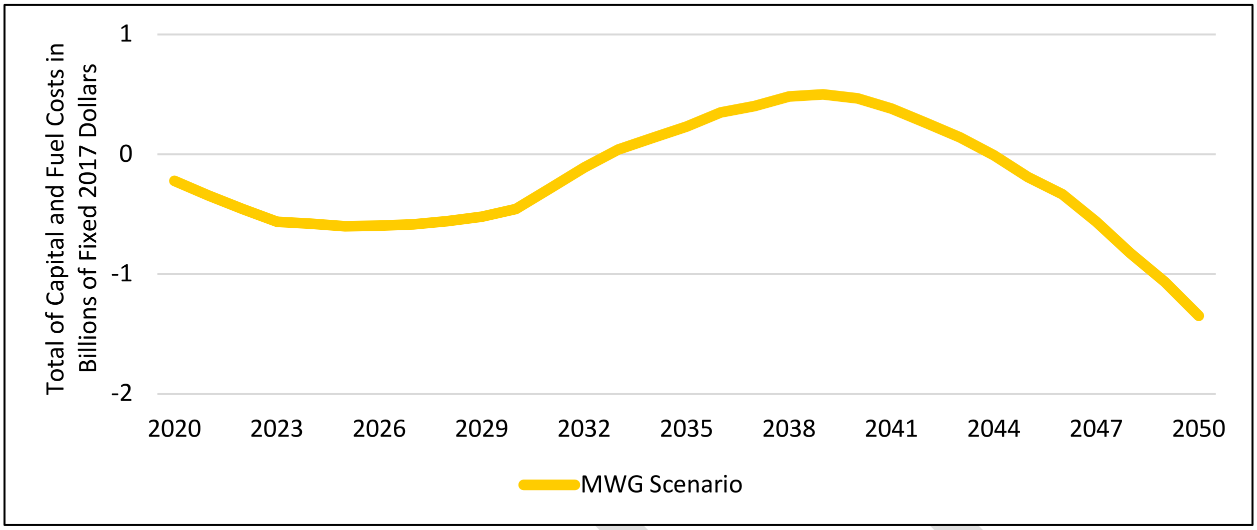
- For electrification and efficiency gains in buildings, this includes 95 percent of new heat pump sales by 2050 and 100 percent high efficiency electric appliance sales by 2030.
- In the transportation sector, 800,000 additional zero emissions light duty vehicles will be sold (compared to the reference case) with this total rising to 5 million by 2050. For heavy duty vehicles, it is assumed that 40 percent of sales by 2030 will be electric or diesel hybrid vehicles. By 2050, this grows to 95 percent. MDOT plans to achieve 100 percent electrification of transit busses and construction vehicles by 2050 and 2040, respectively.

The following sections contain the economic results of the MWG Scenario.

1.5.2 Spending and Electricity Demand in the MWG Scenario

Similar to the Draft GGRA Plan, the interplay between capital expenditures and fuel costs is a large factor in determining the economic outcomes. Economy-wide, when capital expenditures offset fuel savings, this produces negative economic results. On the other hand, when fuel savings are able to overcompensate for any increases in capital expenditures, this is a benefit to the economy. As seen below in Figure 24, costs in the MWG Scenario increase relative to the reference case from 2033 to 2043, but remain below the reference case in all other years of the model.

Figure 24: Total Costs from PATHWAYS for the MWG Scenario Relative to the Reference Case

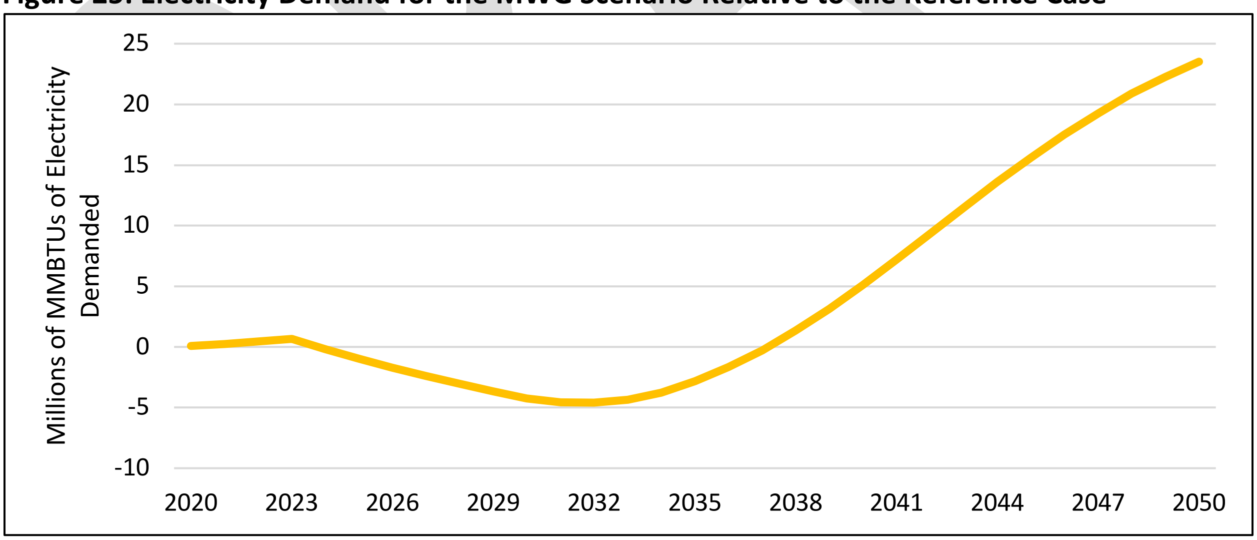


Sources: E3, MDE, RESI

When total costs are below zero, this means that capital expenditures are being offset by fuel savings. This is observed in the period before 2030. After 2030 through the mid-2040s, fuel savings do not outweigh expenditures on capital.

While electricity demand starts off slowly in the MWG Scenario, in 2038 demand begins to exceed reference case levels, as seen below.

Figure 25: Electricity Demand for the MWG Scenario Relative to the Reference Case



Sources: E3, MDE, RESI

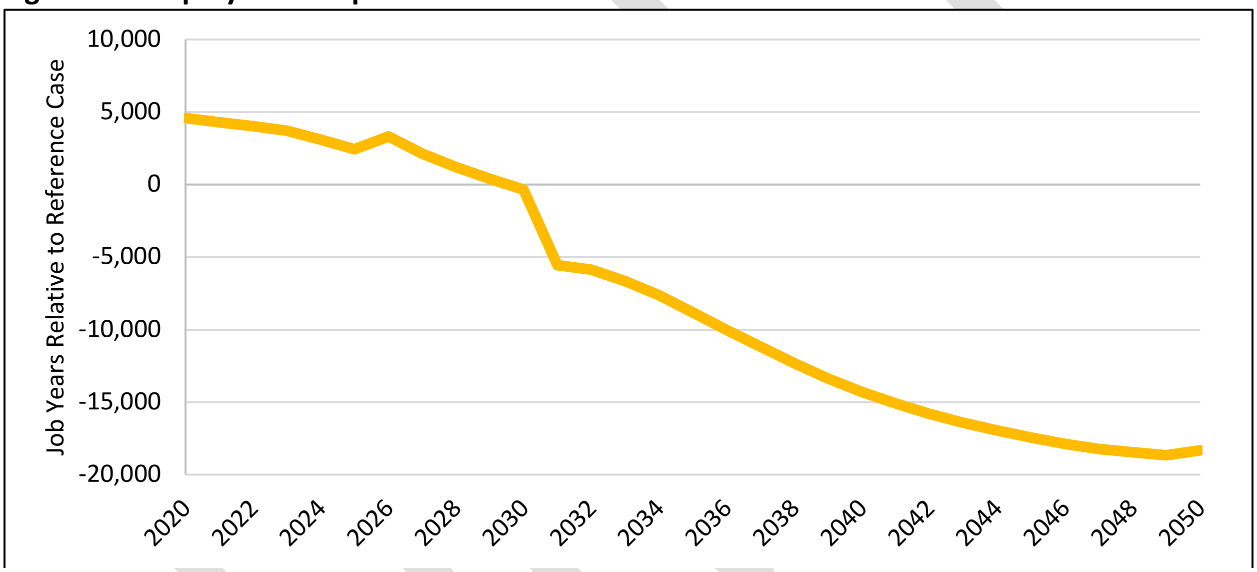
1.5.3 Employment

To meet the economic goals as described in Section 1.3.7, policy scenarios must achieve positive job growth, on average, through 2030. This section presents detailed employment results for each policy scenario. Employment in the MWG Scenario is measured along the same dimensions as in the Draft GGRA Plan in Section 1.4.3.1.

On average, the MWG Scenario supports approximately 2,624 jobs annually through 2030. These impacts largely result from transportation strategies implemented by MDOT. Specifically, transportation programs such as Intermodal Freight Centers Access Improvement and Transit Capacity/Service Expansion are responsible for a significant portion of the near-term transportation-related jobs.

Figure 26 shows employment changes in the MWG Scenario, with significant declines beginning after 2025. These drops in employment correspond with MDOT project timelines, most of which are forecasted to be completed by 2025, with some projects having an estimated completion date of 2030.

Figure 26: Employment Impacts of the MWG Scenario

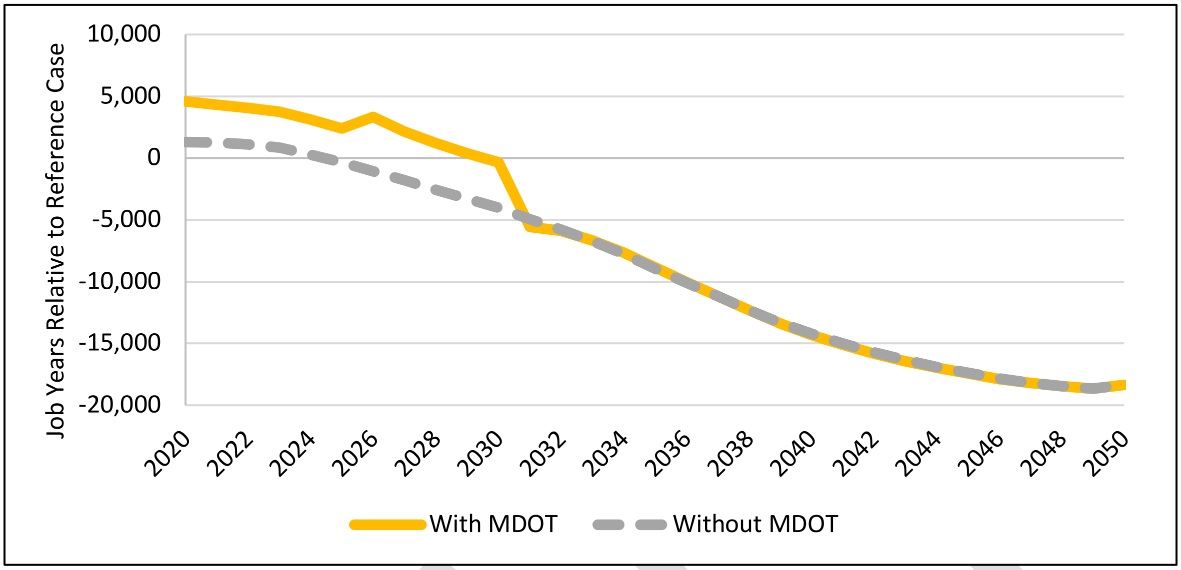


Sources: REMI, E3, MDE, MDOT, RESI

In the years beyond 2030, employment levels drop relative to the reference case. This is mainly due to the more aggressive emissions assumptions for the MWG Scenario. Consumers and businesses are spending more on capital relative to their fuel savings, producing a net cost to the economy. For example, if a consumer invests in a high efficiency air conditioner but the fuel savings do not overcompensate for the additional cost of the purchase (compared to a standard air conditioner).

Figure 27 shows the difference in employment effects with and without funding directed towards transportation measures.

Figure 27: Employment Impacts due to Transportation Measures for MWG Scenario

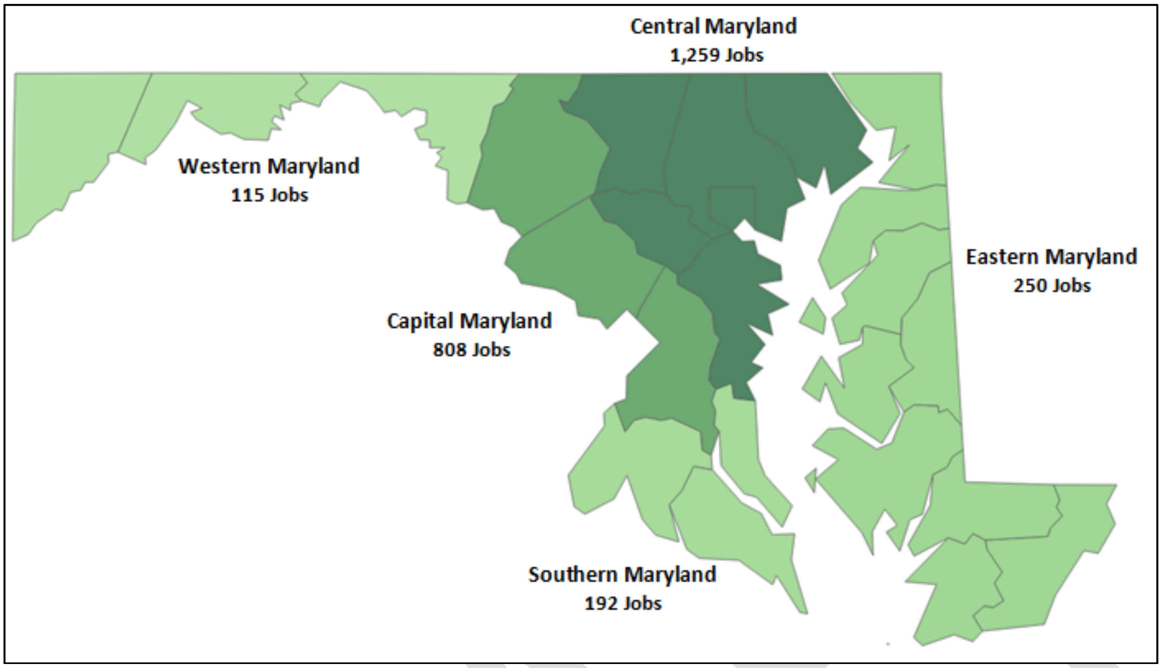


Sources: REMI, E3, MDE, MDOT, RESI

There is divergence in the near-term between the scenarios with and without MDOT projects. The effects become virtually identical after 2030 as the MDOT measures are set to expire. On average through 2030, the scenario without MDOT spending supports 3,382 fewer jobs annually compared to the scenario with MDOT spending. By 2030, both scenarios are forecasted to support fewer jobs than would exist under the reference case.

Figure 28 shows the regional distribution of jobs under the MWG Scenario, with darker-shaded areas having greater average employment gains through 2030.

Figure 28: Average Annual Employment Impacts by Region for MWG Scenario, 2020-2030



Sources: E3, MDE, RESI

Central Maryland shows the largest gains with 1,259 jobs, followed by Capital Maryland with 808 jobs. Job gains in the other regions are modest, with average annual employment impacts of 250 jobs or less in each region.

Employment distributions by major NAICS industries are outlined in Figure 29. As shown below, Construction is responsible for more than 100 percent of the total jobs supported by the MWG Scenario, offsetting job losses seen in a number of other industries.

Figure 29: Employment Impacts by Industry for the MWG Scenario, 2020-2030

NAICS	Industry	Annual Average Number of Jobs, 2020-2030
11	Agriculture, Forestry, Fishing and Hunting	140
21	Mining, Quarrying, and Oil and Gas Extraction	-69
22	Utilities	-132
23	Construction	3,287
31-33	Manufacturing	108
42	Wholesale Trade	-45
44-45	Retail Trade	-935
48-49	Transportation and Warehousing	14
51	Information	-9
52	Finance and Insurance	10
53	Real Estate and Rental and Leasing	-21

54	Professional, Scientific, and Technical Services	-31
55	Management of Companies and Enterprises	-12
56	Administrative and Support and Waste Management and Remediation Services	-8
61	Educational Services	20
62	Health Care and Social Assistance	184
71	Arts, Entertainment, and Recreation	-3
72	Accommodation and Food Services	25
81	Other Services (except Public Administration)	74
92	Public Administration	29
Total		**2,624**

Sources: E3, MDE, REMI, RESI, U.S. Census

Job losses are seen in the same number of industries that experience job growth. The largest loss is seen in Retail Trade, which loses an annual average of 935 jobs between 2020 and 2030, as the need for gas stations falls with increased electric vehicle use.

The occupational distributions of employment changes within the MWG Scenario are detailed in Figure 30.

Figure 30: Employment Impacts by Occupation for MWG Scenario

SOC Code	SOC Description	Annual Average Number of Jobs, 2020-2030
11	Management Occupations	179
13	Business and Financial Operations Occupations	86
15	Computer and Mathematical Occupations	-10
17	Architecture and Engineering Occupations	28
19	Life, Physical, and Social Science Occupations	-3
21	Community and Social Service Occupations	14
23	Legal Occupations	-4
25	Education, Training, and Library Occupations	29
27	Arts, Design, Entertainment, Sports, and Media Occupations	-9
29	Healthcare Practitioners and Technical Occupations	22
31	Healthcare Support Occupations	33
33	Protective Service Occupations	1
35	Food Preparation and Serving Related Occupations	-9
37	Building and Grounds Cleaning and Maintenance Occupations	21
39	Personal Care and Service Occupations	55
41	Sales and Related Occupations	-444

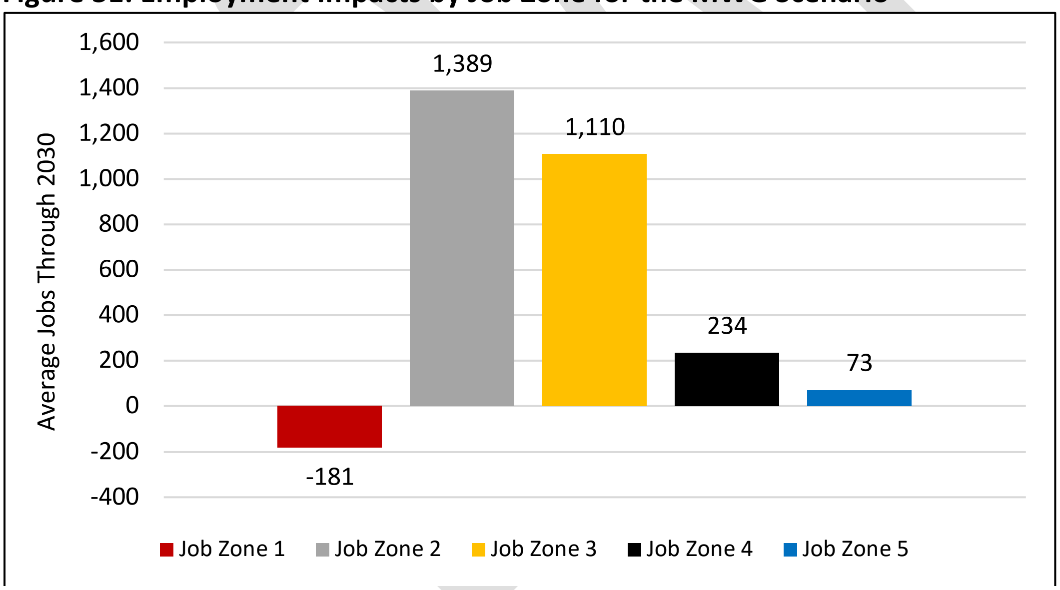
43	Office and Administrative Support Occupations	138
45	Farming, Fishing, and Forestry Occupations	76
47	Construction and Extraction Occupations	2,044
49	Installation, Maintenance, and Repair Occupations	230
51	Production Occupations	76
53	Transportation and Material Moving Occupations	72
Total		**2,624**

Sources: E3, MDE, REMI, RESI, U.S. BLS

In the MWG Scenario, Construction and Extraction Occupations post the largest gains at 2,044 jobs on average through 2030, followed distantly by Installation, Maintenance, and Repair Occupations with an annual average impact of 230 jobs. A number of occupational groups experience little-to-no impact under this scenario. One occupational group, Sales and Related Occupations, shows a more significant average annual loss in jobs relative to the reference case. This annual negative impact of 444 jobs is the second-largest impact among all occupations in absolute terms.

Figure 31 provides annual employment impacts for each of the five job zones defined in Section 1.4.3.1.

Figure 31: Employment Impacts by Job Zone for the MWG Scenario

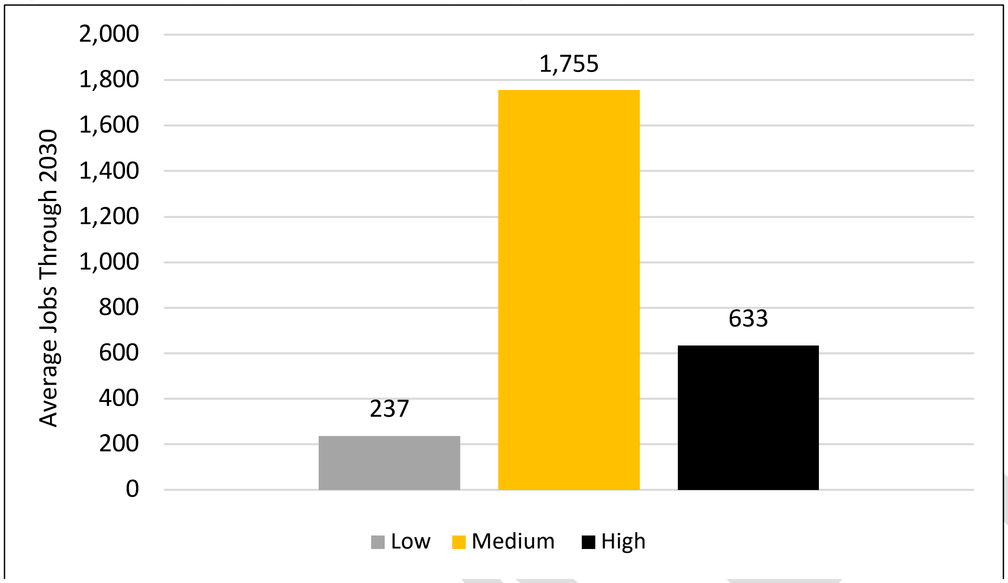


Sources: E3, MDE, O*Net, REMI, RESI

The simulation results for the MWG Scenario show that the largest employment gains will be in Job Zone 2 and Job Zone 3. Job gains in zones that require less education or training may help to increase the labor force participation rate in the state, as these jobs have fewer barriers to entry. Under this plan, jobs with the absolute lowest barrier to entry (Job Zone 1) experience a net loss in jobs relative to the reference case.

Employment distributions by wage group for the MWG Scenario are illustrated in Figure 32.

Figure 32: Employment Impacts by Wage Group for MWG Scenario

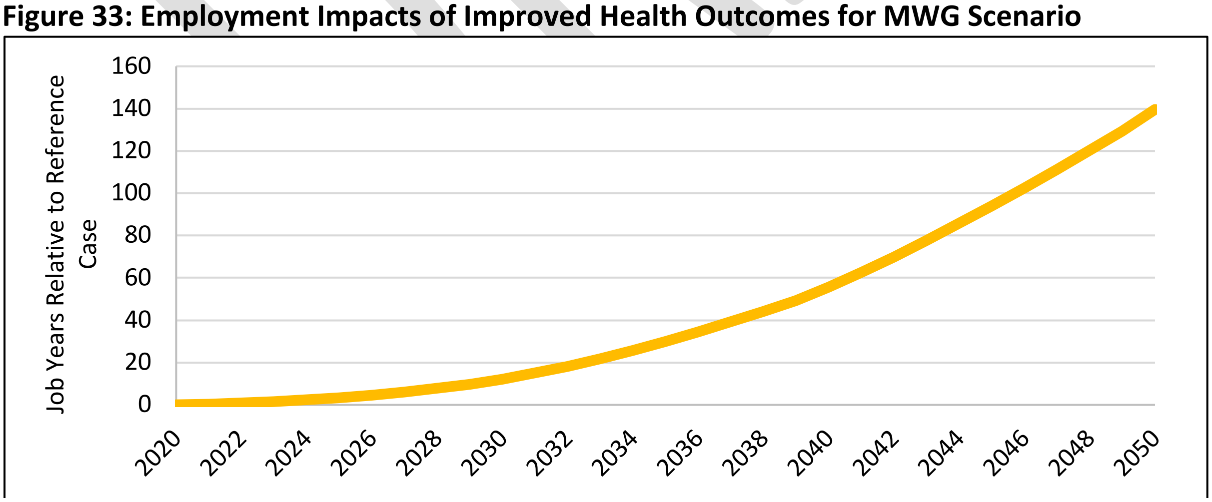


Sources: E3, MDE, REMI, RESI, U.S. BLS

Medium-wage occupations show the largest gains under the MWG Scenario. Similar to the Draft GGRA Plan, the MWG Scenario also supports fewer low- and high-wage jobs. Unlike the Draft GGRA Plan, new high-wage jobs outnumber new low wage-jobs. This is likely due to the larger proportion of jobs in Office and Administrative Support occupations. These occupations are likely supported by the strong job gains in the construction industry.

The employment impacts due to improved health outcomes for the MWG Scenario are illustrated in Figure 33.

Figure 33: Employment Impacts of Improved Health Outcomes for MWG Scenario



Sources: E3, MDE, MDOT, RESI, U.S. EPA

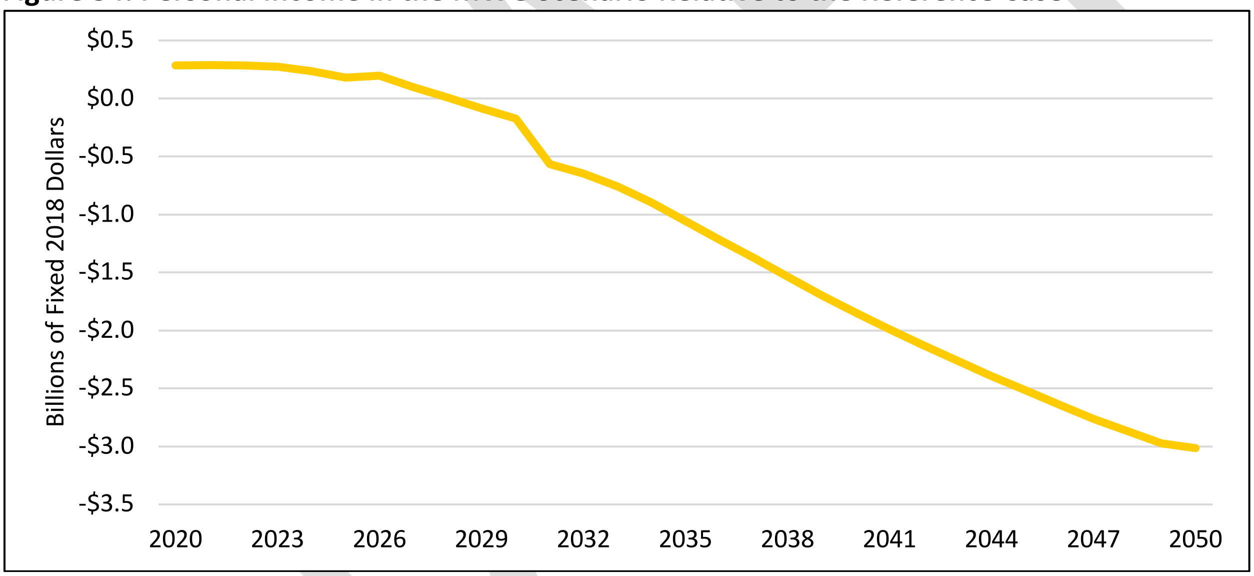
Notably, because emissions reductions are more substantial in the MWG Scenario, the magnitude of job gains resulting from health improvements are larger, supporting an average of four jobs through 2030 and 44 jobs through 2050. Detailed results for health impacts are found in Appendix C.5.

1.5.3 Personal Income in the MWG Scenario

In addition to employment, it is also important to consider how personal income will be affected. Personal income within REMI is calculated as the sum of the total wages and salaries, supplements to these wages and salaries, property income, and personal current transfer receipts. Of these, wages and salaries represent the majority of personal income in Maryland.

The MWG Scenario shows gains of $0.1 billion on average through 2030.[33] As illustrated in Figure 34, the trends over time vary considerably by policy scenario. The MWG Scenario shows a large decrease in personal income after 2030, due to a combination of the expiration of MDOT transportation projects, as well as the increased expenditures on capital relative to fuel savings.

Figure 34: Personal Income in the MWG Scenario Relative to the Reference Case



Source: E3, MDE, REMI, RESI

1.5.4 Gross State Product (GSP) in the MWG Scenario

The Project Team also considered impacts to Maryland's economy measured as changes to gross state product (GSP), which is the sum of consumption, investment, government expenditures, and net exports for the state. In 2017, Maryland's GSP totaled nearly $400 billion dollars.[34] The Project Team considered impacts to 2030 as well as between 2030 and 2050. To

[33] Figures represent scenarios that include MDOT project spending.

[34] "Total Gross Domestic Product for Maryland (MDNGSP)," FRED Federal Reserve Bank of St. Louis, last modified November 19, 2018, accessed February 14, 2019, https://fred.stlouisfed.org/series/MDNGSP.

capture impacts over time, the Project Team measured dollars over time using cumulative net present value, a common way of comparing the return on investment when looking at the financial viability of multiple projects or policies over a period of time.

For this analysis, the Project Team used a discount rate of 3 percent.

Figure 35: Cumulative Net Present Value

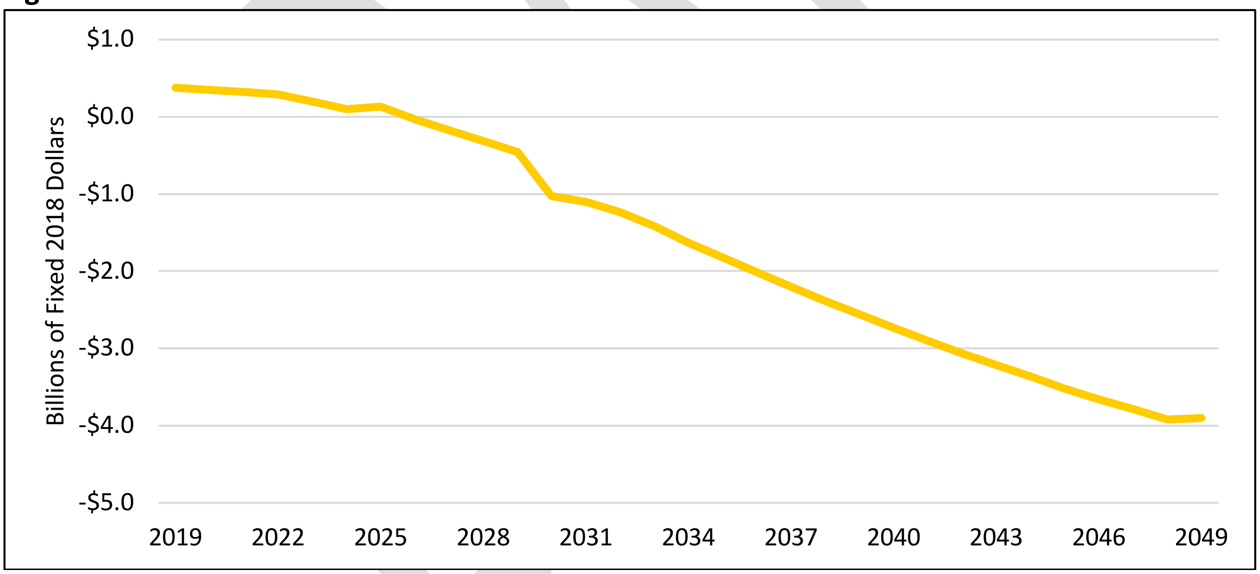
	MWG Scenario
2020 Through 2030	$926,166,774
2030 Through 2050	-$25,769,002,909

Sources: E3, MDE, REMI, RESI

Contributions to GSP remain positive through 2030.[35] The MWG Scenario sees gains of $0.9 billion to the state's GSP through 2030 but drops negative through 2050. Note that this negative GSP does not imply an economic contraction (i.e., economic growth remains positive in all years), but is negative relative to the reference case.

Figure 36 below details changes to Maryland's GSP under both scenarios through 2050.

Figure 36: Gross State Product in the MWG Scenario Relative to the Reference Case



Sources: E3, MDE, REMI, RESI

Changes to Maryland's GSP are forecasted to be positive through 2025 in the MWG Scenario but decline in subsequent years, relative to the reference case.

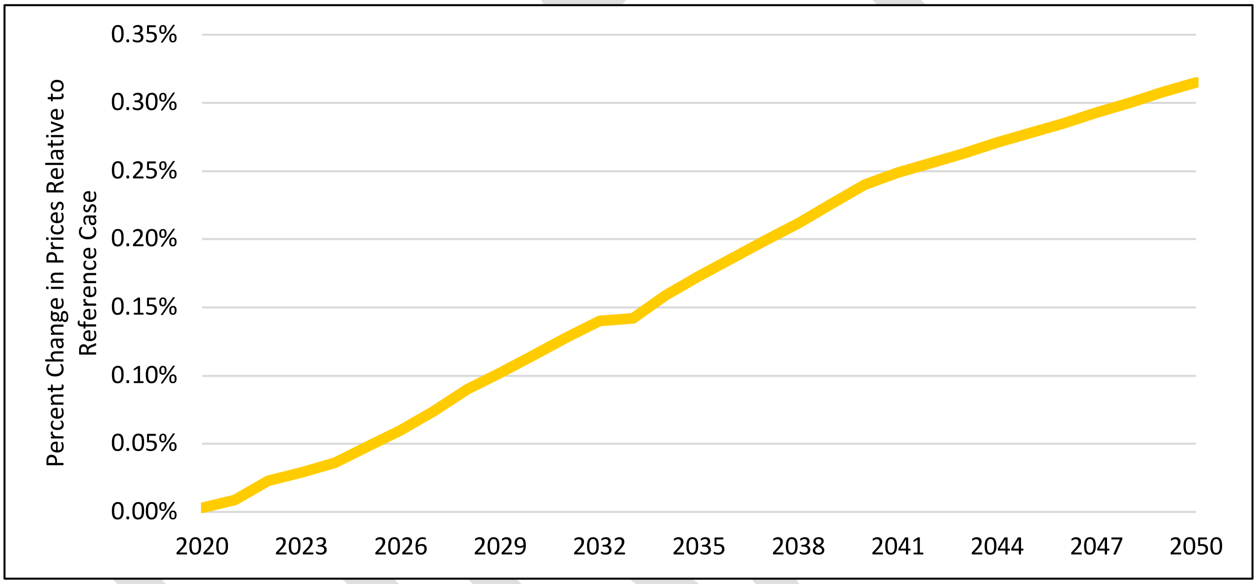
35 Figures represent scenarios that include MDOT project spending.

1.5.5 Consumer Prices in the MWG Scenario

The Project Team also considered how the policy scenarios could impact the prices that Maryland residents would pay for goods and services. To do so, price changes were analyzed using the Personal Consumption Expenditure (PCE) Price Index relative to the reference case. The PCE Price Index, similar to the Consumer Price Index (CPI), measures the change in prices for a basket of goods. While the CPI asks consumers directly how much they spend, the PCE Price Index uses sales data from businesses to construct the index.

On average, as illustrated in Figure 37, the MWG Scenario shows price increases of 0.08 percent relative to the reference case on average through 2030.[36] After 2030, the MWG Scenario continues to show a rise in consumer prices, averaging a 0.18 percent increase through 2050.

Figure 37: Change in the PCE Price Index in the MWG Scenario

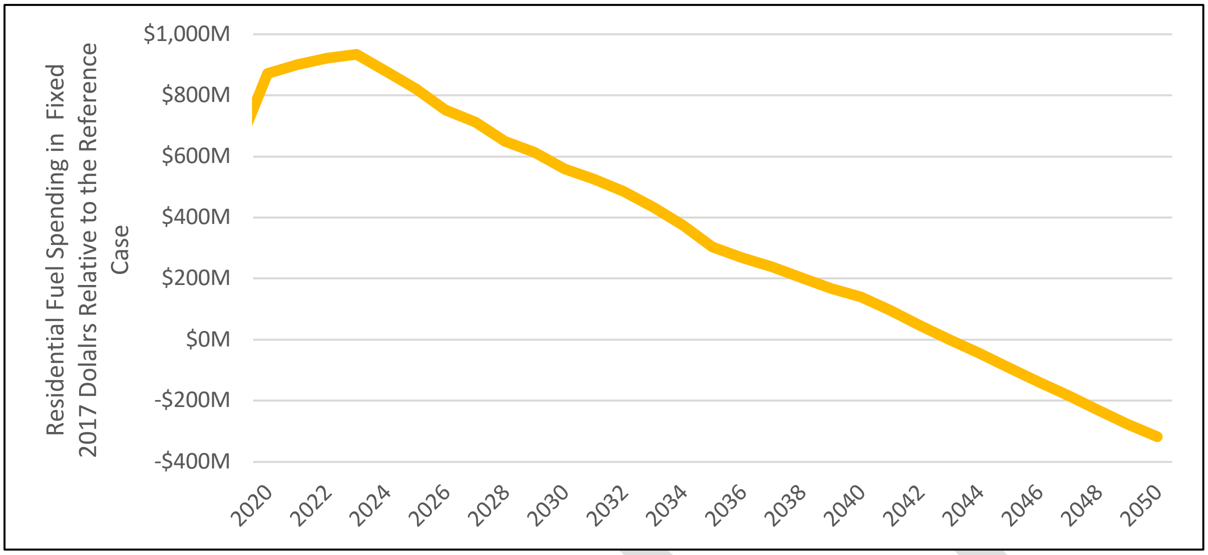


Sources: E3, MDE, REMI, RESI

In addition to considering the impacts on overall consumer prices, the Project Team considered how the policy scenarios could affect the total cost of fuel for residential customers. A number of policies in the MWG Scenario will affect the price and consumption of various fuels, leading to changes in total costs. Figure 38 details the projected change in residential fuel costs until 2050 for the MWG Scenario.

[36] Figures represent scenarios that include MDOT project spending.

Figure 38: Change in Total Residential Fuel Costs in the MWG Scenario



Source: E3, MDE, REMI, RESI

In 2030, residential spending on non-transportation utilities is higher than the reference case in the MWG Scenario. However, by 2050, residential spending in the MWG Scenario is lower than the reference case. In the MWG Scenario, spending on electricity increases, due to the increased cost of generation, as well as the increased usage of electricity instead of other fuels. Usage of electricity increases as consumers convert to using more energy efficient appliances. Natural gas spending drops in MWG Scenario.

1.6 Final GGRA Plan

After the emissions and economic impacts associated with the Draft GGRA Plan and the MWG Scenario were estimated and analyzed, the Final GGRA Plan was constructed both to achieve the emissions requirements laid forth in the GGRA and provide a blueprint for future efforts to reduce greenhouse gas emissions. Compared to the MWG Scenario, this plan contains marginally less aggressive policies in some sectors, including electrification and increased efficiency in buildings, transportation (including both light duty and heavy-duty vehicle sales), and industrial energy use. On the other hand, compared to the Draft GGRA Plan, the final plan contains significantly more aggressive measures in those sectors.

1.6.1 Policy Scenario Four Results

Similar to the Draft GGRA Plan and the MWG Scenario, the Final GGRA Plan meets the economic goals outlined in Section 1.3.7. As shown in Figure 39, all policy scenarios achieve the 2030 economic goals and meet both the 2020 and 2030 emissions targets.

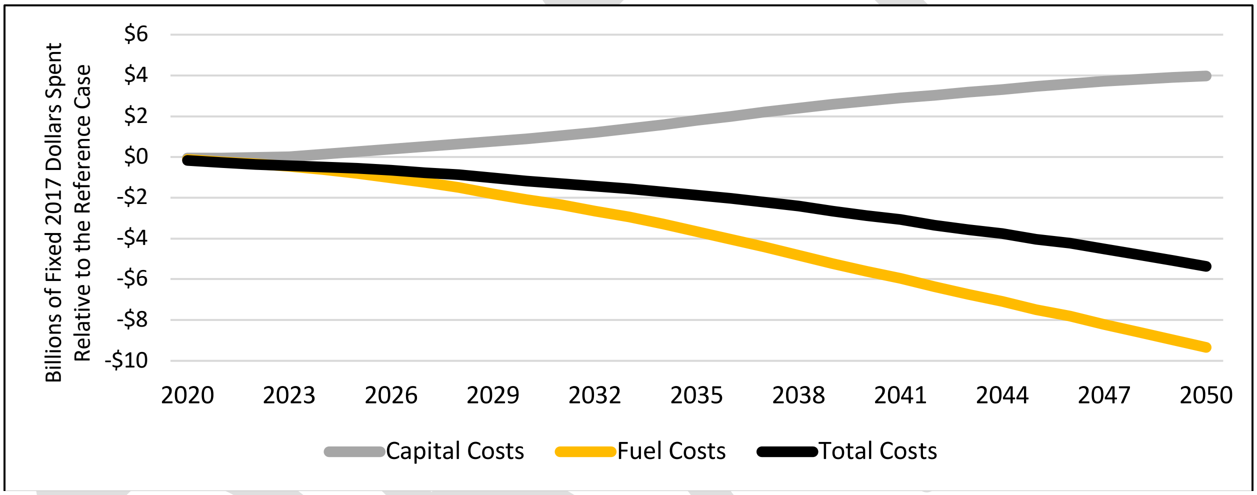
Figure 39: Summary of Policy Scenarios

Policy Scenario	Achieve 2020 Emissions Goal?	Achieve 2030 Emissions Goal?	Achieve 2030 Economic Goal?
Draft GGRA Plan	Yes	Yes	Yes
MWG Scenario	Yes	Yes	Yes
Final GGRA Scenario	Yes	Yes	Yes

Source: RESI

Notably, the Final GGRA Plan achieves these goals with low levels of spending. As illustrated in Figure 40, for every year of the Final GGRA Plan, consumers and businesses spend less on total costs (capital costs plus fuel costs) relative to the reference case.

Figure 40: Total Costs from PATHWAYS in the Final GGRA Plan Relative to the Reference Case



Sources: E3, MDE, RESI

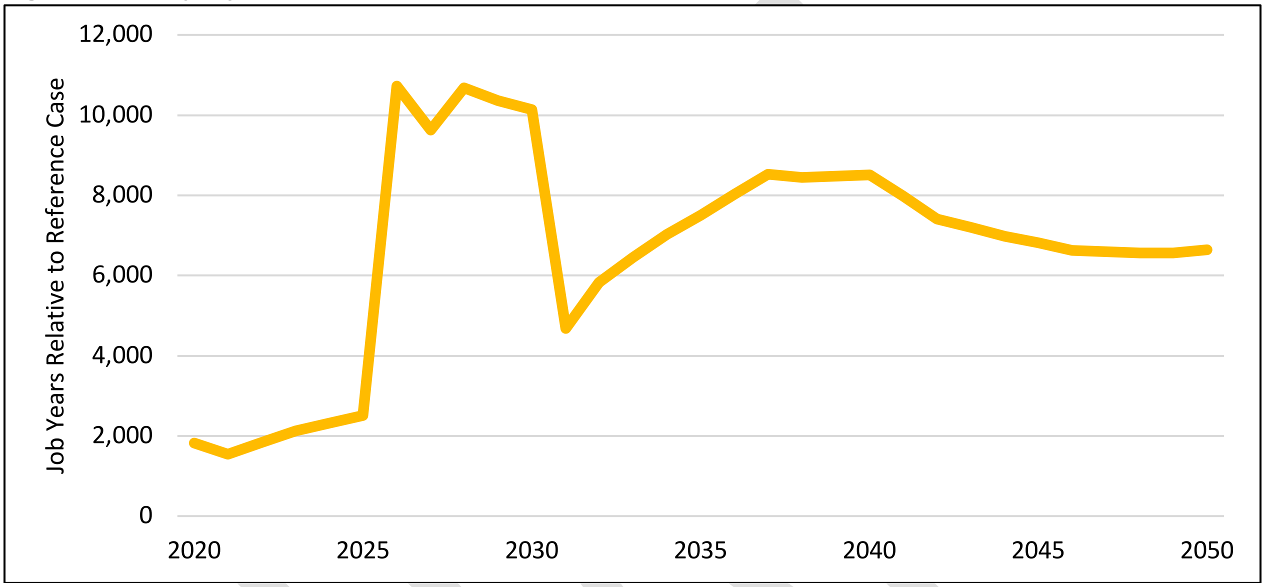
As seen in Figure 40, although consumers and businesses are spending more on capital costs (e.g., new energy-efficient appliances or new electric vehicles) in the Final GGRA Plan than in the reference case, fuel savings exceed this amount every year. This result is attributable to two general trends.

1. Spending on transportation infrastructure projects is significant in the Final GGRA Plan. 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 bus electrification).
2. Total costs are generally the lowest when compared to the Draft GGRA Plan and the MWG Scenario. In both the Draft GGRA Plan and the MWG Scenario, total costs increase post-2030 before eventually declining. The Final GGRA Plan has a consistent decline in costs through 2050.

1.6.1.1 Employment in the Final GGRA Plan

The impacts of infrastructure spending, capital/fuel costs, and renewable energy generation can all be seen when examining the economic impacts of the Final GGRA Plan. As seen in Figure 41, the Final GGRA Plan supports an average of 5,788 jobs each year through 2030 relative to the reference case.

Figure 41: Employment in the Final GGRA Plan Relative to the Reference Case

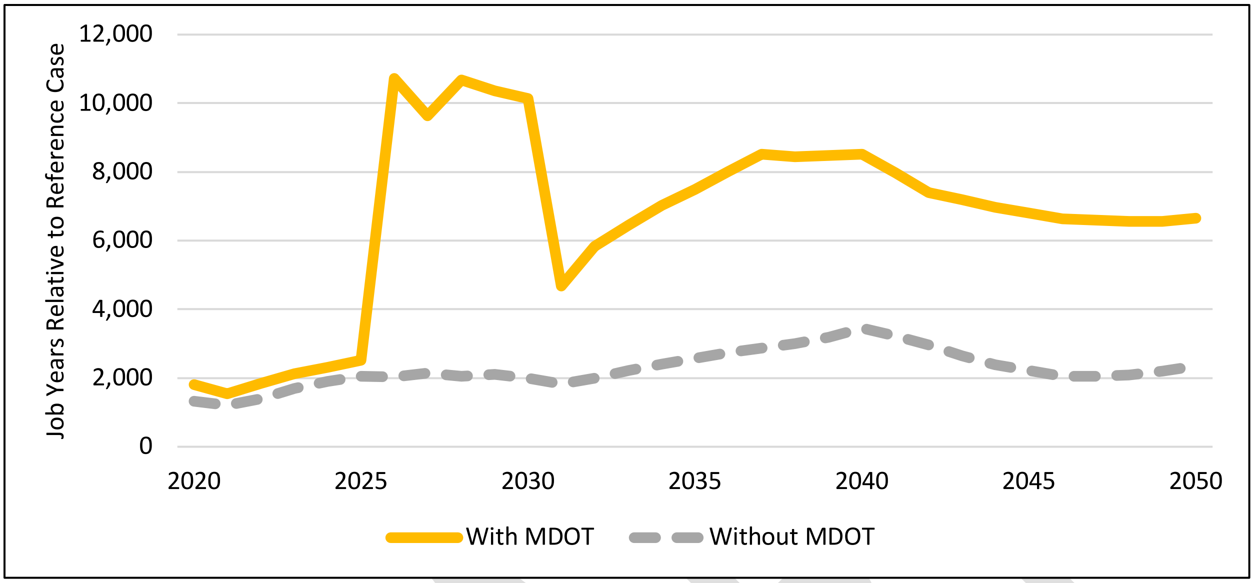


Sources: E3, MDE, REMI, RESI

Through 2030, transportation infrastructure projects largely drive employment impacts, as seen in other policy scenarios. After 2030, employment impacts remain positive relative to the reference case. The steady increase in employment after 2030 is due in part to the capital cost to fuel cost ratio, as well as the increased demand for state-produced renewable energy. Because total spending is lower, consumers have more money to spend on other goods and services, and businesses are profitable.

To visualize the impact of spending on transportation infrastructure on the economic impact results for the Final GGRA Plan, Figure 42 below shows employment differences under the scenario with and without this spending.

Figure 42: Employment in the Final GGRA Plan With and Without Transportation Spending Relative to the Reference Case

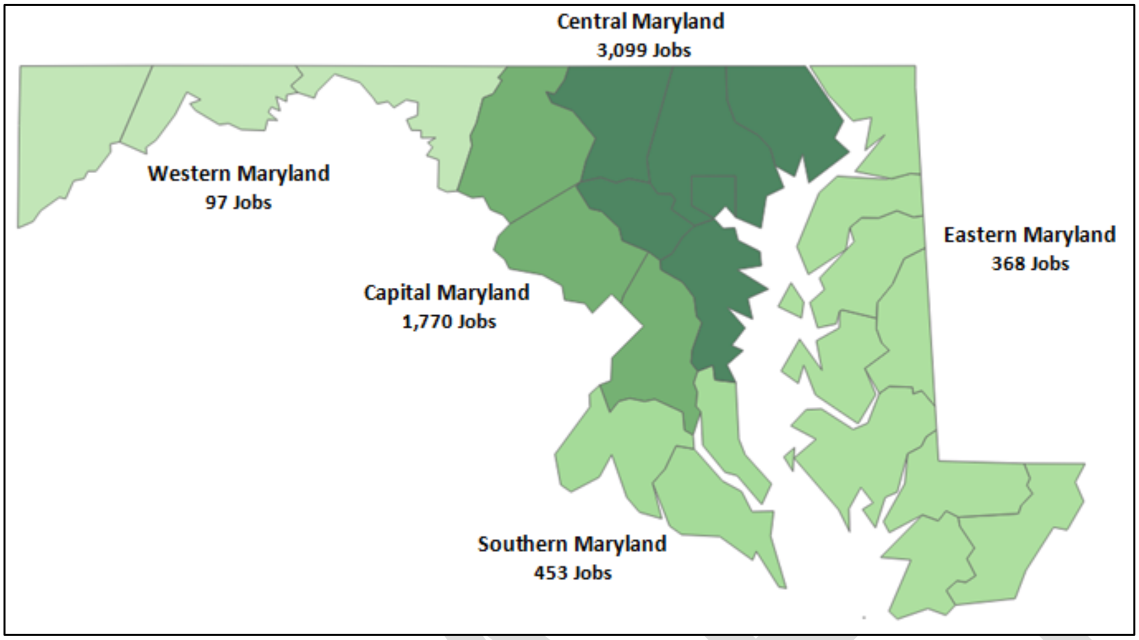


Sources: E3, MDE, REMI, RESI

The impact of transportation spending in the Final GGRA Plan is similar to the impacts in the other policy scenarios. However, a methodological change for the Final GGRA Plan results in higher average job creation after 2030. Instead of assuming that all transportation investments end in 2030, the linear average of program costs is used to approximate future investment through 2050. On average through 2030, transportation infrastructure measures support 3,977 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 Final GGRA Plan.

As shown in Figure 43, all regions of Maryland experience positive job growth relative to the reference case through 2030 for the Final GGRA Plan.

Figure 43: Employment Impacts by Region for Final GGRA Plan



Sources: E3, MDE, REMI, RESI

Following a similar pattern as with the other policy scenarios, Central Maryland sustains the largest employment gains of 3,099 jobs. The Capital Maryland region also shows significant employment increases of 1,770 jobs. Central, Eastern, and Southern Maryland have the most significant employment impact when adjusting for population, each gaining a number of annual jobs approximately equal to 0.1 percent of the region's population. Western Maryland adds jobs at only a quarter of that rate.

Figure 44 below details employment impacts under the Final GGRA Plan through 2030 by industry. Of the annual average of 5,788 jobs, the Construction industry comprises the majority of positions at 3,074 jobs and is driven largely by spending on transportation infrastructure policies during this period.

Figure 44: Employment Impacts by Industry for the Final GGRA Plan, 2020 Through 2030

NAICS	Industry	Annual Average Number of Jobs, 2020-2030
11	Agriculture, Forestry, Fishing and Hunting	134
21	Mining, Quarrying, and Oil and Gas Extraction	-12
22	Utilities	-111
23	Construction	3,074
31-33	Manufacturing	136
42	Wholesale Trade	55
44-45	Retail Trade	101
48-49	Transportation and Warehousing	-24
51	Information	28
52	Finance and Insurance	128
53	Real Estate and Rental and Leasing	150
54	Professional, Scientific, and Technical Services	278
55	Management of Companies and Enterprises	23
56	Administrative and Support and Waste Management and Remediation Services	156
61	Educational Services	60
62	Health Care and Social Assistance	573
71	Arts, Entertainment, and Recreation	68
72	Accommodation and Food Services	288
81	Other Services (except Public Administration)	349
92	Public Administration	334
Total		**5,788**

Sources: E3, REMI, RESI, U.S. Census Bureau

Under the Final GGRA Plan, the Health Care and Social Assistance and Other Services (except Public Administration) industries have the second- and third-highest average gains of 573 and 349 jobs, respectively. Employment decreases are seen in three industries, with the largest drop occurring in Utilities, which loses an average of 111 positions annually through 2030.

No occupational group is expected to have an annual decline under the Final GGRA Plan, as shown in Figure 45 below. The greatest impacts are seen in Construction and Extraction Occupations, with an increase of 1,940 jobs estimated annually through 2030.

Figure 45: Employment Impacts by Occupation for Final GGRA Plan

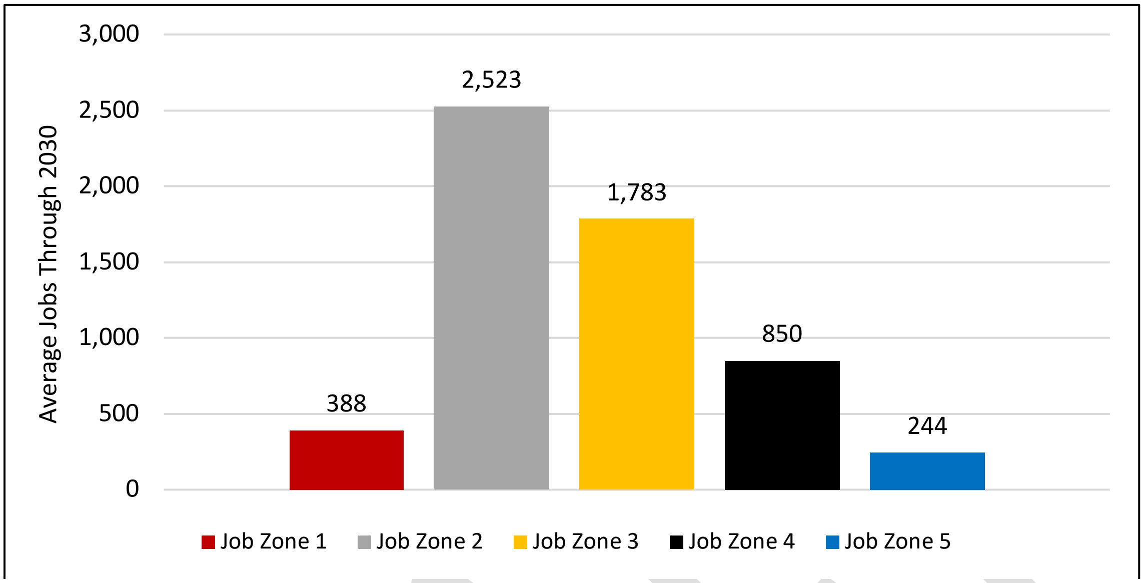
SOC Code	SOC Description	Average Jobs Through 2030
11	Management Occupations	339
13	Business and Financial Operations Occupations	257
15	Computer and Mathematical Occupations	96
17	Architecture and Engineering Occupations	75
19	Life, Physical, and Social Science Occupations	24
21	Community and Social Service Occupations	55
23	Legal Occupations	29
25	Education, Training, and Library Occupations	175
27	Arts, Design, Entertainment, Sports, and Media Occupations	48
29	Healthcare Practitioners and Technical Occupations	203
31	Healthcare Support Occupations	131
33	Protective Service Occupations	62
35	Food Preparation and Serving Related Occupations	276
37	Building and Grounds Cleaning and Maintenance Occupations	135
39	Personal Care and Service Occupations	254
41	Sales and Related Occupations	246
43	Office and Administrative Support Occupations	656
45	Farming, Fishing, and Forestry Occupations	76
47	Construction and Extraction Occupations	1,940
49	Installation, Maintenance, and Repair Occupations	360
51	Production Occupations	149
53	Transportation and Material Moving Occupations	205
Total		**5,788**

Sources: E3, MDE, REMI, RESI, U.S. BLS

Office and Administrative Support Occupations have the second-highest growth at 656 positions annually, followed by Installation, Maintenance, and Repair Occupations with 360 jobs. An additional seven occupational groups are expected to experience growth of at least 200 positions annually through 2030.

The estimated employment effects by job zone under the Final GGRA Plan are shown in Figure 46. As illustrated below, the plurality of occupational growth occurs in in Job Zone 2 and represents nearly half of the jobs gained annually.

Figure 46: Employment Impacts by Job Zone for Final GGRA Plan

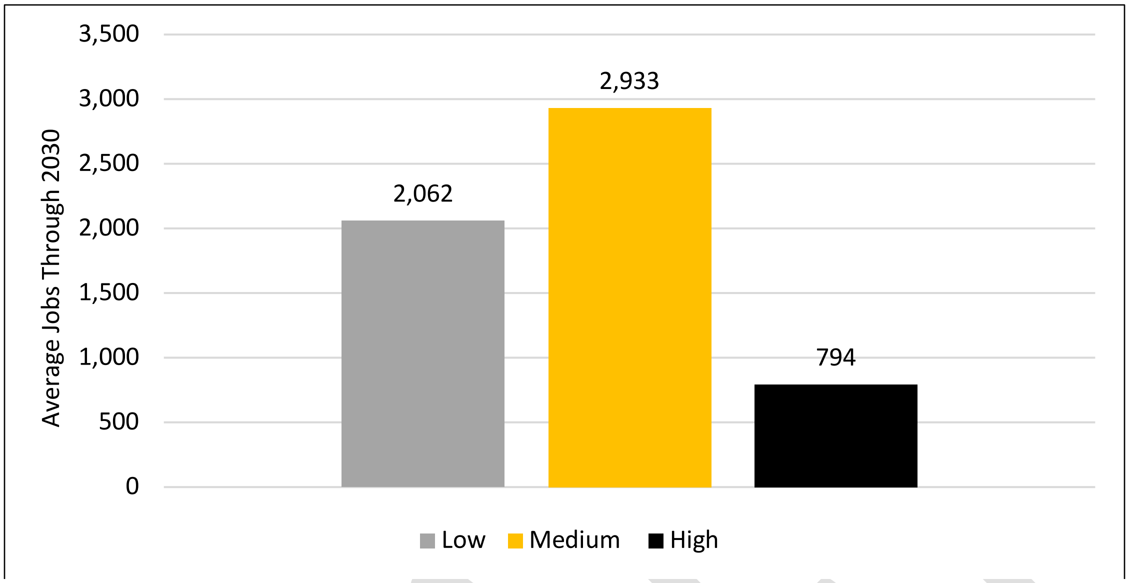


Sources: E3, MDE, O*Net, REMI, RESI

The distribution of employment by job zone in the Final GGRA Plan closely resembles that of the Draft GGRA Plan and MWG Scenario, with the most-substantial increases in jobs that typically require modest preparation and a high school diploma (Job Zone 2), followed by positions that generally require an associate degree or vocational training (Job Zone 3). This is beneficial in that retraining and educational needs are expected to be relatively less extensive and time consuming. No negative impacts are seen in any job zone under the Final GGRA Plan, with the smallest annual increases represented in Job Zone 5.

Employment distribution by wage groups for the Final GGRA Plan are shown in Figure 47 below.

Figure 47: Employment Impacts by Wage Group for Final GGRA Plan

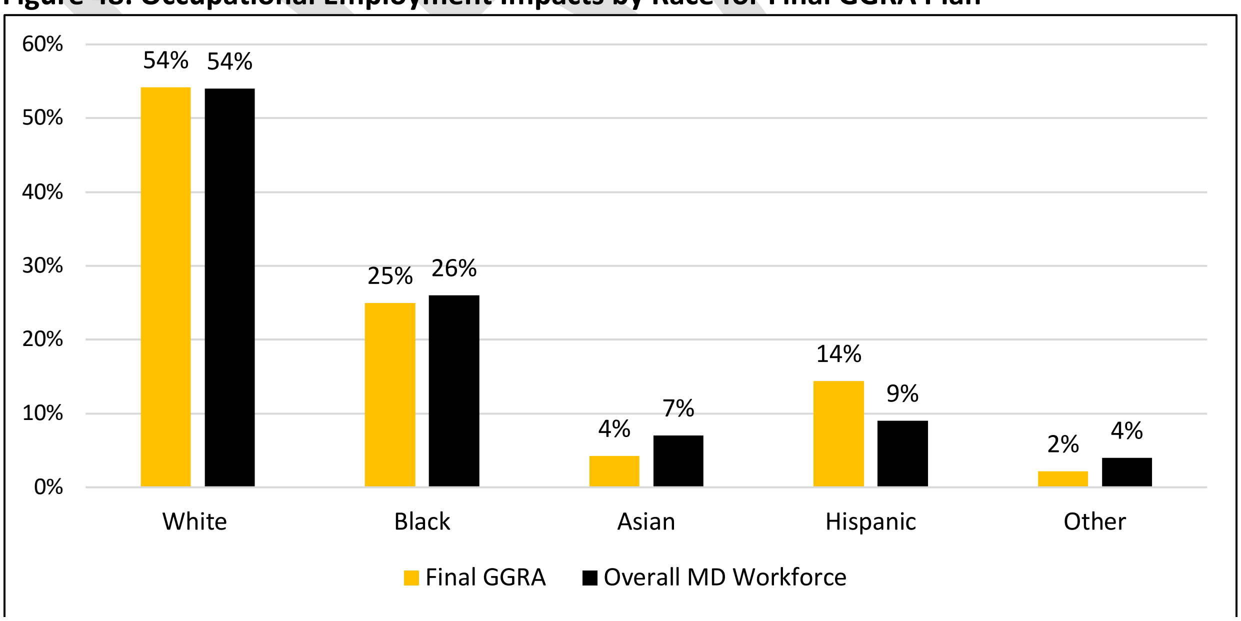


Sources: E3, MDE, REMI, RESI, U.S. BLS

Just over half of the employment impacts under the Final GGRA Plan (2,933 jobs) are found in medium-wage occupations earning between $35,000 and $65,000 annually. A higher number of positions are found in low-wage jobs than high-wage jobs, with more than twice the number of low-wage jobs than in the high-wage category.

Figure 48 shows how employment impacts in the Final GGRA Plan are distributed among racial groups, relative to the state's workforce as a whole.

Figure 48: Occupational Employment Impacts by Race for Final GGRA Plan

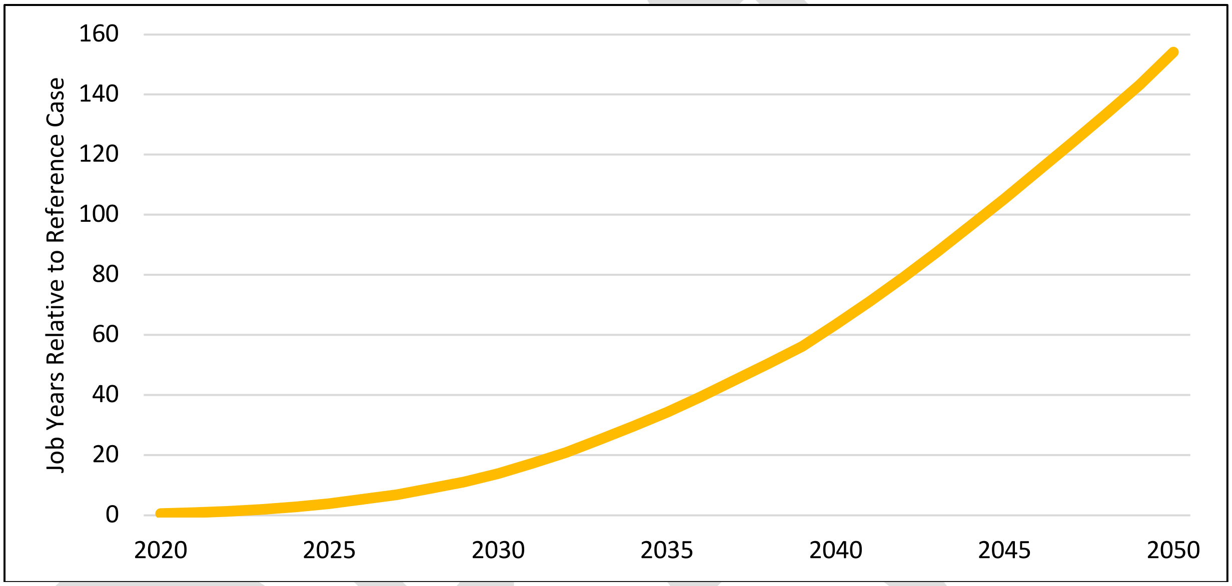


Sources: REMI, E3, MDE, MDOT, RESI, U.S. Census

As seen above, employment in the Final GGRA Plan is expected to track closely with the racial breakdown of Maryland's overall workforce, though there are some differences. Employment for Black and Asian workers is expected to be slightly underrepresented relative to the overall workforce, while Hispanic workers are forecasted to obtain a higher number of jobs relative to their overall representation.

Figure 49 shows the employment impacts that result specifically from improved health outcomes in the Final GGRA Plan.

Figure 49: Employment Impacts of Improved Health Outcomes for Final GGRA Plan



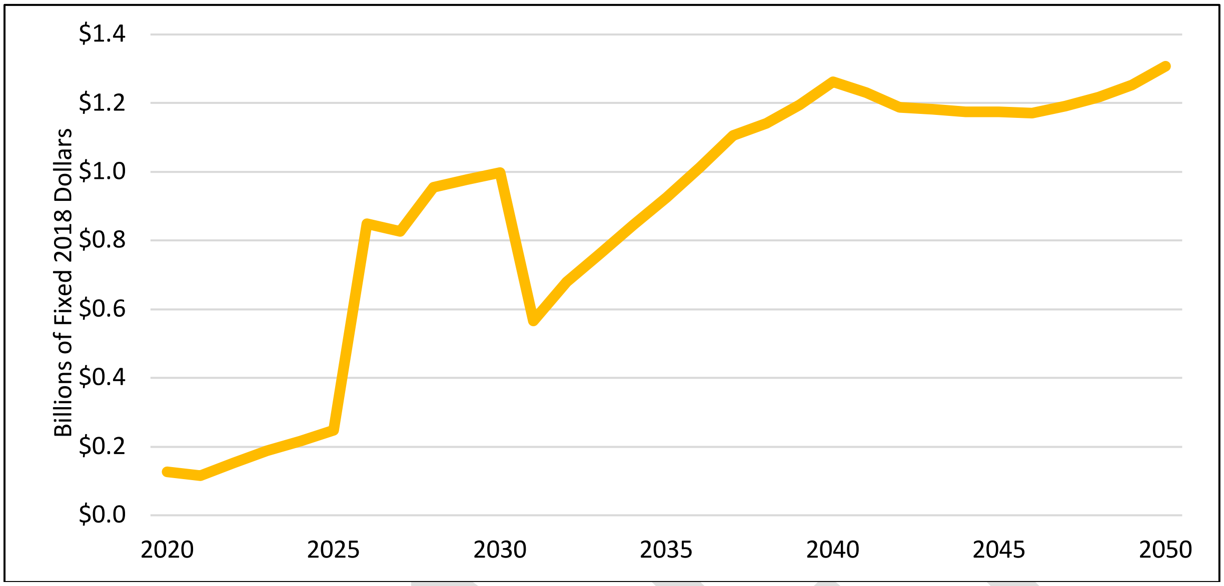
Sources: E3, MDE, MDOT, RESI, U.S. EPA

Between 2020 and 2030, improved health outcomes from the Final GGRA Plan will support an average of five jobs annually. This average increases to 50 jobs when extended to 2050. Detailed results for health impacts are found in Appendix C.5.

1.6.1.2 Personal Income in the Final GGRA Plan

As previously noted, personal income within REMI is calculated as the sum of total wages and salaries, supplements to these wages and salaries, property income, and personal current transfer receipts. Figure 50 below shows changes in personal income levels under the Final GGRA Plan, which remain positive through 2030.

Figure 50: Personal Income in the Final GGRA Plan Relative to the Reference Case



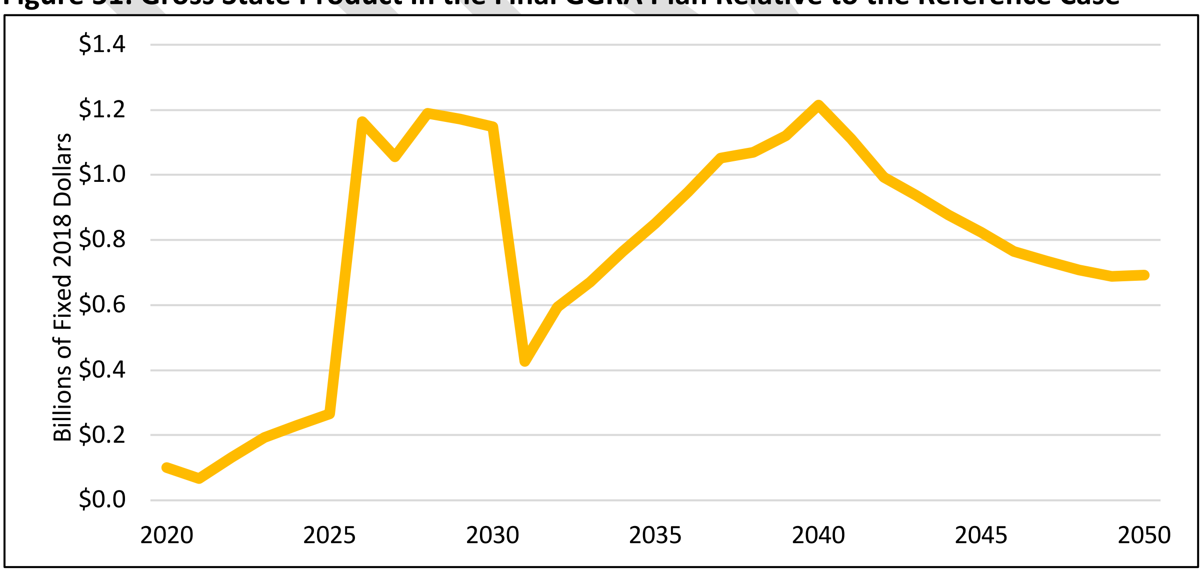
Sources: E3, MDE, REMI, RESI

Personal income is expected to rise under the Final GGRA Plan. Between 2020 and 2030, personal income exceeds the reference scenario by an average of $0.5 billion. A significant portion of this increase is due to spending on transportation infrastructure projects.

1.6.1.3 Gross State Product in the Final GGRA Plan

Gross state product (GSP) is the sum of consumption, investment, government spending, and net exports out of the state in a given year. Figure 51 shows the expected changes to Maryland's GSP under the Final GGRA Plan presented in billions of fixed 2018 dollars.

Figure 51: Gross State Product in the Final GGRA Plan Relative to the Reference Case



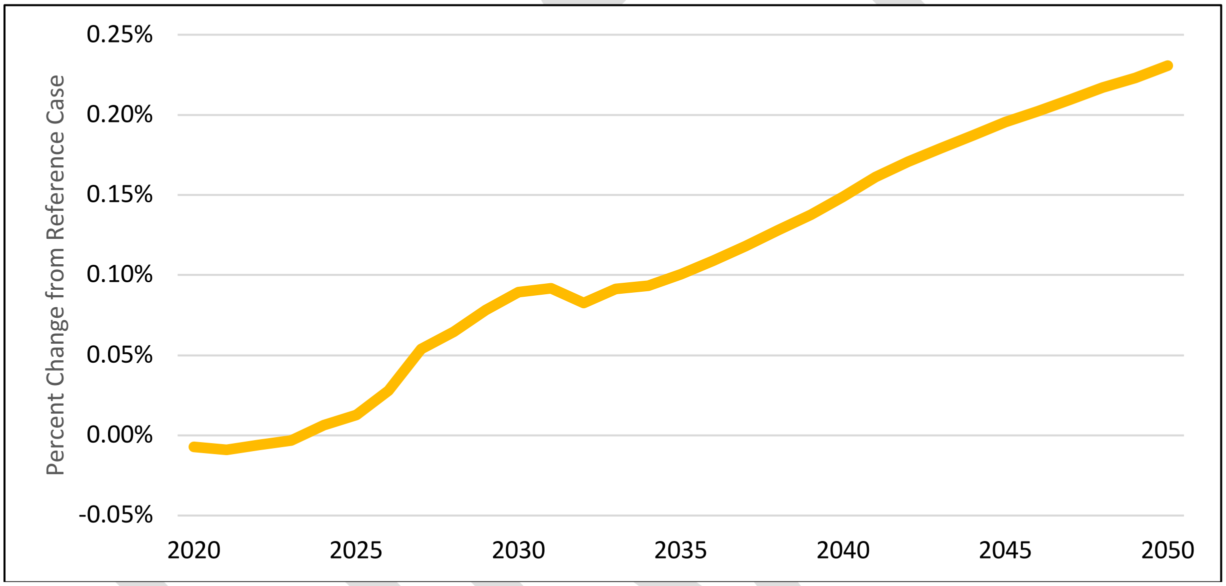
Sources: E3, MDE, REMI, RESI

Under the Final GGRA Plan, Maryland's GSP is forecasted to increase relative to the reference case in every year between 2020 and 2050. The change remains positive on average both with and without transportation infrastructure spending.

1.6.1.4 Consumer Prices in the Final GGRA Plan

Consumer prices are only expected to rise modestly under the Final GGRA Plan. As illustrated in Figure 52, on average, prices will rise 0.03 percent per year relative to the reference case between 2020 and 2030. Through 2050, prices will rise 0.11 percent relative to the reference case. This implies that a good or service that costs $1.00 in 2020 will cost less than one additional penny per year above inflation through both 2030 and 2050.

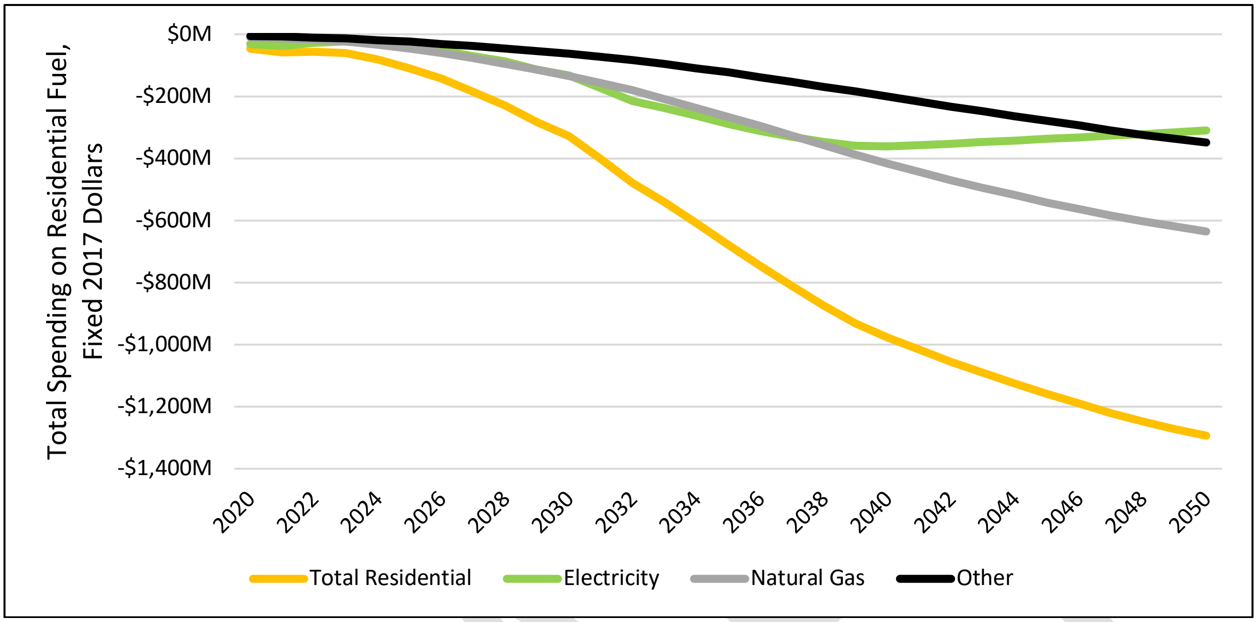
Figure 52: Percent Change in Consumer Prices in Final GGRA Plan Relative to the Reference Case



Sources: E3, MDE, REMI, RESI

When considering policies to reduce greenhouse gas emissions, one of the most relevant spending categories for consumers is utilities. Figure 53 shows residential non-transportation fuel spending in the Final GGRA Plan.

Figure 53: Total Residential Spending on Non-Transportation Fuel By Fuel Type in the Final GGRA Plan, Relative to the Reference Case



Sources: E3, MDE, RESI

As seen in Figure 53, total non-transportation fuel spending declines over time. This decline in spending in reflected across all types of residential fuel, including electricity and natural gas. Generally, electricity demand decreases for all sectors of the economy as consumers and businesses invest in more efficient appliances. The exception to this is the increase in electricity demand by the transportation sector, which reflects the transition from fossil fuels to electricity.

1.7 References

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Table 2-1. Key Assumptions in Baseline and Reference Scenario

	Baseline Scenario	**Reference Scenario (Existing Policies)**
Clean Electricity Standard	None	50% RPS by 2030 (Clean Energy Jobs Act)
RGGI	None	30% cap reduction from 2020 to 2030
Nuclear power	Assume Calvert Cliffs retires in 2034/2036 at end of license, and is replaced with electricity imports	Assume Calvert Cliffs is relicensed in 2034/2036 at end of license
Existing coal power plants	IPM planned retirements (670 MW of coal by 2023)	IPM planned retirements (670 MW of coal by 2023)
Rooftop PV	Current levels of 200 MW	Continued growth in deployment until net metering cap (1500 MW by 2026)
Energy Efficiency (Res., Com. & Industrial)	None	EmPOWER goals for 2015-2023, Calibrated to EmPOWER filing targets
Building Code	None	Continued building code improvement that leads to improved building shells in all new construction by 2030
Electrification of buildings (e.g. NG furnace to heat pumps)	None	None
Transportation	Federal CAFE standards for LDVs by 2026	Federal CAFE standards for LDVs by 2026; continued growth in ZEV LDVs driven by the ZEV Mandate
Other transportation sectors (e.g. aviation)	AEO 2017 reference scenario growth rates by fuel	AEO 2017 reference scenario growth rates by fuel
Industrial energy use	AEO 2017 reference scenario growth rates by fuel	AEO 2017 reference scenario growth rates by fuel
Biofuels	Existing ethanol and biodiesel blends, but no assumed increase	Existing ethanol and biodiesel blends, but no assumed increase
Other (fossil fuel industry, industrial processes, agriculture, waste management, forestry)	Assume held constant at MDE 2017 GHG Inventory levels	Small amount of forest management and healthy soils conservation practices

Each policy scenario was designed with a specific philosophy in mind. Detailed assumptions for each Scenario are detailed in Table 2-2. The MWG Scenario assumes more aggressive energy efficiency measures and building and light-duty vehicle electrifications. The 2030 GGRA Plan features more medium and heavy-duty vehicle electrifications and higher in-state clean energy resource requirement for electricity generation.

1. **MWG Scenario**: Policies and measures selected by the Mitigation Working Group (MWG) for consideration by the State
2. **2030 GGRA Plan**: MDE's plan to potentially achieve beyond the 2030 GHG target

Key Assumptions in Policy Scenarios from Documentation of Maryland PATHWAYS Scenario Modeling

	MWG Scenario	**2030 GGRA Plan**
Clean Electricity Standard	75% Clean energy by 2030, 100% by 2040	75% Clean and Energy Standard (CARES) by 2030, 100% by 2040; carveout for in-state clean energy resources reaching 10% by 2030 and 30% by 2040
RGGI	Accelerated RGGI cap that achieves 100% reductions by 2040	
Nuclear power	Assume Calvert Cliffs is relicensed in 2034/2036 at end of license	
Existing coal power	Chalk Point retired by 2022; all remaining in-state coal-fired power plants are ramped down and retired by 2030 as market forces cause coal retirements and Maryland complies with the increasingly stringent RGGI cap	
Rooftop PV	Increased net metering cap to 3 GW by 2030	
Energy Efficiency (Res., Com. & Industrial)	Additional EmPOWER achievements in efficiency as proxy for 3% annual savings goal (100% high efficiency electric sales by 2030, reduction in transmission and distribution losses from 5.4% to 4.6%)	Continued effort for efficiency in buildings (50% high efficiency electric sales by 2030, 25% for natural gas appliance sales); Renewed EmPOWER program pursing broader efficiency improvement (improved building shells for all new construction and 25% of retrofit buildings by 2030)
Electrification of buildings (e.g. NG furnace to heat pumps)	Aggressive building electrification (heat pump sales increase to 95% by 2050)	High levels of building electrification (heat pumps sales increase to 50% by 2030 and 80% by 2040) reflecting reformed EmPOWER program pursuing broader GHG and energy efficiency goals.
Fuel Economy Standards	Federal CAFE standards for LDVs through 2026	Extension of Federal CAFE standards for LDVs through 2030

Zero Emission Vehicles in Light Duty	Aggressive sales after 2025 (800,000 by 2030, 5 Million by 2050)	Increased sales after 2025, and aggressive sales after 2030 (790,000 by 2030, 4.5 Million by 2050) consistent with analysis performed for the Transportation and Climate Initiative (TCI).
Heavy Duty Vehicles	Aggressive sales of electric and diesel hybrid HDVs (40% sales by 2030 and 95% by 2050); truck stop electrification and zero-emission truck corridors	Aggressive sales of ZEV HDVs to meet the ZEV Truck Mandate (35% sales by 2030 and 100% by 2050); truck stop electrification and zero-emission truck corridors
Vehicle Miles Traveled	0.6% growth rate for LDV VMTs: Additional smart growth and transit measures	
Other transportation sectors (e.g. buses, construction vehicles)	Electrification of 50% of transit buses by 2030, 100% by 2050; Electrification of 50% of construction vehicles by 2040, 100% by 2050	Electrification of 75% of transit buses by 2030
Industrial energy use	30% reduction below Reference Scenario by 2050	
Biofuels	Existing ethanol and biodiesel blends	
Other (fossil fuel industry, industrial processes, agriculture, waste management, forestry)	More aggressive measures in enteric fermentation & manure management, forest management and healthy soils	Additional acreage in forest management and healthy soils conservation practices; reduced methane emissions from natural gas transmission and distribution.

Appendix A—Detailed Assumptions by Policy Scenario

This appendix contains information regarding how the policy scenarios were constructed as well as a comparison between the four scenarios.

Appendix B—Methodology

This appendix contains more information regarding the methodology that the Project Team utilized for the economic analysis. For more detail regarding the emissions modeling that was used as the basis of the economic analysis, please see Chapter 1.6.

B.1 REMI

To quantify the economic impacts of economic events or policy changes, RESI uses the Regional Economic Models, Inc. (REMI) model version 2.2. The REMI model is a high-end dynamic modeling tool used by various federal and state government agencies in economic policy analysis. Utilization of REMI helps RESI build a sophisticated model that is calibrated to the specific demographic features of the study area. This model enumerates the combined economic impacts of each dollar spent by the following: employees relating to the economic events, other supporting vendors (business services, retail, etc.), each dollar spent by these vendors on other firms, and each dollar spent by the households of the event's employees, other vendors' employees, and other businesses' employees. The REMI model reports economic impacts above the economic activity that would have occurred without the policy change or event.

As a dynamic model, REMI features the ability to capture price effects, wage changes, and behavioral effects through time. Another benefit of the model compared to traditional static models, such as IMPLAN, is that the regional constraint is built in, which accounts for limited resources over time. A situation like this is built into the model using current industry data and employment information from Bureau of Economic Analysis (BEA) data. The REMI model also allows RESI to capture the effects occurring between industries and minimize the potential for double-counting in employment, output, and wages. The ability to capture effects throughout a span of time provides a detailed representative of an economic event over time and its effects on the study area.

B.2 COBRA

The EPA's CO-Benefits Risk Assessment (COBRA) model assists state and local governments with estimating the costs and benefits of clean energy policies. Originally developed by Abt Associates in 2002, and most recently updated in 2017, COBRA "estimate[s] the economic value of the health benefits associated with clean energy policies and programs" so that these values can be weighed against the economic costs of a proposed policy.[37,38]

To use the COBRA model, a user first needs to estimate the reduction in emissions that would occur as a result of the clean energy policy. COBRA utilizes emission estimates for five different forms of air pollution: particulate matter ($PM_{2.5}$), sulfur dioxide (SO_2), nitrogen oxides (NO_X), ammonia (NH_3), and volatile organic compounds (VOCs).[39] Baseline emission estimates are included for both 2017 and 2025, allowing users to change emissions in either year.[40] Once the emission estimates for the policy are determined, the user can then input any corresponding emission increases or decreases from the baseline into the model. These changes can be input as either percentage changes from the baseline or as a specific quantity of emissions in tons.

Beyond year and pollutant type, emission changes can be further customized to specifically match the scenario being estimated through the model.[41] Changes can be entered at a national, state, or county level, including the 48 contiguous states and the District of Columbia. Changes can be further specified by the source of the emissions, with options such as highway vehicles or electric utility plants. COBRA allows the user to build a scenario with multiple changes across various locations and emissions, allowing a single scenario to contain variations in emission levels across different states or across different counties within the same state.

Regardless of the type(s) of air pollution input as changes into the model, COBRA will translate the changes in pollution into changes in ambient $PM_{2.5}$. In addition to changes to primary particles as a result of directly inputting changes in $PM_{2.5}$, changing one of the other emissions results in a change in secondary $PM_{2.5}$. Secondary $PM_{2.5}$ is formed by chemical reactions in the atmosphere involving other gaseous emissions.[42] For example, SO_2 will create sulfates in the atmosphere while NO_x will form nitrates, both of which are forms of $PM_{2.5}$.[43]

The changes in ambient $PM_{2.5}$ are then further translated into health impacts, which cover a wide range of effects from mortality and non-fatal heart attacks to work days missed and minor

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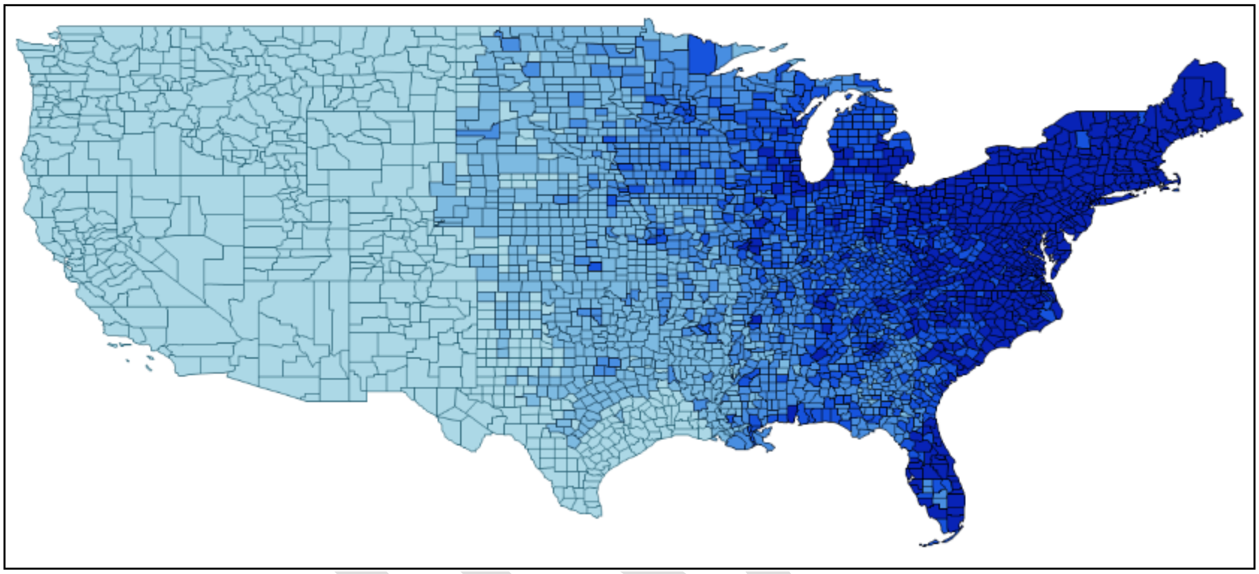
37 U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 3.
38 "CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool," U.S. Environment Protection Agency.
39 U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 18.
40 COBRA also contains the ability to import a custom emissions baseline for any other year, however this functionality was not used for this analysis.
41 U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 6-14.
42 U.S. Environment Protection Agency, "Particulate Matter Emissions," accessed August 9, 2018, 1, https://cfpub.epa.gov/roe/indicator_pdf.cfm?i=19.
43 U.S. Environment Protection Agency, "Particulate Matter Emissions," 1.

restricted activity days (MRADs).[44] Finally, these various health impacts are assigned economic values in 2017 dollars.[45] Both a low and a high economic estimate are provided, based on "two sets of assumptions about the sensitivity of adult mortality and non-fatal heart attacks to changes in ambient $PM_{2.5}$."[46]

Although the most significant health impacts will be seen in the geographic location where the emissions were changed, COBRA provides the impact to air pollution levels within every county in the model, since air pollution is not subject to state and county lines. Figure 54 below is a map produced by COBRA illustrating total economic benefits for each county in the United States following a reduction in Maryland emissions. Generally, greater economic benefits are seen in counties closer to the reductions and in counties with higher populations.

Figure 54: Example of Emissions Result Map from COBRA



Source: U.S. EPA

COBRA is an industry and academically recognized tool for quantifying health impacts related to emissions. In 2016, a paper in the *International Journal of Environmental Research and Public Health* used COBRA to estimate the health and economic effects of Volkswagen's violations of the Clean Air Act. Volkswagen had installed software onto its diesel-fueled passenger cars that deactivated the NO_x emissions control system while driving but would reactivate the system

[44] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 43-44.
[45] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 7-8.
[46] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 23.

whenever the car underwent emissions testing.[47] This illegal software caused each car to emit NO_x at a rate "10 to 40 times higher than the EPA's current Tier 2 vehicle emission standard."[48]

Using COBRA, the authors estimated that the additional NO_x from Volkswagen vehicles resulted in economic losses ranging from $43 million to $423 million related to premature deaths and other negative health impacts.[49,50] The wide range of the impact is a result of running multiple scenarios covering the range of increased emissions reported by the EPA, in addition to reporting both the high and low economic estimates from COBRA for each of these scenarios.

COBRA has also been previously used in studies specific to Maryland and the surrounding region. In 2016, the Chesapeake Climate Action Network used the tool to advocate for an increase in the renewable energy used by the District of Columbia. The organization estimated that the expansion of renewable energy could carry an economic benefit of up to $572 million annually from the resulting improvement in air quality.[51]

An extensive study was conducted by Abt Associates, the developers of COBRA, to examine the public health impacts and related economic benefits of the Regional Greenhouse Gas Initiative (RGGI) from 2009 to 2014. Using both COBRA and the more complex BenMAP tool, Abt Associates estimated that RGGI resulted in an economic benefit of $3.0 billion to $8.3 billion, stemming from the avoided negative health effects of air pollution over the six-year period.[52] Notably, Abt found significant health and economic benefits both in RGGI states and in neighboring states that did not participate in RGGI.[53]

[47] Lifang Hou et al., "Public Health Impact and Economic Costs of Volkswagen's Lack of Compliance with the United States' Emission Standards," *International Journal of Environmental Research and Public Health* 13, no. 9 (2016): 1-2, accessed August 9, 2018, doi:10.3390/ijerph13090891.
[48] Hou et al., "Public Health Impact and Economic Costs of Volkswagen's Lack of Compliance with the United States' Emission Standards," 2.
[49] Hou et al., "Public Health Impact and Economic Costs of Volkswagen's Lack of Compliance with the United States' Emission Standards," 4.
[50] Values in this study are in 2010 dollars.
[51] Chesapeake Climate Action Network, "B21-0650—Renewable Portfolio Standard Expansion Amendment Act of 2016," 2, May 23, 2016, accessed August 9, 2018, http://chesapeakeclimate.org/wp/wp-content/uploads/2016/05/CCAN_B21-0650_testimony_DC-RPS.pdf.
[52] Abt Associates, "Analysis of the Public Health Impacts of the Regional Greenhouse Gas Initiative, 2009-2014," 2, January 2017, accessed August 9, 2018, https://www.abtassociates.com/sites/default/files/2018-06/Analysis%20of%20the%20public%20health%20impacts%20of%20regional%20greenhouse%20gas.pdf.
[53] Abt Associates, "Analysis of the Public Health Impacts of the Regional Greenhouse Gas Initiative, 2009-2014," 32

Appendix C—Detailed Results

C.1 Employment

Figure 55: Total Employment Impacts by Policy Scenario without Transportation Measures by Year Relative to the Reference Case, 2020-2050

Year	Draft GGRA	MWG	Final GGRA
Average through 2030	1,748	951	1,812
Average through 2050	3,085	-6,431	2,271
2020	810	1,921	1,322
2021	1,085	1,913	1,208
2022	1,380	1,887	1,399
2023	1,675	2,028	1,703
2024	1,723	1,787	1,906
2025	1,781	1,453	2,049
2026	1,828	993	2,039
2027	1,971	514	2,153
2028	2,136	-31	2,054
2029	2,365	-610	2,105
2030	2,470	-1,389	1,991
2031	2,146	-2,572	1,834
2032	1,847	-3,770	1,993
2033	1,643	-4,906	2,211
2034	1,552	-5,969	2,411
2035	1,532	-7,067	2,565
2036	1,648	-8,029	2,745
2037	1,882	-8,844	2,867
2038	2,166	-9,647	3,001
2039	2,566	-10,345	3,189
2040	3,139	-10,875	3,453
2041	3,585	-11,552	3,218
2042	4,027	-12,182	2,956
2043	4,455	-12,785	2,651
2044	4,895	-13,330	2,389
2045	5,339	-13,809	2,219
2046	5,750	-14,297	2,052
2047	6,254	-14,637	2,061
2048	6,797	-14,880	2,097
2049	7,318	-15,094	2,192
2050	7,872	-15,223	2,356

Sources: E3, MDE, REMI, RESI

Figure 56: Total Employment Impacts by Policy Scenario with Transportation Measures by Year Relative to the Reference Case, 2020-2050

Year	Draft GGRA	MWG	Final GGRA
Average through 2030	11,963	3,705	5,788
Average through 2050	6,655	-5,482	6,661
2020	11,949	4,526	1,816
2021	11,938	4,265	1,543
2022	11,947	4,143	1,842
2023	11,903	4,227	2,123
2024	11,618	3,959	2,317
2025	11,348	3,610	2,510
2026	12,707	4,747	10,724
2027	12,175	3,842	9,630
2028	11,990	3,158	10,674
2029	12,018	2,529	10,365
2030	12,004	1,750	10,130
2031	1,245	-3,127	4,685
2032	1,309	-3,817	5,827
2033	1,227	-4,770	6,455
2034	1,252	-5,791	7,022
2035	1,324	-6,921	7,502
2036	1,515	-7,945	8,022
2037	1,810	-8,827	8,526
2038	2,143	-9,687	8,438
2039	2,576	-10,425	8,479
2040	3,174	-10,980	8,511
2041	3,639	-11,666	7,980
2042	4,093	-12,295	7,403
2043	4,529	-12,888	7,194
2044	4,976	-13,419	6,974
2045	5,423	-13,882	6,811
2046	5,836	-14,352	6,632
2047	6,344	-14,676	6,597
2048	6,892	-14,906	6,565
2049	7,419	-15,109	6,563
2050	7,981	-15,228	6,646

Sources: E3, MDE, REMI, RESI

C.2 Gross State Product (GSP)

Figure 57: Gross State Product Impacts by Policy Scenario without Transportation Measures by Year Relative to the Reference Case, 2020-2050 (in Billions of 2018 Dollars)

Year	Draft GGRA	MWG	Final GGRA
Average through 2030	$0.24	$0.05	$0.15
Average through 2050	$0.57	-$1.11	$0.09
2020	$0.08	$0.18	$0.05
2021	$0.12	$0.18	$0.03
2022	$0.15	$0.18	$0.09
2023	$0.19	$0.20	$0.15
2024	$0.20	$0.16	$0.18
2025	$0.23	$0.12	$0.21
2026	$0.26	$0.06	$0.21
2027	$0.30	$0.00	$0.22
2028	$0.35	-$0.07	$0.19
2029	$0.40	-$0.15	$0.19
2030	$0.42	-$0.27	$0.15
2031	$0.40	-$0.43	$0.09
2032	$0.38	-$0.59	$0.10
2033	$0.37	-$0.75	$0.12
2034	$0.37	-$0.91	$0.15
2035	$0.38	-$1.09	$0.16
2036	$0.40	-$1.22	$0.18
2037	$0.44	-$1.34	$0.20
2038	$0.50	-$1.45	$0.22
2039	$0.57	-$1.55	$0.26
2040	$0.69	-$1.62	$0.36
2041	$0.75	-$1.78	$0.28
2042	$0.81	-$1.93	$0.19
2043	$0.88	-$2.07	$0.10
2044	$0.94	-$2.21	$0.00
2045	$1.01	-$2.35	-$0.08
2046	$1.08	-$2.50	-$0.16
2047	$1.16	-$2.63	-$0.20
2048	$1.24	-$2.75	-$0.24
2049	$1.32	-$2.88	-$0.26
2050	$1.40	-$2.99	-$0.26

Sources: E3, MDE, REMI, RESI

Figure 58: Gross State Product Impacts by Policy Scenario with Transportation Measures by Year Relative to the Reference Case, 2020-2050 (in Billions of 2018 Dollars)

Year	Draft GGRA	MWG	Final GGRA
Average through 2030	$1.18	$0.30	$0.61
Average through 2050	$0.88	-$1.03	$0.77
2020	$1.03	$0.39	$0.10
2021	$1.06	$0.37	$0.07
2022	$1.08	$0.37	$0.13
2023	$1.11	$0.38	$0.19
2024	$1.10	$0.35	$0.23
2025	$1.11	$0.31	$0.27
2026	$1.27	$0.40	$1.16
2027	$1.26	$0.30	$1.06
2028	$1.29	$0.23	$1.19
2029	$1.33	$0.14	$1.17
2030	$1.35	$0.03	$1.15
2031	$0.26	-$0.50	$0.43
2032	$0.29	-$0.60	$0.59
2033	$0.29	-$0.74	$0.67
2034	$0.30	-$0.90	$0.77
2035	$0.32	-$1.08	$0.85
2036	$0.36	-$1.22	$0.95
2037	$0.41	-$1.34	$1.05
2038	$0.47	-$1.46	$1.07
2039	$0.55	-$1.56	$1.12
2040	$0.67	-$1.64	$1.21
2041	$0.73	-$1.80	$1.11
2042	$0.80	-$1.95	$0.99
2043	$0.86	-$2.09	$0.94
2044	$0.93	-$2.23	$0.88
2045	$1.00	-$2.37	$0.82
2046	$1.07	-$2.51	$0.77
2047	$1.15	-$2.64	$0.74
2048	$1.24	-$2.76	$0.71
2049	$1.32	-$2.88	$0.69
2050	$1.40	-$3.00	$0.69

Sources: E3, MDE, REMI, RESI

C.3 Personal Income

Figure 59: Personal Income Impacts by Policy Scenario without Transportation Measures by Year Relative to the Reference Case, 2020-2050 (in Billions of 2018 Dollars)

Year	Draft GGRA	MWG	Final GGRA
Average through 2030	$0.16	-$0.08	$0.18
Average through 2050	$0.39	-$1.50	$0.35
2020	$0.05	$0.14	$0.09
2021	$0.08	$0.13	$0.09
2022	$0.10	$0.12	$0.12
2023	$0.13	$0.13	$0.15
2024	$0.14	$0.07	$0.18
2025	$0.16	$0.00	$0.20
2026	$0.17	-$0.09	$0.21
2027	$0.20	-$0.18	$0.23
2028	$0.22	-$0.28	$0.24
2029	$0.25	-$0.39	$0.25
2030	$0.27	-$0.53	$0.24
2031	$0.25	-$0.71	$0.23
2032	$0.23	-$0.89	$0.25
2033	$0.22	-$1.08	$0.28
2034	$0.21	-$1.26	$0.32
2035	$0.22	-$1.45	$0.35
2036	$0.23	-$1.63	$0.39
2037	$0.26	-$1.79	$0.42
2038	$0.29	-$1.96	$0.46
2039	$0.34	-$2.13	$0.52
2040	$0.41	-$2.26	$0.59
2041	$0.46	-$2.41	$0.58
2042	$0.52	-$2.56	$0.56
2043	$0.58	-$2.71	$0.53
2044	$0.64	-$2.85	$0.50
2045	$0.71	-$2.99	$0.48
2046	$0.77	-$3.13	$0.46
2047	$0.84	-$3.27	$0.47
2048	$0.92	-$3.39	$0.48
2049	$1.00	-$3.51	$0.52
2050	$1.08	-$3.63	$0.57

Sources: E3, MDE, REMI, RESI

Figure 60: Personal Income Impacts by Policy Scenario with Transportation Measures by Year Relative to the Reference Case, 2020-2050 (in Billions of 2018 Dollars)

Year	Draft GGRA	MWG	Final GGRA
Average through 2030	$1.04	$0.06	$0.51
Average through 2050	$0.73	-$1.46	$0.88
2020	$0.80	$0.28	$0.13
2021	$0.87	$0.25	$0.12
2022	$0.93	$0.24	$0.15
2023	$0.98	$0.24	$0.19
2024	$1.00	$0.19	$0.22
2025	$1.03	$0.12	$0.25
2026	$1.13	$0.12	$0.85
2027	$1.14	-$0.01	$0.83
2028	$1.16	-$0.12	$0.95
2029	$1.19	-$0.24	$0.98
2030	$1.22	-$0.37	$1.00
2031	$0.40	-$0.78	$0.57
2032	$0.36	-$0.91	$0.68
2033	$0.32	-$1.08	$0.76
2034	$0.29	-$1.26	$0.85
2035	$0.28	-$1.45	$0.92
2036	$0.29	-$1.63	$1.01
2037	$0.31	-$1.80	$1.11
2038	$0.34	-$1.98	$1.14
2039	$0.38	-$2.14	$1.20
2040	$0.45	-$2.28	$1.26
2041	$0.50	-$2.43	$1.23
2042	$0.55	-$2.58	$1.19
2043	$0.61	-$2.72	$1.18
2044	$0.67	-$2.87	$1.18
2045	$0.74	-$3.01	$1.17
2046	$0.80	-$3.15	$1.17
2047	$0.88	-$3.28	$1.19
2048	$0.96	-$3.40	$1.22
2049	$1.04	-$3.52	$1.25
2050	$1.12	-$3.63	$1.31

Sources: E3, MDE, REMI, RESI

C.4 Producer Consumption Expenditures (PCE)

Figure 61: PCE-Price Index (2009=100) Under Final GGRA Plan

Year	With Transportation Measures	Without Transportation Measures
Average through 2030	0.028	0.010
Average through 2050	0.109	0.069
2020	-0.007	-0.007
2021	-0.009	-0.010
2022	-0.006	-0.008
2023	-0.003	-0.005
2024	0.006	0.003
2025	0.013	0.010
2026	0.028	0.015
2027	0.054	0.019
2028	0.065	0.026
2029	0.078	0.029
2030	0.089	0.037
2031	0.092	0.039
2032	0.082	0.041
2033	0.092	0.044
2034	0.093	0.047
2035	0.101	0.053
2036	0.109	0.060
2037	0.118	0.066
2038	0.128	0.074
2039	0.138	0.083
2040	0.149	0.094
2041	0.161	0.107
2042	0.171	0.116
2043	0.179	0.125
2044	0.187	0.133
2045	0.195	0.140
2046	0.202	0.147
2047	0.210	0.154
2048	0.217	0.161
2049	0.223	0.166
2050	0.231	0.174

Sources: E3, MDE, REMI, RESI

C.5 Health Impacts

Figure 62: Jobs Due to Health Impacts by Policy Scenario

Year	Draft GGRA	MWG	Final GGRA
Average Through 2030	4.75	4.49	5.24
Average Through 2050	29.36	44.38	49.97
2020	0.73	0.06	0.58
2021	1.21	0.39	0.85
2022	1.76	0.89	1.33
2023	2.38	1.55	1.98
2024	3.07	2.35	2.79
2025	3.96	3.43	3.93
2026	4.97	4.67	5.29
2027	6.17	6.14	6.93
2028	7.61	7.88	8.91
2029	9.22	9.83	11.15
2030	11.14	12.23	13.96
2031	13.27	15.03	17.23
2032	15.55	18.20	20.93
2033	18.01	21.80	25.10
2034	20.54	25.71	29.59
2035	23.16	29.91	34.38
2036	25.88	34.43	39.50
2037	28.66	39.17	44.86
2038	31.53	44.16	50.47
2039	34.44	49.36	56.31
2040	37.82	55.73	63.42
2041	41.39	62.60	71.04
2042	45.17	69.90	79.13
2043	49.21	77.71	87.75
2044	53.42	85.72	96.50
2045	57.84	93.99	105.47
2046	62.46	102.51	114.67
2047	67.25	111.27	124.07
2048	72.15	120.16	133.56
2049	77.19	129.25	143.21
2050	82.94	139.64	154.17

Sources: E3, MDE, MDOT, RESI, U.S. EPA

Figure 63: Avoided Mortality and Estimated Value by Policy Scenario

Year	Draft GGRA		MWG		Final GGRA	
	Mortality Avoided	Value	Mortality Avoided	Value	Mortality Avoided	Value
Average Through 2030	7.83	$77,921,556	10.25	$101,965,805	17.37	$172,795,656
Average Through 2050	28.03	$278,903,141	46.80	$465,640,433	72.75	$723,768,906
2020	2.34	$23,303,269	4.02	$40,006,798	3.61	$35,899,882
2021	3.15	$31,292,510	4.98	$49,576,950	5.48	$54,554,047
2022	3.88	$38,639,638	5.75	$57,189,878	7.36	$73,208,211
2023	4.64	$46,124,924	6.53	$64,939,152	9.23	$91,862,375
2024	5.40	$53,748,367	7.32	$72,824,772	11.11	$110,516,540
2025	6.82	$67,849,226	9.12	$90,729,028	15.52	$154,425,034
2026	8.30	$82,565,903	10.80	$107,466,202	19.25	$191,496,640
2027	9.97	$99,160,555	12.68	$126,198,572	22.97	$228,568,246
2028	11.82	$117,633,182	14.77	$146,926,139	26.70	$265,639,852
2029	13.63	$135,624,171	16.68	$165,970,494	30.43	$302,711,458
2030	16.20	$161,195,366	20.08	$199,795,875	39.39	$391,869,935
2031	18.27	$181,731,324	23.42	$232,968,210	44.73	$444,977,852
2032	20.32	$202,121,837	27.10	$269,574,917	50.06	$498,085,770
2033	22.35	$222,366,906	31.12	$309,615,998	55.40	$551,193,687
2034	24.10	$239,765,512	34.95	$347,714,180	60.74	$604,301,605
2035	25.88	$257,437,810	38.85	$386,477,625	66.08	$657,409,522
2036	27.68	$275,383,800	42.81	$425,906,333	71.42	$710,517,439
2037	29.51	$293,603,482	46.84	$466,000,304	76.75	$763,625,357
2038	31.37	$312,096,855	50.94	$506,759,539	82.09	$816,733,274
2039	33.26	$330,863,920	55.10	$548,184,037	87.43	$869,841,191
2040	36.58	$363,911,152	63.85	$635,210,429	107.68	$1,071,278,223
2041	39.27	$390,666,003	69.79	$694,367,280	112.59	$1,120,108,794
2042	42.05	$418,363,035	75.71	$753,221,990	117.49	$1,168,939,366

Year	Draft GGRA		MWG		Final GGRA	
	Mortality Avoided	Value	Mortality Avoided	Value	Mortality Avoided	Value
2043	44.93	$447,002,247	81.59	$811,774,559	122.40	$1,217,769,937
2044	47.38	$471,370,118	85.77	$853,298,575	127.31	$1,266,600,508
2045	49.86	$496,082,985	90.00	$895,384,663	132.22	$1,315,431,080
2046	52.38	$521,140,850	94.28	$938,032,826	137.13	$1,364,261,651
2047	54.93	$546,543,712	98.63	$981,243,062	142.03	$1,413,092,222
2048	57.52	$572,291,572	103.03	$1,025,015,371	146.94	$1,461,922,793
2049	60.15	$598,384,428	107.48	$1,069,349,754	151.85	$1,510,753,365
2050	65.11	$647,732,708	116.91	$1,163,129,919	171.80	$1,709,240,224

Sources: E3, MDE, RESI, U.S. EPA

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Maryland Department of the Environment

Appendix H

Impact Analysis of the GGRA of 2009 on Manufacturing Industry in MD

2030 GGRA Plan

Impact Analysis of the Greenhouse Gas Reduction Act of 2009 on the Manufacturing Industry in Maryland

Prepared for
Maryland Department of Environment

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1.0 Executive Summary

1.1 Overview

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

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

1.2 Historical Trend Analysis

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

- The average weekly wages in the Manufacturing industry increased from $933 in 2002 to $1,324 in 2012.
- Preliminary estimates indicate that average weekly wages increased by $16 between 2012 and 2013—an increase from $1,324 in 2012 to $1,340 in 2013.[1]
- The industry accounted for 5.9 percent of Maryland's total output in 2012.

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

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

[1] "Quarterly Census of Employment and Wages," Bureau of Labor Statistics, accessed April 9, 2014, http://data.bls.gov/pdq/SurveyOutputServlet.

agencies will be vital to producing the workforce needed to implement the policies outlined in the GGRA.

1.3 Economic Impact Findings

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

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

RESI's economic impact analysis confirms historical and current trend analyses. To implement the strategies outlined in the GGRA, Maryland will create an additional 113 jobs in the Manufacturing industry by 2020. Of these 113 jobs, nearly 54 percent will be created within higher skilled sectors, such as *Computer and electronic product manufacturing* and *Electrical equipment and appliance manufacturing*. Some sectors, such as *Food Manufacturing* and *Textile mills; Textile product mills* will see minimal job declines between 2010 and 2020 as the industry shifts to a higher-skilled workforce demand to meet policy implementation associated with the GGRA. Despite all the change in Maryland's Manufacturing industry, there is no conclusive evidence that any closures or relocations outside Maryland are directly attributable to the GGRA or climate change planning. Based on the analysis provided within this report, RESI finds no discernible impacts on the manufacturing sector as a result of the GGRA programs. Furthermore, RESI recommends based on this analysis that Maryland not adopt any manufacturing specific GHG regulations in the future.

2.0 Introduction

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

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

3.0 Literature Review

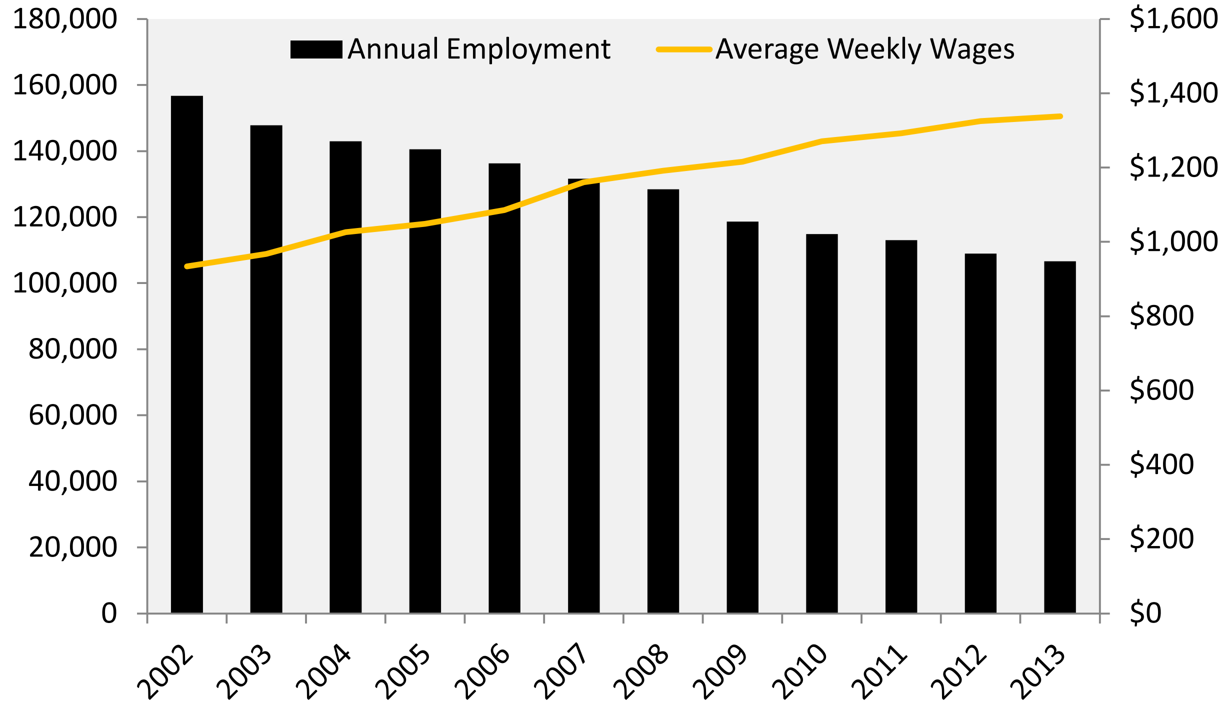
3.1 Trends in Manufacturing in Maryland

Since 2002 employment in Manufacturing in Maryland has steadily declined. In 2002 average annual employment in the manufacturing sector reached nearly 157,000 but dropped to approximately 109,000 in 2012.[2] Manufacturing as a percent of total Maryland employment has seen a less drastic change than employment within the manufacturing sector alone. In 2002 Manufacturing encompassed more than 6 percent of Maryland's total employment; by 2012 that share decreased slightly to 4 percent.[3] Despite employment declines, average weekly wages per worker have steadily increased. According to the Department of Labor, Licensing and Regulation (DLLR), average wages increased from $933 to $1,324 between 2002 and 2012. Average wages in Manufacturing have remained greater than average wages for Maryland industries overall.[4]

As seen in Figure 1, preliminary data for 2013 support the existing employment and wage trends. Employment in Manufacturing in Maryland decreased to fewer than 107,000 workers in 2013. [5] Preliminary figures for 2013 show that average weekly wages continue to increase; average weekly wages rose to approximately $1,340 in 2013, a $16 increase from 2012.[6]

[2] "Employment and Payrolls - Industry Series – Maryland," Department of Labor, Licensing and Regulation, September 30, 2013, accessed October 24, 2013, http://www.dllr.state.md.us/lmi/emppay/tab1md.shtml.
[3] Ibid.
[4] Ibid.
[5] "Quarterly Census of Employment and Wages," Bureau of Labor Statistics.
[6] Ibid.

Figure 1: Manufacturing Employment and Wages for Maryland[7]



Sources: BLS, QCEW

Regardless of employment declines, the manufacturing industry remains a vital enterprise for Maryland. In 2012 the manufacturing industry in Maryland

- Accounted for 5.9 percent of the total output in the state,
- Comprised 4.3 percent of the state's total employed workforce,
- Produced output of $18.7 billion, and
- Exported nearly $11 billion worth of goods.[8]

According to the 2014 report "Impact of the Manufacturing Renaissance from Energy Intensive Sources" prepared for the U.S. Conference of Mayors and the Council on Metro Economies and the New American City, the manufacturing industry has been a "keystone of economic growth" since the end of the recession—specifically, in the nation's metropolitan areas, such as the Baltimore-Columbia-Towson metropolitan statistical area (MSA), and in regard to industries that are energy intensive, such as Manufacturing.[9] Metropolitan areas encompass a vast

[7] QCEW wages and employment data reported here are seasonally adjusted.
[8] "Maryland Manufacturing Facts," National Association of Manufacturers, 1-2, 2012, accessed October 24, 2013, http://www.nam.org/~/media/40D1B093FBD64A17BCC68940B5A7F167/Maryland.pdf.
[9] "U.S. Metro Economies Report on Impact of Manufacturing Renaissance from Energy Intensive Sectors," Global Insight and iHS, 1, 2013, accessed April 10, 2014, http://www.usmayors.org/pressreleases/uploads/2014/0320-report-MetroEconomiesManufacturing.pdf.

amount of the nation's total employment. In 2012 metropolitan areas encompassed nearly 80 percent of the nation's total employment and more than 80 percent of "real sales" that resulted from energy-intensive manufacturing industry components.[10] The report forecasts that employment within energy-intensive manufacturing industry components will expand at the same rate as that expected on the national level through 2020. At 72 percent, the majority of projected expansion will occur in metropolitan areas.[11]

Maryland has multiple organizations that support and/or promote the manufacturing industry. Since 1990 the Regional Manufacturing Institute (RMI) of Maryland has acted as an advocate for Maryland manufacturers.[12] With the help of a recent $3 million grant, provided by the Maryland Public Service Commission and the Maryland Energy Administration, RMI aims to assist Maryland manufacturers in targeting energy efficiency opportunities.[13] Maryland is also home to one of the nation's centers of the Manufacturing Extension Partnership (MEP) and the Maryland World Class Manufacturing Consortium.

Through partnerships with other MEP centers nationwide, as well as the National Institute of Standards and Technology, the Maryland MEP facilitates the growth of manufacturers.[14] These partnerships allow the Maryland MEP to offer training in "Lean, Innovation Engineering, Advanced Manufacturing and Marketing." [15] Additional Manufacturing support comes from the Maryland World Class Manufacturing Consortium. The Consortium aids manufacturers in meeting international demand and standards.[16]

3.2 Maryland's Manufacturing Industry and Greenhouse Gas Reduction

Under the Greenhouse Gas Reduction Act (GGRA) of 2009, the State of Maryland is required to produce the 25 percent reduction from 2006 levels by 2020. The bill also states that Manufacturing can only be regulated at a federal level, and the industry is therefore excluded from the GGRA.[17] Greenhouse gas (GHG) emissions resulting from the state's Manufacturing

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[10] "U.S. Metro Economies Report on Impact of Manufacturing Renaissance from Energy Intensive Sectors," Global Insight and iHS, 1.
[11] Ibid.
[12] "About RMI," Regional Manufacturing Institute of Maryland, accessed October 24, 2013, http://rmiofmaryland.com/about-rmi/.
[13] "Join the RMI's Next-Gen-M Energy Efficiency Program," Regional Manufacturing Institute of Maryland, October 14, 2013, accessed October 24, 2013, http://rmiofmaryland.com/join-the-rmis-next-gen-m-energy-efficiency-program/.
[14] "Maryland Direct Financial Incentives 2014," Area Development, 2014, accessed April 10, 2014, http://www.areadevelopment.com/stateResources/maryland/MD-Direct-Financial-Incentives-2014-124356.shtml.
[15] Ibid.
[16] Ibid.
[17] "Facts About The Greenhouse Gas Reduction Act of 2009," Maryland Department of the Environment, 1, accessed October 24, 2013, http://www.mde.state.md.us/assets/document/Air/ClimateChange/GGRA_factsheet.pdf.

industry make up a relatively small portion, only 4 percent, of the state's total GHG emissions—this percent is not expected to change significantly by 2020.[18]

Regulation Impacts on Competitiveness

Maryland manufacturers must contend with regional, national, and international competitors. Due to this competitiveness, the industry's GHG emissions are thought to be best regulated on a national level.[19] State regulations cannot require the manufacturing industry to reduce GHG emissions nor can such regulations place higher financial burden on Maryland manufacturers unless required at the federal level.[20] Doing so would place Maryland's Manufacturing sector at a competitive disadvantage.

While Manufacturing is currently excluded from GHG emissions reduction requirements, the GGRA encourages the manufacturing industry to reduce emissions voluntarily. In the future, it is possible that Manufacturing will be subject to reduction requirements; any GHG emissions reductions accomplished in Manufacturing in the short term will be applied to future reduction requirements. [21] With the GGRA of 2009, Maryland continues to advocate for a strong federal GHG reduction program. [22]

Energy Efficiency Investments

Across the U.S., companies have committed to at least a 25 percent reduction in energy intensity associated with manufacturing within 10 years—these companies are recognized by the Department of Energy's as Better Plants Program Partners.[23] Some of these companies have already reached the 25 percent reduction goal, while others have accepted the Better Buildings, Better Plants Challenge and strive to obtain "enhanced levels of transparency and innovation" and have "agreed to make a significant near-term investment in energy efficiency at a chosen facility." [24]

On a more local level, progress is evident throughout the state. For example, in 2012 seasoning company McCormick & Company announced that its distribution center based in Belcamp, Maryland, reached "net-zero" through energy conservation measures—in other words, the

[18] Facts About The Greenhouse Gas Reduction Act of 2009," Maryland Department of the Environment.
[19] "Chapter 172 (Senate Bill 278)," Maryland General Assembly, 2, 2009, accessed October 24, 2013, http://mgaleg.maryland.gov/2009rs/chapters_noln/Ch_172_sb0278E.pdf.
[20] Ibid, 7.
[21] "Facts About The Greenhouse Gas Reduction Act of 2009," Maryland Department of the Environment, 2.
[22] Ibid.
[23] Office of Energy Efficiency & Renewable Energy, "Better Plants Program Partners," U.S. Department of Energy, accessed January 7, 2015, http://www.energy.gov/eere/amo/better-plants-program-partners.
[24] Ibid.

distribution center uses less electricity that it produces.[25] To achieve net-zero status at its Belcamp location, McCormick installed "energy-efficient interior and exterior lighting, occupancy sensors, HVAC upgrades, and energy efficient pallet conveyors," with a solar array generating the surplus energy.[26]

The Regional Manufacturing Institute of Maryland (RMI), in partnership with the Maryland Energy Administration, is using a recently obtained $3 million grant "to help target energy efficiency opportunities with Maryland manufacturers in the BGE service territory." [27] Those firms that meet program criteria can receive business services, such as a comprehensive energy audit and energy efficiency training, at minimal out-of-pocket cost (services that could cost more than $30,000). [28] These services have the potential to reduce energy costs by 15 to 25 percent. [29] Current participants include the following:

- Chesapeake Specialty Chemical (Building Materials),
- Danko Arlington (pattern shop, foundry, and machine shop),
- Ellicott Dredge (Dredging Equipment Sector),
- Green Bay Packaging (Packaging Sector),
- GM Baltimore Operations (Automotive Sector),
- Maritime Applied Physics Corporation (Shipping Sector),
- Maryland Thermoform (Plastics Sector),
- Medifast (Dietary Meals/Snacks),
- Northrop Grumman Electronic Systems (Defense Electronics Sector),
- Sun Automation (Machinery Motors),
- U.S. Gypsum (Construction Materials), and
- Zentech Manufacturing (Electronics Sector).[30]

Firms that have seen production increases due to previous energy efficiency measures, such as Hunt Valley's Green Bay Packaging, have spoken out in favor of improved energy efficiency.[31] Other programs, such as BGE's Smart Energy Savers program, are aiding Maryland's journey toward energy efficiency. BGE's "success stories" include El Andariego, Mars Supermarkets, Pet

[25] "McCormick Distribution Center Achieves Net-Zero Energy Status," Environmental Leader, April 17, 2012, accessed January 7, 2015, http://www.environmentalleader.com/2012/04/17/mccormick-distribution-center-achieves-net-zero-energy-status/.
[26] Ibid.
[27] Energy Solutions Center, "About the RMI Energy Efficiency Program," Regional Manufacturing Institute of Maryland, accessed January 7, 2015, http://rmienergysolutions.com/about-us/.
[28] Ibid.
[29] Ibid.
[30] Ibid.
[31] Jamie Smith Hopkins, "A bid to lower manufacturers' energy bills," The Baltimore Sun, April 21, 2014, accessed January 7, 2015. http://articles.baltimoresun.com/2014-04-21/business/bs-bz-manufacturers-energy-efficiency-20140414_1_energy-efficiency-energy-bills-manufacturers.

Depot, Ski Haus, and Under Armour.[32] Under Armour operates two 300,000-plus-squarefoot distribution centers in Baltimore. Working with BGE, for a nearly 50 percent savings in retrofit costs, Under Armour recently installed nearly 900 new lighting fixtures between the two distribution centers. [33] These projects both aligned with the company's UA Green corporate mission, while producing a 28 percent reduction in kilowatt-hour (kWh) use per year and, therefore, generating ongoing energy savings in the future.[34]

Others, such as Gaithersburg's MedImmune have "been able to achieve savings in such an aggressive way due to its partnerships with DOE's Industrial Assessment Center program and the Maryland Energy Administration, as well as energy efficiency rebates available via its electric utility, Pepco."[35] MedImmune aims to reduce energy intensity by 25 percent by 2020, and as of 2013 MedImmune has achieved an energy intensity reduction of 19.2 percent.[36]

3.3 Greenhouse Gas Emissions Reduction Guidelines for Manufacturing

In the U.S., the greatest sources of GHG emissions include electricity production, transportation, industry, commercial and residential, agriculture, and land use and forestry.[37] Worldwide, electricity production followed by industry activity and forestry are the greatest sources of GHG emissions.[38] In 2006, the baseline year, industrial activity was responsible for approximately 7 percent of the total GHG emissions in Maryland.[39] In 2011 industrial activity was responsible for 20 percent of the total GHG emissions in the U.S. [40] To reduce GHG emissions, manufacturers and other industrial producers could increase energy efficiency, consider fuel switching, recycling, and institute training and awareness programs.[41] Many of these options have been successfully implemented both nationally and worldwide.

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[32] "Success Stories," BGE, accessed January 7, 2015, http://www.bge.com/waystosave/business/bizlearnmore/bizsuccessstories/Pages/default.aspx.
[33] "Under Armour," BGE, accessed January 7, 2015, http://www.bge.com/waystosave/business/bizlearnmore/bizsuccessstories/Pages/Under-Armour.aspx.
[34] Ibid.
[35] MedImmune, "Maryland Manufacturer Pursues Energy Efficiency Improvements for Operational Savings," Maryland Energy Administration, accessed January 7, 2015, http://energy.maryland.gov/SEN/pdfs/MedImmune%20One%20Pager-042513.pdf.
[36] Ibid.
[37] "Sources of Greenhouse Gas Emissions Overview," United States Environmental Protection Agency, September 9, 2013, accessed October 24, 2013, http://www.epa.gov/climatechange/ghgemissions/sources.html.
[38] "Global Greenhouse Gas Emissions Data," United States Environmental Protection Agency, September 9, 2013, accessed April 18, 2014, http://www.epa.gov/climatechange/ghgemissions/global.html.
[39] "Maryland's Plan to Reduce Greenhouse Gas Emissions," Maryland Department of the Environment, 8, December 31, 2011, accessed October 28, 2013. http://www.mde.state.md.us/programs/Air/ClimateChange/Documents/2011%20Draft%20Plan/2011GGRADRAFTPlan.pdf.
[40] "Sources of Greenhouse Gas Emissions Overview," United States Environmental Protection Agency.
[41] "Sources of Greenhouse Gas Emissions Industry Sector Emissions," United States Environmental Protection Agency, October 30, 2013, accessed October 30, 2013, http://www.epa.gov/climatechange/ghgemissions/sources/industry.html.

Alabama

In Alabama, national policy affecting reduction of GHG emissions will impact a variety of industries, such as coal mining, energy, and manufacturing. These industries all have strong representation in the state.[42] To mitigate GHG emissions, the recommended policy options for the state include the following:

- Increased energy efficiency,
- Waste reduction and increased recycling,
- Increased use of methane/natural gas,
- Transportation changes, and
- Sequestration.[43]

California

Assembly Bill 32 passed in California in 2006. The bill included requirements that will help California meet GHG emissions reduction goals.[44] Specific requirements related to industrial activity include the adoption of required reporting regarding the level of greenhouse gas emissions as well as the adoption of set emissions limits.[45]

Pennsylvania

While climate change will impact Pennsylvania's energy industry, activities associated with renewable energy, such as manufacturing activities, will provide new jobs and revenue growth.[46] Coal, which has the highest carbon content when compared to other fossil fuels, will remain the major fuel source in the state, creating the challenge of managing GHG emissions associated with coal.[47] [48] In 2000, Pennsylvania's base year, coal production and use was responsible for 93 percent of the state's total energy-related emissions. [49] Due to the relatively controversial nature of coal and other fossil fuels, and Pennsylvania's abundance of such fuels, the state must seek viable uses of these natural resources.[50]

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[42] Robert A. Griffin, William D. Gunther, and William J. Herz, "Policy Planning to Reduce Greenhouse Gas Emissions in Alabama Final Report," The University of Alabama, 16, December 1997, accessed October 28, 2013, http://www.epa.gov/statelocalclimate/documents/pdf/Alabama_action_plan.pdf.
[43] Ibid, 16-20.
[44] "Assembly Bill 32: Global Warming Solutions Act," California Environmental Protection Agency, accessed October 28, 2013, http://www.arb.ca.gov/cc/ab32/ab32.htm.
[45] Ibid.
[46] "Final Climate Change Action Plan," Pennsylvania Environmental Protection Agency, 2-3, December 18, 2009, accessed October 29, 2013, http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_001957.pdf.
[47] "Coal," Center for Climate and Energy Solutions, accessed April 18, 2014, http://www.c2es.org/energy/source/coal.
[48] "Final Climate Change Action Plan," Pennsylvania Environmental Protection Agency, 2-3.
[49] "Final Climate Change Action Plan," Pennsylvania Environmental Protection Agency, 4-3.
[50] Ibid, 2-3.

Comparative International Findings

Efforts to reduce GHG emissions are not limited to the U.S.; nations and organizations worldwide are working toward GHG emissions reductions. Canada, for instance, is committed to reducing GHG emissions—primarily through regulations pertaining to Canada's high emissions producing industries, like transportation and electricity.[51] Canada has seen a decrease in emissions of 5.1 percent from 2005 to 2012; this decrease did not hinder economic growth, which increased by 10.1 percent during the same period. [52] Other regulations implemented by Canada's climate change plan are performance standards for the major sources of emissions, with a focus on oil and gas, and other industrial emitters.[53]

A multitude of well-known global corporations, such as Unilever, Avon, SC Johnson, and Whirlpool, have all moved toward processes to reduce the GHG emissions created during the manufacturing process. Unilever aims to reduce emissions to or below 2008 levels by 2020 (a reduction of 40 percent per tonne of production), to increase its use of renewable energy to 40 percent of total energy with a long-term goal of using 100 percent renewable energy.[54] In 2012 Unilever's emission reductions were equivalent to that of reducing roadway congestion by approximately 200,000 cars.[55] As of 2012, all of Unilever's sites located in the U.S., Canada, and European Union utilized certified renewable electricity sources.[56]

Avon joined the Green Lights program, run by the U.S. Environmental Protection Agency, in 1994. At this time, Avon retrofitted many of its U.S.-based manufacturing and distribution locations with energy-efficient lighting.[57] Avon hoped to reduce GHG emissions created during operations by 20 percent compared to 2005 levels by 2020—a goal Avon exceeded in 2012 when reductions from the 2005 baseline reached 41 percent.[58] In the future, Avon hopes to switch to 100 percent clean energy, therefore eliminating emissions entirely.[59]

[51] "Canada's Action on Climate Change," Government of Canada, April 11, 2014, accessed April 18, 2014, http://www.climatechange.gc.ca/default.asp?lang=En&n=72F16A84-1.
[52] "Reducing Greenhouse Gases," Government of Canada, April 11, 2014, accessed April 18, 2014, http://www.climatechange.gc.ca/default.asp?lang=En&n=4FE85A4C-1.
[53] Ibid.
[54] "Reducing GHG from Manufacturing," Unilever, 2014, accessed April 10, 2014, http://www.unilever.com/sustainable-living/greenhousegases/reducingghgfrommanufacturing/.
[55] Ibid.
[56] Ibid.
[57] "Energy & Greenhouse Gas Emissions Reduction Efforts," Avon, the Company for Women, 2014, accessed April 10, 2014, http://www.avoncompany.com/corporatecitizenship/corporateresponsibility/sustainability/minimizingoperationalfootprint/energy-greenhouse-gas-reduction.html.
[58] "Energy & Greenhouse Gas Emissions Reduction Efforts," Avon.
[59] Ibid.

In 2000 SC Johnson established benchmarks for its largest plants, five in total at the international level, regarding GHG emissions.[60] In 2002 the corporation implemented additional reduction guidelines covering all operations in the U.S.; these goals were surpassed in 2005.[61] Over the past several years, SC Johnson has repeatedly set new reduction goals and continued to meet them. Most recently, SC Johnson began working toward an emissions reduction from global manufacturing of 48 percent compared to 2000 levels by 2016. [62] As of 2012, emissions from global sites compared at 40.2 percent of 2000 levels, with preliminary 2013 figures moving SC Johnson even closer to its 2016 goal. [63]

In 2003 Whirlpool stated its aim to accomplish a three percent emissions reduction from the 1998 base year by 2008.[64] Between 2003 and 2006, Whirlpool reduced GHG emissions by 4.1 million metric tons—the equivalent of planting nearly 1.4 million acres of trees.[65] In 2007 Whirlpool announced that it would further reduce GHG emissions by 6.6 percent by 2012; this announcement was made in support of Whirlpool's commitment to environmentally-sound business practices.[66] Whirlpool hopes to meet its overall reduction goals through the introduction of energy efficient models to its product line to reduce the impact of these products, as well as implementing improvements in both manufacturing and freight operations.[67]

Policies around the world are having vast impacts, and it is clear that successful policies regarding GHG emissions reduction have several key components in common. A 2003 Organization for Economic Co-Operation and Development report found three factors for success with greenhouse gas mitigation policies. Policies must be environmentally effective (i.e., reduce rather than reallocate), economically efficient (i.e., flexible options with minimal cost options), and have support.[68] These factors are also necessary if manufacturers worldwide are to remain competitive.

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[60] "Reducing Greenhouse Gas Emissions," SC Johnson, A Family Company, 2013, accessed April 10, 2014, http://www.scjohnson.com/en/commitment/focus-on/conserving/reducing.aspx.
[61] Ibid.
[62] Ibid.
[63] Ibid.
[64] "Reducing Greenhouse Gas Emissions," Whirlpool Corporation, accessed April 10, 2014, http://www.whirlpoolcorp.com/responsibility/environment/performance/reducing_greenhouse_gas_emissions.aspx.
[65] Ibid.
[66] Ibid.
[67] Ibid.
[68] "Policies to Reduce Greenhouse as Emissions in Industry - Successful Approaches and Lessons Learned: Workshop Report," Organisation for Economic Co-operation and Development International Energy Agency, 10, 2003, accessed March 12, 2014, http://www.oecd.org/env/cc/2956442.pdf.

3.4 The Effect of Greenhouse Gas Emissions Reduction

Energy Costs

A 2014 Boston Consulting Group study finds that manufacturers in the U.S. are poised to benefit from the rising production of natural gas nationwide. [69] The lower electricity prices have already spurred investment in energy-intensive industries—even in industries that are less energy-intensive, low cost natural gas is estimated to shave "1 to 2 percent off of U.S. manufacturing costs as the benefits eventually flow downstream through the value chain."[70] BCG estimates that soon natural gas and electricity will account for just 2 percent and 1 percent, respectively, of average U.S. manufacturing costs—compared to the combined 7 to 13 percent energy costs seen in Japan and in the European Union. [71] Low energy costs will further narrow the cost gap between the manufacturers in the U.S. and in China. [72]

Transportation

Since 2010, following new greenhouse gas emissions standards implemented by the Obama administration, upfront vehicle prices have slightly increased (by approximately $1,000) yet lifetime fuel savings have surpassed that—coming in at $4,000 over the lifetime of the vehicle.[73] These estimates reflect a fuel efficiency of 35.5 miles per gallon required for standard cars and light trucks by model year 2016.[74] Since then, hybrid and electric vehicles have become increasingly popular—with the availability of electricity overweighing the availability of natural gas, vehicles of this type require less investment when compared to natural gas vehicles.[75] Alternatively, "the greatest opportunity to reduce greenhouse gas emissions…is through fuel substitution in fleets and heavy-duty vehicles." [76]

In some states, such as California, new transportation fuel policies benefit drivers and communities; however, trucking companies are not fairing as well—the EPA Regulations are putting some trucking companies out of business.[77] [78] The same regulations implemented by

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[69] "Nearly Every Manufacturer in the U.S. Will Benefit from Low-Cost Natural Gas," The Boston Consulting Group, February 13, 2014, accessed January 7, 2015, http://www.bcg.com/media/PressReleaseDetails.aspx?id=tcm:12-154623.
[70] Ibid.
[71] Ibid.
[72] Ibid.
[73] Juliet Eilperin, "Emissions limits, greater fuel efficiency for cars, light trucks made official," The Washington Post, April 2, 2010, accessed January 7, 2015, http://www.washingtonpost.com/wp-dyn/content/article/2010/04/01/AR2010040101412.html.
[74] Ibid.
[75] "Leveraging Natural Gas to Reduce Greenhouse Gas Emissions," Center for Climate and Energy Solutions, June 2013, accessed January 7, 2015, http://www.c2es.org/publications/leveraging-natural-gas-reduce-greenhouse-gas-emissions.
[76] Ibid.
[77] Erica Morehouse, "Transportation fuel policies continue to benefit drivers and communities across California," Environmental Defense Fund, May 16, 2014, accessed January 7, 2015,

the California Air Resources Board (CARB) that will save drivers money will also put an "overwhelming burden for businesses, especially small businesses." [79] [80] As of January 1, 2015, "trucks weighing 14,000 pounds to 26,000 pounds will be forced to install PM retrofits;" retrofits cost are generally between $10,000 and $20,000.[81]

Growth Opportunities

Natural gas exploration has taken place in more than 30 states nationwide, creating local jobs in its wake.[82] Since the beginning of the Great Recession, states undergoing shale exploration have added nearly 1.4 million jobs; conversely states without shale exploration have lost more than 400,000 jobs.[83] According to 2014 study by the Perryman Group, natural gas exploration generates more than 9.3 million jobs and nearly $1.2 trillion in annual gross product.[84] Moreover, a PricewaterhouseCoopers study, done on the behalf of the National Association of Manufacturers, estimated that natural gas will generate an additional 1 million U.S. manufacturing jobs by 2025.[85]

3.5 Workforce Redevelopment

Manufacturing in Maryland and the U.S. as a whole has seen steady employment declines since 2002. The industry's average per capita weekly wage, however, has increased. This trend indicates a shift in the type of Manufacturing jobs available. According to the Manufacturing Institute, due in part to the increased "technological sophistication" of manufacturing, the industry now requires "more process-oriented, team-oriented workers."[86] As the industry evolves and the technical knowledge required of industry workers increases, the quality of available jobs is also increasing. Manufacturing jobs now require a higher level of training and education compared to traditional Manufacturing jobs. In 2000, 22 percent of the

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http://blogs.edf.org/californiadream/2014/05/16/transportation-fuel-policies-continue-to-benefit-drivers-and-communities-across-california/.

[78] Wesley Coopersmith, "California EPA Regulation Puts Trucking Companies Out of Business," June 20, 2012, access January 7, 2015, http://www.freedomworks.org/content/california-epa-regulation-puts-trucking-companies-out-business.

[79] Morehouse, "Transportation fuel policies continue to benefit drivers and communities across California."

[80] Coopersmith, "California EPA Regulation Puts Trucking Companies Out of Business."

[81] Ibid.

[82] "Jobs," America's Natural Gas Alliance, accessed January 7, 2015, http://anga.us/why-natural-gas/jobs#.VKbsOyvF9yw.

[83] Tyler Durden, "Jobs: Shale States vs Non-Shale States," Zero Hedge, December 3, 2014, accessed January 7, 2015, http://www.zerohedge.com/news/2014-12-03/jobs-shale-states-vs-non-shale-states.

[84] Mella McEwen, "Study: Oil & Gas Industry Creates 9.3 Million Jobs in U.S.," Midland Reporter-Telegram, August 31, 2014, accessed January 7, 2015, http://www.cpapracticeadvisor.com/news/11674995/study-oil-gas-industry-creates-93-million-jobs-in-us.

[85] "Jobs," America's Natural Gas Alliance.

[86] "Percent of Manufacturing Workforce by Education Level," Manufacturing Institute, April 2014, accessed June 2, 2014, http://www.themanufacturinginstitute.org/Research/Facts-About-Manufacturing/Workforce-and-Compensation/Workforce-by-Education/Workforce-by-Education.aspx.

Manufacturing workforce in the U.S. held a Bachelor's degree or higher; this figure rose to approximately 29 percent in 2012.[87]

Having evolved to a new level of technological sophistication, Manufacturing now requires the use of "precision machinery, computer modeling and high-tech tooling."[88] According to the National Association of Manufacturers (NAM), the industry needs employee development, lifelong learning, and adult education, and many think it is necessary to develop these aspects well before beginning a career.[89] [90]

In recent years, many states have adopted a Common Core (CC) curriculum for K-12 grade levels. The CC curriculum focuses on higher universal standards in regard to literacy and mathematics, focuses which help prepare students "for these higher-skilled, internationally competitive jobs."[91] Beyond improvements made to the K-12 school system, many students who go on to earn a college degree often remain at a disadvantage. The industry lacks a standardized credentialing system, a limitation which creates an inadequate pool of desirable college graduates for employers in the industry.[92]

The aim of the newly launched Skills for America's Future program is to "provide 500,000 community college students with standardized manufacturing credentials that will promise secure jobs within the sector." [93] Through the program, students can "earn valuable credentials that are portable and demanded by vast amounts of firms." [94] Partners of the for-credit program of study include the Gates Foundation, the Lumina Foundation, and several members involved in education and training such as individuals from the American Welding Society, the National Institute of Metalworking Skills, the Society of Manufacturing Engineers, and the Manufacturing Skills Standards Council.[95]

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[87] Ibid.
[88] Richard Haass and Klaus Kleinfeld, "Column: Lack of skilled employees hurting manufacturing," *USA Today News*, July 3, 2012, accessed June 2, 2014, http://usatoday30.usatoday.com/news/opinion/forum/story/2012-07-02/public-private-manufacuting/56005466/1.
[89] "Workforce Development and Training," National Association of Manufacturers, accessed June 2, 2014, http://www.nam.org/Issues/Employment-and-Labor/Manufacturing-Workforce-Development.aspx.
[90] "HRP-01 Education and the Workforce," National Association of Manufacturers, accessed June 2, 2014, http://www.nam.org/Issues/Official-Policy-Positions/Human-Resources-Policy/HRP-01-Education-and-the-Workforce.aspx#202.
[91] Haass and Kleinfeld, "Column: Lack of skilled employees hurting manufacturing."
[92] "President Obama and Skills for America's Future Partners Announce Initiatives Critical to Improving Manufacturing Workforce," Office of the Press Secretary, The White House, June 8, 2011, accessed June 2, 2014, http://www.whitehouse.gov/the-press-office/2011/06/08/president-obama-and-skills-americas-future-partners-announce-initiatives.
[93] Ibid.
[94] "President Obama and Skills for America's Future Partners Announce Initiatives Critical to Improving Manufacturing Workforce," Office of the Press Secretary.
[95] Ibid.

Skills for America's Future's partnerships also promote several other initiatives, such as the following:

- Helping manufacturers realize the need to implement credentials through "Boots on the Ground,"
- Building credentials into high school pathways,
- Providing new online tools for workers to earn and utilize these credentials,
- Improving awareness of such credentials through a Career Awareness Campaign,
- Increasing opportunities for at-risk youth to seek these careers and credentials, and
- Creating the next-generation engineering workforce.[96]

Locally, the Maryland Manufacturing Extension Partnership (MD MEP) has several programs designed to train the new manufacturing workforce. These programs include the Manufacturing Boot Camp and the Manufacturing Incumbent Workforce Training Partnership.[97] Both programs are made possible through the Employment Advancement Right Now (EARN) program. The Manufacturing Boot Camp, a six-week training program, aims to "increase the skills of potential workers and enhance their employability." [98] Following an assessment of trainee skills, individuals will undergo training for skills including but not limited to the following:

- Work ethic,
- Job readiness,
- Professionalism,
- Problem solving,
- Basic mathematics and English,
- Communication, and
- Basic manufacturing skills.[99]

An abbreviated version of this program was successfully piloted with Garrett Container Systems, Inc., a shipping and storage container manufacturer located in Western Maryland. Upon their completion of the program, ten of the program participants were hired by the company.[100]

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[96] Ibid.

[97] Courtney Gaddi, "Maryland Manufacturing Extension Partnership Works to Grow Manufacturing in Maryland," *Columbia Patch*, February 20, 2014, accessed June 2, 2014, http://columbia.patch.com/groups/business-updates/p/maryland-manufacturing-extension-partnership-works-to-grow-manufacturing-in-maryland.

[98] "EARN Maryland 2014 Planning Grant Strategic Industry Partnerships," Maryland Department of Labor, Licensing and Regulation, 7, accessed June 2, 2014, http://www.dllr.maryland.gov/earn/earnsipsummaries.pdf.

[99] Gaddi, "Maryland Manufacturing Extension Partnership Proves Manufacturing Bootcamp Program Successful With Pilot Program."

[100] Gaddi, "Maryland Manufacturing Extension Partnership Proves Manufacturing Bootcamp Program Successful With Pilot Program."

In addition to the Manufacturing Boot Camp, the MD MEP proposed the Manufacturing Incumbent Workforce Training Partnership**.** This proposal seeks to "address skills gaps in advanced machining, master craftsmen and other areas," while alleviating the "burden on individual employers of incumbent worker training, such as tuition costs, wages and lost production time."[101]

4.0 Relevant Maryland Case Studies

While Manufacturing is excluded from current state regulations that require a 25 percent reduction in GHG emissions from 2006 levels by 2020, impacts associated with reduction efforts are occurring in the industry. RESI reached out to manufacturers in Maryland to discuss the impacts that reduction requirements have made. To date, Redland Brick and General Motors Baltimore Operations are the two completed case studies.

4.1 Redland Brick

On Thursday, December 12, 2013, team members from RESI and MDE visited and toured Redland Brick, Inc., in Williamsport, Maryland. Barry Miller (Manager of Safety, Environmental, and Quality) met with team members to discuss the impacts that legislation has had on Redland Brick and to provide a guided tour of the Williamsport facilities.

A subsidiary of Belden Holding & Acquisition Company, Inc., Redland Brick has six brick manufacturing plants, including two in Maryland (Cushwa and Rocky Ridge) and one each in Pennsylvania (Harmar), Connecticut (KF), and Virginia (Lawrenceville). Redland Brick produces a wide range of brick products, including handmade, moulded, and extruded styles.[102] Redland Brick's two moulded brick plants, located in Maryland, "have established themselves as the premier moulded brick producers in the United States."[103] In 2001 Redland Brick commissioned Harmar, located in suburban Pittsburgh, Pennsylvania. This plant offers "a variety of products including fireclay, red shale, and sand coated bricks" and is completely automated.[104] Located in South Windsor, Connecticut, is Redland's KF plant. According to the company's website, this plant "is a modern extruded plant that supplies quality brick products for New England and the Mid-Atlantic markets."[105] Redland also owns the two plants of Lawrenceville Brick in Lawrenceville, Virginia. Redland Brick has the unique ability to limit waste resulting from manufacturing. If at any time during the brick making process a brick is deemed flawed, it can be cycled back through to the beginning of the brickmaking process.

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[101] "EARN Maryland 2014 Planning Grant Strategic Industry Partnerships," Maryland Department of Labor, Licensing and Regulation, 7.
[102] "Redland Brick Inc. – Brick Manufacturer," Redland Brick, 2011, accessed April 14, 2014, http://www.redlandbrick.com/aboutus.asp.
[103] Ibid.
[104] Ibid.
[105] "Redland Brick Inc. – Brick Manufacturer," Redland Brick.

To meet the Environmental Protection Agency's (EPA) Maximum Achievable Control Technology (MACT) requirements, in 2008 Redland Brick installed a new scrubber that cost approximately $1 million.[106] This particular scrubber uses high-quality, expensive limestone in the scrubbing process. In the interest of further reducing waste, Mr. Miller has worked with the Connecticut Agricultural Experiment Station to complete an analysis that shows that the limestone used by Redland Brick, and therefore the limestone waste resulting from the scrubbing process, provides a pH level comparable to the regular lime commonly used in farming when added to topsoil. After the expensive changes made by Redland Brick to meet the 2008 MACT requirements, the legislation was overturned. EPA is now finalizing a second MACT standard for the same emissions.

Depending upon the outcome, Redland Brick may need to replace that scrubber, continue to operate it, or have it determined that the scrubber was never necessary. The combination of regulatory requirements and the housing market crash has crippled the brick industry. Redland is not aware of technology available on the market today that can be used in a brick kiln to reduce greenhouse gas emissions. If forced to reduce greenhouse gas emissions, Redland would likely be forced to reduce production. Reducing production would lead to job losses and an additional sizable strain on Redland Brick's ability to operate.

4.2 General Motors Baltimore Operations

In June 2015, team members from RESI spoke with a representative from the General Motors (GM) Baltimore Operations. Michael Martinko, Senior Environmental Engineer, spoke with team members to discuss the impacts that legislation has had on GM's Baltimore Operations since the early 2000s.

GM is a dynamic motor vehicle manufacturer with operations worldwide.[107] GM's domestic brands include Buick, Cadillac, Chevrolet, and GMC. With nearly 400 facilities and more than 20,000 dealers, GM's wide spread activity encompasses 6 continents and 120 countries.[108] GM strives to create new vehicles and technology as well as engineer state-of-the-art plants.[109] Through innovative technology development, such as electric vehicles and fuel saving technology, GM is working to shape the automotive industry of the future.[110] The GM Baltimore Operations facility is located in White Marsh, Maryland.[111]

[106] While MACT is not a GHG reduction requirement, it is aimed at criteria pollutants.
[107] "Our Company," General Motors, accessed June 22, 2015, http://www.gm.com/company/aboutGM/our_company.html.
[108] Ibid.
[109] Ibid.
[110] "Our Company," General Motors.
[111] "Baltimore Operations," GM News, accessed June 22, 2015, http://media.gm.com/media/us/en/gm/company_info/facilities/powertrain/baltimore.html.

Opened in December 2000, GM Baltimore Operations encompasses more than 580,000 square feet.[112] This plant houses 1.81 megawatts of rooftop solar arrays and is landfill-free, meaning it recycles, reuses, or converts to energy all waste created from daily operations.[113] In April 2011, the facility took first place in the *Baltimore Business Journal*'s Annual Green Business Award Event; that same year, the facility earned Wildlife Habitat Council certification.[114] In June 2012, the facility was included among the winners of the Maryland Green Registry Leadership Awards, and in 2013 Baltimore County honored Baltimore Operations in the Baltimore County Chamber of Commerce Business Hall of Fame for the facility's environmental efforts.[115] More recently, in June 2014, the facility was recognized with a Project of Distinction Award from PV America for a smart microgrid charging technology, which uses a solar array and solar EV charging canopy to charge Chevrolet Volts or stores energy in a system to support the grid.[116]

GM committed to reduce its facilities' carbon intensity globally by 20 percent by 2020. While the solar array generates approximately 6 percent of GM Baltimore Operation's electricity, natural gas used in heat treating remains the facility's key contributor to GHG emissions. However, the plant maintains its commitment to operating landfill-free by recycling or reusing 90 percent of waste in 2013. In addition to the solar array on site at the facility, GM Baltimore Operations strives to reduce power usage during lunch hours by shutting down lights and running at a 20 percent level of production on weekends. GM Baltimore Operations recently met the Environmental Protection Agency's ENERGY STAR® Challenge for Industry by reducing the energy intensity of its operations by 15.5 percent in just three years. The site has continued other initiatives to reduce energy costs, such as moving from single speed compressors to variable speed compressors, a change that helps to reduce both energy and maintenance costs. Although the upfront cost is greater, Mr. Martinko noted that the long-term costs are diminished, which balances the short-term investment. GM Baltimore Operations attributes much of its success in leading the way as a manufacturer to collaborative environmental efforts with companies like Constellation Energy and TimberRock. These partnerships help GM Baltimore Operations continue to reduce its impact on climate change.

5.0 Economic Impacts from the GGRA on Manufacturing

Maryland's Manufacturing industry was one of the hardest hit industries in the state during the recession from 2007 through 2009. Upon passage of the GGRA, concerns arose about Manufacturing's ability to remain competitive if more costs were added after the recession. However, RESI's analysis shows that there are no net discernible impacts on Manufacturing from GGRA implementation.

[112] Ibid.
[113] Ibid.
[114] Ibid.
[115] Ibid.
[116] Ibid.

To determine the potential impacts associated with the GGRA, RESI used agency-specific data and external research to determine inputs for the analysis. These inputs included the following:

- Industry sales data,
- Energy consumption reduction estimates,
- Industry-level demand, and
- Tax credits.

Using these inputs, RESI ran the analysis using the REMI PI+ model, specifically calibrated to Maryland's economy, to determine impacts from 2010 through 2020. The following section discusses the impacts on employment, output, and wages.

5.1 Economic Impacts

To determine the level of impact on the Manufacturing industry, RESI ran all GGRA initiatives outlined in the GGRA from investment through operation. The following results are the impacts expected to occur in Maryland for the Manufacturing industry by 2020. Overall, RESI found no discernible impact on employment in the Manufacturing industry between 2010 and 2020. Figure 3 reports the findings for the 20 sectors that make up the industry at the four-digit NAICS level for employment in 2020.

Figure 2: Manufacturing Employment Impacts from GGRA Initiatives, 2020[117]

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	3.9	-0.4	3.5
Beverage and tobacco product manufacturing	4.4	-1.7	2.7
Chemical manufacturing	4.2	-1.0	3.2
Computer and electronic product manufacturing	9.3	29.2	38.5
Electrical equipment and appliance manufacturing	23.0	-0.4	22.6
Fabricated metal product manufacturing	16.3	-0.5	15.8
Food manufacturing	5.3	-13.7	-8.4
Furniture and related product manufacturing	-0.7	1.7	1
Machinery manufacturing	-2.9	5.2	2.3
Miscellaneous manufacturing	-1.1	3.4	2.3
Motor vehicles, bodies and trailers, and parts manufacturing	0.2	1.0	1.2
Nonmetallic mineral product manufacturing	14.3	-2.7	11.6
Other transportation equipment manufacturing	-1.5	-0.8	-2.3
Paper manufacturing	2.7	-1.5	1.2
Petroleum and coal products manufacturing	0.7	-0.3	0.4
Plastics and rubber product manufacturing	6.2	-2.2	4
Primary metal manufacturing	0.6	-1.0	-0.4
Printing and related support activities	14.1	-0.7	13.4
Textile mills; Textile product mills	0.0	-0.6	-0.6
Wood product manufacturing	4.9	-3.8	1.1

Sources: REMI PI+, RESI

As reported in Figure 2, the two greatest gaining sectors in terms of employment by 2020 from GGRA initiatives are *Computer and electronic product manufacturing* and *Electrical equipment and appliance manufacturing*. The sectors that are likely to experience minimal to no loss are *Food manufacturing*, *Other transportation equipment manufacturing*, and *Textile mills; Textile product mills.* Overall, most sectors are expect to see some minor increases in employment during that period.

In addition to an increase in employment, output for the industry is expected to grow through 2020. Impacts associated with the changes in output are reported in Figure 3.

Figure 3: Manufacturing Output Impacts from GGRA Initiatives, 2020[118]

[117] The following impacts are those that are expected to occur in year 2020. Therefore, in year 2020, RESI expects that the *Apparel manufacturing; Leather and allied product manufacturing* sector will increase by 3.5 jobs.

Impact Analysis of the GGRA of 2009 on Manufacturing in Maryland
RESI of Towson University

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$213,645	-$38,618	$175,027
Beverage and tobacco product manufacturing	$1,931,614	-$423,644	$1,507,970
Chemical manufacturing	$6,739,902	$1,829,887	$8,569,789
Computer and electronic product manufacturing	$1,836,413	$2,108,593	$3,945,006
Electrical equipment and appliance manufacturing	$4,378,054	-$128,919	$4,249,135
Fabricated metal product manufacturing	$2,347,909	-$8,334	$2,339,575
Food manufacturing	$34,898,986	-$35,919,825	-$1,020,839
Furniture and related product manufacturing	-$1,245,385	$1,238,741	-$6,644
Machinery manufacturing	$1,222,865	-$1,213,066	$9,799
Miscellaneous manufacturing	$1,214,402	-$1,124,451	$89,951
Motor vehicles, bodies and trailers, and parts manufacturing	$1,463,898	-$1,647,134	-$183,236
Nonmetallic mineral product manufacturing	$1,766,294	$410,368	$2,176,662
Other transportation equipment manufacturing	$1,775,479	-$1,865,199	-$89,720
Paper manufacturing	$520,176	$7,570	$527,746
Petroleum and coal products manufacturing	$2,934,225	-$2,128,244	$805,981
Plastics and rubber product manufacturing	$3,420,268	-$1,553,721	$1,866,547
Primary metal manufacturing	-$53,062	$663,211	$610,149
Printing and related support activities	$1,597,468	$178,777	$1,776,245
Textile mills; Textile product mills	$93,151	-$75,113	$18,038
Wood product manufacturing	$1,238,096	-$2,137,476	-$899,380

Sources: REMI PI+, RESI

By 2020, the greatest increase in output will be associated with the *Computer and electronic production manufacturing* and the *Chemical Manufacturing* sectors. Smaller sectors such as *Other transportation equipment manufacturing* and *Textile mills; Textile product mills* are expected to see minimal gains during that period.

Finally, RESI found that wages are expected to rise through 2020 in the manufacturing industry if all GGRA initiatives are implemented. Figure 5 reports the wage impacts over the 20 sectors that comprise the Manufacturing industry.

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[118] The following impacts are those that are expected to occur in year 2020. Therefore, in year 2020, RESI expects that the *Apparel manufacturing; Leather and allied product manufacturing* sector will increase by $175,027 in output.

Figure 4: Manufacturing Wage Impacts from GGRA Initiatives, 2020[119]

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$67,541	-$7,935	$59,606
Beverage and tobacco product manufacturing	$130,895	$25,425	$156,320
Chemical manufacturing	$443,825	$139,011	$582,836
Computer and electronic product manufacturing	$1,685,521	$3,862,656	$5,548,177
Electrical equipment and appliance manufacturing	$1,825,196	-$59,269	$1,765,927
Fabricated metal product manufacturing	$1,057,189	-$59,759	$997,430
Food manufacturing	$663,109	-$1,018,840	-$355,731
Furniture and related product manufacturing	-$262,103	$284,368	$22,265
Machinery manufacturing	$268,869	-$178,872	$89,997
Miscellaneous manufacturing	-$188,135	$220,202	$32,067
Motor vehicles, bodies and trailers, and parts manufacturing	$83,647	-$44,139	$39,508
Nonmetallic mineral product manufacturing	$604,918	$72,718	$677,636
Other transportation equipment manufacturing	$277,546	-$166,669	$110,877
Paper manufacturing	$508,840	-$420,837	$88,003
Petroleum and coal products manufacturing	$101,596	-$79,035	$22,561
Plastics and rubber product manufacturing	-$228,819	$536,758	$307,939
Primary metal manufacturing	-$41,682	$74,578	$32,896
Printing and related support activities	$284,661	$212,314	$496,975
Textile mills; Textile product mills	-$116,148	$124,413	$8,265
Wood product manufacturing	$277,286	-$352,867	-$75,581

Sources: REMI PI+, RESI

According to Figure 4, the sectors with the greatest gain in wages through 2020 are *Computer and electronic product manufacturing* and *Electrical equipment and appliance manufacturing.* Smaller gains are likely to be recorded in the *Textile mills; Textile product mills* sector and the *Petroleum and coal products manufacturing* sector.

5.2 Discussion

According to RESI's analysis, manufacturing will experience no discernible impact on employment between 2010 and 2020 if all policies are implemented. Manufacturing sectors

[119] The following impacts are those that are expected to occur in year 2020. Therefore, in year 2020, RESI expects that the *Apparel manufacturing; Leather and allied product manufacturing* sector will increase by $59.606 in wages.

associated with high and middle skilled labor, such as *Computer and electronic product manufacturing*, *Chemical manufacturing*, and *Electrical equipment and appliance manufacturing*, will experience the greatest impacts. Occupations within *Computer and electronic product manufacturing* include the following:

- Computer hardware engineers,
- Computer software engineers, applications,
- Computer software engineers, systems software,
- Electrical and electronic engineering technicians,
- Electrical and electronic equipment assemblers, and,
- Semiconductor processors.[120]

Some of the occupations within this sector, such as computer hardware engineers, require at least a Bachelor's degree.[121] This occupation pays a median salary of $100,920, which is well above the median income for a Bachelor's degree according to The National Center for Education Statistics.[122] [123] However, some occupations, such as electrical and electronic engineering technicians, require less additional education opening career pathways for non-college graduates. According to the BLS's Occupational Outlook Handbook, electrical and electronic engineering technician jobs require a minimum of an Associate's degree.[124]

Overall, RESI found that the GGRA's impact on Maryland may benefit Manufacturing for high- to middle-skilled labor. Although the workforce needed to meet this demand is likely to require additional education and training to meet specifics industry needs, Maryland is poised to provide this workforce to prospective employees. Continued partnerships, as discussed in Section 3.0, will provide the fundamental groundwork in meeting employer demand related to implementation and operation of GGRA initiatives. However, there is no conclusive evidence that any change in the Manufacturing industry operations has been directly attributable to the GGRA.

[120] "Industries at a Glance: Computer and Electronic Product Manufacturing: NAICS 334," Bureau of Labor Statistics, date extracted on April 29, 2014, accessed April 29, 2014, http://www.bls.gov/iag/tgs/iag334.htm.
[121] "Occupational Outlook Handbook: Computer Hardware Engineers," Bureau of Labor Statistics, last modified on January 8, 2014, accessed April 29, 2014, http://www.bls.gov/ooh/architecture-and-engineering/computer-hardware-engineers.htm.
[122] Ibid.
[123] "Fast Facts: Income of Young Adults," National Center for Education Statistics, updated 2013, accessed April 30, 2014. http://nces.ed.gov/fastfacts/display.asp?id=77
[124] "Occupational Outlook Handbook: Electrical and Electronics Engineering Technicians," Bureau of Labor Statistics, last modified on January 8, 2014, accessed April 29, 2014, http://www.bls.gov/ooh/architecture-and-engineering/electrical-and-electronics-engineering-technicians.htm.

6.0 Conclusion

The reduction of greenhouse gas emissions is not only a statewide issue but one that extends internationally. Internationally recognizable companies such as Avon, Whirlpool, SC Johnson, and General Motors have worked with the industry to achieve reductions in greenhouse gas emissions domestically and abroad. Nationally, partnerships between industry leaders, and state and federal agencies continue to pursue greenhouse gas emissions. Regional partnerships such as those between RMI and PSC have assisted manufacturers in effectively reducing energy consumption through funding opportunities.

RESI's research indicates that the Manufacturing industry will see no discernible impacts from the greenhouse gas reduction strategies as outlined in the GGRA. In addition to this finding, RESI expects the following:

- The manufacturing industry will create 113 jobs by 2020 to meet the demand for greenhouse gas reduction.
- Sectors within the industry such as *Computer and electronic product manufacturing* and *Electrical equipment and appliance manufacturing* will see the greatest growth during this time.
- Lower skilled sectors such as *Food manufacturing* and *Textile mills* will see minimal declines in employment between 2010 and 2020.
- Wages for the industry will increase by $10.7 million and output for the industry will grow by $26.5 million by 2020.

Some manufacturers have implemented energy-efficient strategies as a method for reducing production costs rather than a method for achieving greenhouse gas reduction. As stated by Mr. Miller from Redland Brick, the brick industry sector has transformed its energy use over time. From wood to coal and finally to natural gas, these reductions have been more focused on reducing costs than reducing emissions. The use of natural gas rather than coal reduces emissions but also allows the producer to reduce production costs and remain competitive.

The EIA expects these energy costs to increase over the next five years. During this time, manufacturers will need to seek new methods of cost reduction to retain competitiveness. The expansion of new technologies, energy efficiency methods, and partnerships to achieve these goals at the least cost will be key in the success of the GGRA as well as the Manufacturing industry through 2020. RESI's findings indicate that workforce training will be crucial in meeting industry demand as more GGRA initiatives are implemented and fully operational by 2020.

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Appendix A—Annual Employment Impacts for the Manufacturing Industry

The following tables highlight the employment impacts associated with the GGRA to the Manufacturing industry in Maryland between 2010 and 2020.

Figure 5: Manufacturing Employment Impacts from GGRA Initiatives, 2010

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	1.3	0.0	1.3
Beverage and tobacco product manufacturing	1.6	0.0	1.6
Chemical manufacturing	10.1	0.6	10.7
Computer and electronic product manufacturing	3.7	2.5	6.2
Electrical equipment and appliance manufacturing	5.0	0.0	5
Fabricated metal product manufacturing	18.0	-0.3	17.7
Food manufacturing	2.5	-0.1	2.4
Furniture and related product manufacturing	2.2	0.2	2.4
Machinery manufacturing	1.8	0.3	2.1
Miscellaneous manufacturing	1.6	0.1	1.7
Motor vehicles, bodies and trailers, and parts manufacturing	1.7	0.0	1.7
Nonmetallic mineral product manufacturing	14.1	-0.4	13.7
Other transportation equipment manufacturing	0.5	0.1	0.6
Paper manufacturing	2.3	-0.1	2.2
Petroleum and coal products manufacturing	0.8	0.0	0.8
Plastics and rubber product manufacturing	6.0	-0.1	5.9
Primary metal manufacturing	0.6	0.2	0.8
Printing and related support activities	10.2	-0.1	10.1
Textile mills; Textile product mills	0.2	0.0	0.2
Wood product manufacturing	6.2	1.2	7.4

Sources: REMI PI+, RESI

Figure 6: Manufacturing Employment Impacts from GGRA Initiatives, 2011

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	3.0	0.0	3.0
Beverage and tobacco product manufacturing	3.0	-0.1	2.9
Chemical manufacturing	15.7	1.2	16.9
Computer and electronic product manufacturing	21.7	22.0	43.7
Electrical equipment and appliance manufacturing	51.1	-1.1	50.0
Fabricated metal product manufacturing	30.0	0.7	30.7
Food manufacturing	4.5	-0.5	4.0
Furniture and related product manufacturing	2.1	1.6	3.7
Machinery manufacturing	-1.8	5.5	3.7
Miscellaneous manufacturing	0.8	2.3	3.1
Motor vehicles, bodies and trailers, and parts manufacturing	1.6	1.0	2.6
Nonmetallic mineral product manufacturing	23.8	-0.7	23.1
Other transportation equipment manufacturing	0.1	0.7	0.8
Paper manufacturing	3.2	-0.2	3.0
Petroleum and coal products manufacturing	1.4	0.0	1.4
Plastics and rubber product manufacturing	9.8	0.0	9.8
Primary metal manufacturing	1.0	0.3	1.3
Printing and related support activities	14.2	0.1	14.3
Textile mills; Textile product mills	0.2	0.0	0.2
Wood product manufacturing	10.4	0.8	11.2

Sources: REMI PI+, RESI

Figure 7: Manufacturing Employment Impacts from GGRA Initiatives, 2012

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	3.7	-0.1	3.6
Beverage and tobacco product manufacturing	3.7	-0.3	3.4
Chemical manufacturing	15.9	1.2	17.1
Computer and electronic product manufacturing	10.6	11.4	21.9
Electrical equipment and appliance manufacturing	19.8	-0.2	19.6
Fabricated metal product manufacturing	32.6	-0.2	32.4
Food manufacturing	5.4	-1.1	4.3
Furniture and related product manufacturing	3.2	0.7	3.8
Machinery manufacturing	1.9	2.4	4.3
Miscellaneous manufacturing	2.5	1.0	3.5
Motor vehicles, bodies and trailers, and parts manufacturing	2.2	0.4	2.7
Nonmetallic mineral product manufacturing	26.0	-0.9	25.1
Other transportation equipment manufacturing	0.6	0.1	0.8
Paper manufacturing	3.4	-0.4	3.1
Petroleum and coal products manufacturing	1.3	0.0	1.2
Plastics and rubber product manufacturing	11.2	-0.3	10.9
Primary metal manufacturing	1.0	0.4	1.3
Printing and related support activities	16.5	-0.2	16.3
Textile mills; Textile product mills	0.3	-0.1	0.1
Wood product manufacturing	11.8	0.8	12.6

Sources: REMI PI+, RESI

Figure 8: Manufacturing Employment Impacts from GGRA Initiatives, 2013

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	3.5	-0.1	3.4
Beverage and tobacco product manufacturing	3.6	-0.4	3.2
Chemical manufacturing	12.9	1.5	14.4
Computer and electronic product manufacturing	17.9	22.4	40.3
Electrical equipment and appliance manufacturing	44.1	-0.8	43.3
Fabricated metal product manufacturing	35.1	0.2	35.3
Food manufacturing	5.0	-3.2	1.8
Furniture and related product manufacturing	2.1	1.4	3.5
Machinery manufacturing	-1.0	5.2	4.2
Miscellaneous manufacturing	0.6	2.2	2.8
Motor vehicles, bodies and trailers, and parts manufacturing	1.6	0.9	2.5
Nonmetallic mineral product manufacturing	29.1	-1.1	28.0
Other transportation equipment manufacturing	0.0	0.3	0.3
Paper manufacturing	3.5	-0.5	3.0
Petroleum and coal products manufacturing	1.3	-0.1	1.2
Plastics and rubber product manufacturing	11.3	-0.4	10.9
Primary metal manufacturing	1.1	0.5	1.6
Printing and related support activities	15.6	-0.1	15.5
Textile mills; Textile product mills	0.2	-0.2	0.0
Wood product manufacturing	12.4	-0.1	12.3

Sources: REMI PI+, RESI

Figure 9: Manufacturing Employment Impacts from GGRA Initiatives, 2014

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	3.9	-0.2	3.7
Beverage and tobacco product manufacturing	3.8	-0.6	3.2
Chemical manufacturing	11.4	1.7	13.1
Computer and electronic product manufacturing	11.6	15.8	27.4
Electrical equipment and appliance manufacturing	24.7	-0.3	24.5
Fabricated metal product manufacturing	27.0	-0.2	26.8
Food manufacturing	4.9	-4.9	0.0
Furniture and related product manufacturing	2.1	0.9	3.0
Machinery manufacturing	0.2	3.3	3.5
Miscellaneous manufacturing	1.2	1.3	2.6
Motor vehicles, bodies and trailers, and parts manufacturing	1.6	0.6	2.2
Nonmetallic mineral product manufacturing	22.4	-1.1	21.3
Other transportation equipment manufacturing	0.1	-0.1	0.0
Paper manufacturing	3.2	-0.7	2.5
Petroleum and coal products manufacturing	1.1	-0.1	1.0
Plastics and rubber product manufacturing	9.6	-0.4	9.1
Primary metal manufacturing	0.9	0.4	1.3
Printing and related support activities	15.6	-0.4	15.2
Textile mills; Textile product mills	0.2	-0.2	-0.1
Wood product manufacturing	9.6	-0.9	8.6

Sources: REMI PI+, RESI

Figure 10: Manufacturing Employment Impacts from GGRA Initiatives, 2015

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	4.6	-0.2	4.4
Beverage and tobacco product manufacturing	4.7	-0.7	3.9
Chemical manufacturing	13.9	1.8	15.7
Computer and electronic product manufacturing	24.7	30.5	55.2
Electrical equipment and appliance manufacturing	53.0	-1.0	52.0
Fabricated metal product manufacturing	37.4	0.3	37.7
Food manufacturing	5.8	-6.6	-0.9
Furniture and related product manufacturing	1.7	2.0	3.7
Machinery manufacturing	-3.0	6.9	3.8
Miscellaneous manufacturing	-0.5	3.2	2.7
Motor vehicles, bodies and trailers, and parts manufacturing	1.3	1.2	2.4
Nonmetallic mineral product manufacturing	32.4	-1.6	30.8
Other transportation equipment manufacturing	-0.5	0.3	-0.2
Paper manufacturing	3.9	-0.9	3.1
Petroleum and coal products manufacturing	1.4	-0.1	1.3
Plastics and rubber product manufacturing	12.6	-0.6	12.0
Primary metal manufacturing	1.2	0.4	1.6
Printing and related support activities	19.8	-0.3	19.5
Textile mills; Textile product mills	0.1	-0.3	-0.2
Wood product manufacturing	13.2	-1.5	11.7

Sources: REMI PI+, RESI

Figure 11: Manufacturing Employment Impacts from GGRA Initiatives, 2016

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	4.6	-0.3	4.3
Beverage and tobacco product manufacturing	4.7	-0.9	3.8
Chemical manufacturing	10.8	1.6	12.4
Computer and electronic product manufacturing	15.5	22.4	37.9
Electrical equipment and appliance manufacturing	29.1	-0.4	28.7
Fabricated metal product manufacturing	27.7	-0.3	27.4
Food manufacturing	5.5	-8.3	-2.8
Furniture and related product manufacturing	1.3	1.4	2.7
Machinery manufacturing	-1.5	4.5	3.0
Miscellaneous manufacturing	0.3	2.1	2.4
Motor vehicles, bodies and trailers, and parts manufacturing	1.2	0.8	2.0
Nonmetallic mineral product manufacturing	23.7	-1.6	22.1
Other transportation equipment manufacturing	-0.5	-0.2	-0.7
Paper manufacturing	3.5	-1.1	2.4
Petroleum and coal products manufacturing	1.2	-0.1	1.1
Plastics and rubber product manufacturing	10.1	-0.9	9.2
Primary metal manufacturing	0.9	0.2	1.1
Printing and related support activities	18.0	-0.6	17.4
Textile mills; Textile product mills	0.1	-0.4	-0.3
Wood product manufacturing	9.6	-2.5	7.1

Sources: REMI PI+, RESI

Figure 12: Manufacturing Employment Impacts from GGRA Initiatives, 2017

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	5.1	0.0	5.0
Beverage and tobacco product manufacturing	5.8	-1.1	4.7
Chemical manufacturing	16.2	1.7	17.9
Computer and electronic product manufacturing	83.8	104.6	188.4
Electrical equipment and appliance manufacturing	145.8	-3.4	142.4
Fabricated metal product manufacturing	57.8	4.5	62.4
Food manufacturing	7.0	-9.9	-2.9
Furniture and related product manufacturing	-4.4	8.4	4.0
Machinery manufacturing	-21.2	23.2	2.0
Miscellaneous manufacturing	-13.3	14.7	1.4
Motor vehicles, bodies and trailers, and parts manufacturing	-2.7	4.1	1.4
Nonmetallic mineral product manufacturing	56.5	-2.6	53.9
Other transportation equipment manufacturing	-4.8	3.3	-1.4
Paper manufacturing	5.3	-1.0	4.3
Petroleum and coal products manufacturing	2.1	-0.2	1.9
Plastics and rubber product manufacturing	17.1	-0.6	16.5
Primary metal manufacturing	1.7	0.0	1.7
Printing and related support activities	21.6	2.0	23.5
Textile mills; Textile product mills	-0.2	-0.2	-0.5
Wood product manufacturing	20.0	-2.1	17.9

Sources: REMI PI+, RESI

Figure 13: Manufacturing Employment Impacts from GGRA Initiatives, 2018

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	4.4	0.0	4.4
Beverage and tobacco product manufacturing	5.4	-1.4	4.1
Chemical manufacturing	11.3	1.0	12.3
Computer and electronic product manufacturing	82.0	113.4	195.5
Electrical equipment and appliance manufacturing	157.7	-3.9	153.8
Fabricated metal product manufacturing	45.0	5.2	50.2
Food manufacturing	6.4	-11.6	-5.2
Furniture and related product manufacturing	-7.3	9.4	2.2
Machinery manufacturing	-23.0	23.2	0.2
Miscellaneous manufacturing	-16.5	17.1	0.6
Motor vehicles, bodies and trailers, and parts manufacturing	-3.7	4.3	0.7
Nonmetallic mineral product manufacturing	46.4	-2.7	43.7
Other transportation equipment manufacturing	-5.9	3.7	-2.3
Paper manufacturing	4.3	-1.1	3.2
Petroleum and coal products manufacturing	1.6	-0.2	1.4
Plastics and rubber product manufacturing	13.2	-0.8	12.4
Primary metal manufacturing	1.3	-0.4	0.9
Printing and related support activities	17.5	2.7	20.2
Textile mills; Textile product mills	-0.3	-0.3	-0.6
Wood product manufacturing	15.5	-2.5	13.0

Sources: REMI PI+, RESI

Figure 14: Manufacturing Employment Impacts from GGRA Initiatives, 2019

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	4.0	-0.3	3.7
Beverage and tobacco product manufacturing	4.7	-1.6	3.0
Chemical manufacturing	5.7	-0.5	5.1
Computer and electronic product manufacturing	22.1	45.0	67.1
Electrical equipment and appliance manufacturing	47.7	-1.1	46.7
Fabricated metal product manufacturing	26.6	0.5	27.1
Food manufacturing	5.2	-13.0	-7.7
Furniture and related product manufacturing	-1.5	3.1	1.6
Machinery manufacturing	-6.0	8.6	2.6
Miscellaneous manufacturing	-4.0	6.0	2.0
Motor vehicles, bodies and trailers, and parts manufacturing	-0.4	1.6	1.2
Nonmetallic mineral product manufacturing	24.9	-2.7	22.2
Other transportation equipment manufacturing	-2.2	0.0	-2.2
Paper manufacturing	2.9	-1.4	1.5
Petroleum and coal products manufacturing	1.0	-0.2	0.7
Plastics and rubber product manufacturing	8.3	-1.9	6.4
Primary metal manufacturing	0.8	-0.8	0.0
Printing and related support activities	13.5	0.1	13.6
Textile mills; Textile product mills	-0.1	-0.5	-0.6
Wood product manufacturing	8.3	-3.3	4.9

Sources: REMI PI+, RESI

Figure 15: Manufacturing Employment Impacts from GGRA Initiatives, 2020

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	3.9	-0.4	3.5
Beverage and tobacco product manufacturing	4.4	-1.7	2.7
Chemical manufacturing	4.2	-1.0	3.2
Computer and electronic product manufacturing	9.3	29.2	38.5
Electrical equipment and appliance manufacturing	23.0	-0.4	22.6
Fabricated metal product manufacturing	16.3	-0.5	15.8
Food manufacturing	5.3	-13.7	-8.4
Furniture and related product manufacturing	-0.7	1.7	1.0
Machinery manufacturing	-2.9	5.2	2.4
Miscellaneous manufacturing	-1.1	3.4	2.3
Motor vehicles, bodies and trailers, and parts manufacturing	0.2	1.0	1.2
Nonmetallic mineral product manufacturing	14.3	-2.7	11.6
Other transportation equipment manufacturing	-1.5	-0.8	-2.3
Paper manufacturing	2.7	-1.5	1.2
Petroleum and coal products manufacturing	0.7	-0.3	0.5
Plastics and rubber product manufacturing	6.2	-2.2	4.0
Primary metal manufacturing	0.6	-1.0	-0.4
Printing and related support activities	14.1	-0.7	13.4
Textile mills; Textile product mills	0.0	-0.6	-0.6
Wood product manufacturing	4.9	-3.8	1.1

Sources: REMI PI+, RESI

Appendix B—Annual Output Impacts for the Manufacturing Industry

The following tables highlight the output impacts associated with the GGRA to the Manufacturing industry in Maryland between 2010 and 2020.

Figure 16: Manufacturing Output Impacts from GGRA Initiatives, 2010

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$94,903	-$2,525	$92,378
Beverage and tobacco product manufacturing	$672,766	-$3,862	$668,904
Chemical manufacturing	$5,167,544	$494,917	$5,662,461
Computer and electronic product manufacturing	$1,265,981	$706,372	$1,972,353
Electrical equipment and appliance manufacturing	$738,830	$8,609	$747,439
Fabricated metal product manufacturing	$1,686,367	-$50,148	$1,636,219
Food manufacturing	$894,864	$4,124	$898,988
Furniture and related product manufacturing	$364,258	-$96,868	$267,390
Machinery manufacturing	-$122,588	$403,682	$281,094
Miscellaneous manufacturing	$261,958	$39,613	$301,571
Motor vehicles, bodies and trailers, and parts manufacturing	$4,183,581	-$3,708,946	$474,635
Nonmetallic mineral product manufacturing	$1,200,929	-$35,060	$1,165,869
Other transportation equipment manufacturing	$165,602	$40,459	$206,061
Paper manufacturing	$425,175	-$21,491	$403,684
Petroleum and coal products manufacturing	$1,182,126	-$48,639	$1,133,487
Plastics and rubber product manufacturing	$1,070,274	$4,552	$1,074,826
Primary metal manufacturing	$229,859	$148,953	$378,812
Printing and related support activities	$1,495,866	-$17,480	$1,478,386
Textile mills; Textile product mills	$27,195	-$2,692	$24,503
Wood product manufacturing	$491,313	$64,966	$556,279

Sources: REMI PI+, RESI

Figure 17: Manufacturing Output Impacts from GGRA Initiatives, 2011

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$172,720	-$6,734	$165,986
Beverage and tobacco product manufacturing	$1,341,575	-$72,780	$1,268,795
Chemical manufacturing	$9,321,764	$797,065	$10,118,829
Computer and electronic product manufacturing	$5,023,113	$6,430,400	$11,453,513
Electrical equipment and appliance manufacturing	$8,321,291	-$158,889	$8,162,402
Fabricated metal product manufacturing	$3,482,996	-$75,425	$3,407,571
Food manufacturing	$2,170,760	-$470,388	$1,700,372
Furniture and related product manufacturing	$440,802	$6,320	$447,122
Machinery manufacturing	$466,451	$137,517	$603,968
Miscellaneous manufacturing	$519,019	$16,835	$535,854
Motor vehicles, bodies and trailers, and parts manufacturing	$845,439	-$122,041	$723,398
Nonmetallic mineral product manufacturing	$2,512,994	-$85,010	$2,427,984
Other transportation equipment manufacturing	$227,670	$159,257	$386,927
Paper manufacturing	$629,966	$16,143	$646,109
Petroleum and coal products manufacturing	$2,380,733	-$54,375	$2,326,358
Plastics and rubber product manufacturing	$2,035,651	$3,682	$2,039,333
Primary metal manufacturing	$510,022	$310,610	$820,632
Printing and related support activities	$2,264,693	-$66,287	$2,198,406
Textile mills; Textile product mills	$71,719	-$25,393	$46,326
Wood product manufacturing	$1,032,239	$66,287	$1,098,526

Sources: REMI PI+, RESI

Figure 18: Manufacturing Output Impacts from GGRA Initiatives, 2012

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$227,653	-$11,805	$215,848
Beverage and tobacco product manufacturing	$1,878,507	-$164,235	$1,714,272
Chemical manufacturing	$11,264,988	$1,216,700	$12,481,688
Computer and electronic product manufacturing	$3,340,246	$3,315,252	$6,655,498
Electrical equipment and appliance manufacturing	$3,350,295	-$3,581	$3,346,714
Fabricated metal product manufacturing	$5,084,786	-$149,915	$4,934,871
Food manufacturing	$3,843,341	-$1,681,702	$2,161,639
Furniture and related product manufacturing	$626,299	-$44,096	$582,203
Machinery manufacturing	$1,002,100	-$214,257	$787,843
Miscellaneous manufacturing	$918,073	-$282,951	$635,122
Motor vehicles, bodies and trailers, and parts manufacturing	$1,073,565	-$237,684	$835,881
Nonmetallic mineral product manufacturing	$4,084,305	-$144,965	$3,939,340
Other transportation equipment manufacturing	-$1,261,570	$1,746,332	$484,762
Paper manufacturing	$822,222	-$36,180	$786,042
Petroleum and coal products manufacturing	$2,277,876	-$36,635	$2,241,241
Plastics and rubber product manufacturing	$2,882,450	-$11,457	$2,870,993
Primary metal manufacturing	$654,863	$495,259	$1,150,122
Printing and related support activities	$2,734,350	-$125,457	$2,608,893
Textile mills; Textile product mills	$100,785	-$41,163	$59,622
Wood product manufacturing	$1,731,956	$50,679	$1,782,635

Sources: REMI PI+, RESI

Figure 19: Manufacturing Output Impacts from GGRA Initiatives, 2013

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$251,512	-$17,333	$234,179
Beverage and tobacco product manufacturing	$2,081,966	-$295,504	$1,786,462
Chemical manufacturing	$12,530,887	$828,774	$13,359,661
Computer and electronic product manufacturing	$4,957,832	$6,140,568	$11,098,400
Electrical equipment and appliance manufacturing	$7,418,773	-$100,402	$7,318,371
Fabricated metal product manufacturing	$5,125,728	-$166,124	$4,959,604
Food manufacturing	$854,583	$961,703	$1,816,286
Furniture and related product manufacturing	$605,173	-$22,969	$582,204
Machinery manufacturing	$1,197,037	-$409,985	$787,052
Miscellaneous manufacturing	$2,730,851	-$2,106,407	$624,444
Motor vehicles, bodies and trailers, and parts manufacturing	$991,605	-$219,685	$771,920
Nonmetallic mineral product manufacturing	$4,137,489	-$182,907	$3,954,582
Other transportation equipment manufacturing	$1,395,170	-$962,520	$432,650
Paper manufacturing	$913,107	-$101,149	$811,958
Petroleum and coal products manufacturing	$2,295,401	-$96,267	$2,199,134
Plastics and rubber product manufacturing	$3,076,228	-$26,078	$3,050,150
Primary metal manufacturing	$1,007,213	$493,876	$1,501,089
Printing and related support activities	$2,807,574	-$186,850	$2,620,724
Textile mills; Textile product mills	$278,954	-$214,447	$64,507
Wood product manufacturing	$1,674,523	-$281,708	$1,392,815

Sources: REMI PI+, RESI

Figure 20: Manufacturing Output Impacts from GGRA Initiatives, 2014

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$274,139	-$22,913	$251,226
Beverage and tobacco product manufacturing	$2,451,365	-$564,339	$1,887,026
Chemical manufacturing	$16,168,286	-$1,837,320	$14,330,966
Computer and electronic product manufacturing	$2,689,489	$5,463,488	$8,152,977
Electrical equipment and appliance manufacturing	$4,232,302	$18,281	$4,250,583
Fabricated metal product manufacturing	$4,016,429	-$206,809	$3,809,620
Food manufacturing	$2,702,260	-$1,126,998	$1,575,262
Furniture and related product manufacturing	$718,091	-$155,215	$562,876
Machinery manufacturing	$1,024,614	-$405,242	$619,372
Miscellaneous manufacturing	$482,114	$110,122	$592,236
Motor vehicles, bodies and trailers, and parts manufacturing	$1,269,548	-$578,387	$691,161
Nonmetallic mineral product manufacturing	$3,359,083	-$203,029	$3,156,054
Other transportation equipment manufacturing	$128,712	$266,106	$394,818
Paper manufacturing	$966,832	-$215,261	$751,571
Petroleum and coal products manufacturing	$1,732,295	-$105,705	$1,626,590
Plastics and rubber product manufacturing	$2,953,533	$6,613	$2,960,146
Primary metal manufacturing	$1,083,521	$606,923	$1,690,444
Printing and related support activities	$2,905,159	-$389,393	$2,515,766
Textile mills; Textile product mills	$57,431	$15,206	$72,637
Wood product manufacturing	$1,286,665	-$522,494	$764,171

Sources: REMI PI+, RESI

Figure 21: Manufacturing Output Impacts from GGRA Initiatives, 2015

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$327,851	-$29,535	$298,316
Beverage and tobacco product manufacturing	$2,336,665	-$112,266	$2,224,399
Chemical manufacturing	$3,781,011	$13,596,312	$17,377,323
Computer and electronic product manufacturing	$9,685,559	$5,504,631	$15,190,190
Electrical equipment and appliance manufacturing	$9,128,097	-$91,949	$9,036,148
Fabricated metal product manufacturing	$4,881,700	-$283,430	$4,598,270
Food manufacturing	$2,965,177	-$1,274,888	$1,690,289
Furniture and related product manufacturing	$980,659	-$339,686	$640,973
Machinery manufacturing	$1,791,360	-$1,106,106	$685,254
Miscellaneous manufacturing	$1,606,052	-$961,202	$644,850
Motor vehicles, bodies and trailers, and parts manufacturing	$2,151,327	-$1,613,560	$537,767
Nonmetallic mineral product manufacturing	$4,149,767	-$308,118	$3,841,649
Other transportation equipment manufacturing	-$163,474	$560,612	$397,138
Paper manufacturing	$1,258,261	-$400,506	$857,755
Petroleum and coal products manufacturing	$2,197,149	-$231,220	$1,965,929
Plastics and rubber product manufacturing	$3,749,117	-$83,596	$3,665,521
Primary metal manufacturing	$1,270,825	$781,611	$2,052,436
Printing and related support activities	$2,900,178	$213,412	$3,113,590
Textile mills; Textile product mills	$108,233	-$23,820	$84,413
Wood product manufacturing	$1,564,820	-$738,303	$826,517

Sources: REMI PI+, RESI

Figure 22: Manufacturing Output Impacts from GGRA Initiatives, 2016

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$271,255	-$37,494	$233,761
Beverage and tobacco product manufacturing	$2,530,208	-$698,599	$1,831,609
Chemical manufacturing	$9,954,553	$2,585,322	$12,539,875
Computer and electronic product manufacturing	$3,816,454	$5,520,227	$9,336,681
Electrical equipment and appliance manufacturing	$5,106,054	-$55,186	$5,050,868
Fabricated metal product manufacturing	$4,078,895	-$504,299	$3,574,596
Food manufacturing	$3,694,064	-$2,976,505	$717,559
Furniture and related product manufacturing	$205,647	$146,930	$352,577
Machinery manufacturing	$1,234,626	-$748,723	$485,903
Miscellaneous manufacturing	$27,626	$366,605	$394,231
Motor vehicles, bodies and trailers, and parts manufacturing	-$233,556	$452,424	$218,868
Nonmetallic mineral product manufacturing	$3,521,037	-$435,120	$3,085,917
Other transportation equipment manufacturing	$100,828	$84,907	$185,735
Paper manufacturing	$1,383,137	-$734,514	$648,623
Petroleum and coal products manufacturing	$1,853,499	-$424,105	$1,429,394
Plastics and rubber product manufacturing	$1,880,853	$876,775	$2,757,628
Primary metal manufacturing	$1,068,608	$447,144	$1,515,752
Printing and related support activities	$1,594,898	$683,873	$2,278,771
Textile mills; Textile product mills	$259,256	-$200,131	$59,125
Wood product manufacturing	$1,133,600	-$929,972	$203,628

Sources: REMI PI+, RESI

Figure 23: Manufacturing Output Impacts from GGRA Initiatives, 2017

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$261,522	-$28,729	$232,793
Beverage and tobacco product manufacturing	$3,127,804	-$1,273,199	$1,854,605
Chemical manufacturing	$10,116,640	$1,525,363	$11,642,003
Computer and electronic product manufacturing	$18,668,643	$22,807,428	$41,476,071
Electrical equipment and appliance manufacturing	$25,481,266	-$607,122	$24,874,144
Fabricated metal product manufacturing	$4,110,311	-$549,557	$3,560,754
Food manufacturing	$2,467,082	-$2,208,642	$258,440
Furniture and related product manufacturing	$183,264	-$194,912	-$11,648
Machinery manufacturing	$7,054,717	-$7,470,977	-$416,260
Miscellaneous manufacturing	$12,324,903	-$12,438,817	-$113,914
Motor vehicles, bodies and trailers, and parts manufacturing	$7,346,827	-$8,691,142	-$1,344,315
Nonmetallic mineral product manufacturing	$3,726,945	-$737,582	$2,989,363
Other transportation equipment manufacturing	-$1,489,072	$1,463,004	-$26,068
Paper manufacturing	$3,217,563	-$2,536,655	$680,908
Petroleum and coal products manufacturing	$2,062,788	-$708,029	$1,354,759
Plastics and rubber product manufacturing	$2,571,846	$68,910	$2,640,756
Primary metal manufacturing	$2,390,261	-$1,128,463	$1,261,798
Printing and related support activities	$2,056,315	$502,472	$2,558,787
Textile mills; Textile product mills	-$71,767	$85,215	$13,448
Wood product manufacturing	$996,381	-$1,064,055	-$67,674

Sources: REMI PI+, RESI

Figure 24: Manufacturing Output Impacts from GGRA Initiatives, 2018

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$252,357	-$32,177	$220,180
Beverage and tobacco product manufacturing	$2,922,896	-$1,284,659	$1,638,237
Chemical manufacturing	$5,734,817	$4,290,684	$10,025,501
Computer and electronic product manufacturing	$17,370,557	$22,369,824	$39,740,381
Electrical equipment and appliance manufacturing	$28,036,356	-$703,219	$27,333,137
Fabricated metal product manufacturing	$1,514,875	$1,343,401	$2,858,276
Food manufacturing	$5,959,473	-$6,153,599	-$194,126
Furniture and related product manufacturing	$5,271,158	-$5,522,391	-$251,233
Machinery manufacturing	-$103,083,527	$102,230,974	-$852,553
Miscellaneous manufacturing	-$186,036,880	$185,575,972	-$460,908
Motor vehicles, bodies and trailers, and parts manufacturing	-$47,911,394	$46,142,299	-$1,769,095
Nonmetallic mineral product manufacturing	$16,466,157	-$13,932,561	$2,533,596
Other transportation equipment manufacturing	-$1,251,104	$1,048,773	-$202,331
Paper manufacturing	-$934,274	$1,541,811	$607,537
Petroleum and coal products manufacturing	$2,061,569	-$1,047,719	$1,013,850
Plastics and rubber product manufacturing	$2,436,338	-$235,389	$2,200,949
Primary metal manufacturing	-$421,842	$1,361,164	$939,322
Printing and related support activities	$1,617,420	$609,151	$2,226,571
Textile mills; Textile product mills	-$56,346	$43,389	-$12,957
Wood product manufacturing	$593,083	-$1,025,069	-$431,986

Sources: REMI PI+, RESI

Figure 25: Manufacturing Output Impacts from GGRA Initiatives, 2019

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$227,381	-$38,499	$188,882
Beverage and tobacco product manufacturing	$1,861,513	-$371,444	$1,490,069
Chemical manufacturing	$8,628,825	-$545,061	$8,083,764
Computer and electronic product manufacturing	$4,271,675	$6,064,376	$10,336,051
Electrical equipment and appliance manufacturing	$8,697,316	-$245,073	$8,452,243
Fabricated metal product manufacturing	$346,863	$1,838,945	$2,185,808
Food manufacturing	$9,154,797	-$9,893,362	-$738,565
Furniture and related product manufacturing	$1,452,869	-$1,496,097	-$43,228
Machinery manufacturing	$2,210,542	-$2,359,087	-$148,545
Miscellaneous manufacturing	$1,872,284	-$1,944,182	-$71,898
Motor vehicles, bodies and trailers, and parts manufacturing	$2,755,307	-$3,275,326	-$520,019
Nonmetallic mineral product manufacturing	$1,497,307	$536,369	$2,033,676
Other transportation equipment manufacturing	$329,684	-$462,086	-$132,402
Paper manufacturing	-$311,302	$770,491	$459,189
Petroleum and coal products manufacturing	$3,137,543	-$2,559,628	$577,915
Plastics and rubber product manufacturing	$2,781,636	-$1,075,439	$1,706,197
Primary metal manufacturing	-$293,527	$998,181	$704,654
Printing and related support activities	$1,315,287	$177,773	$1,493,060
Textile mills; Textile product mills	$61,414	-$48,362	$13,052
Wood product manufacturing	$503,621	-$1,282,048	-$778,427

Sources: REMI PI+, RESI

Figure 26: Manufacturing Output Impacts from GGRA Initiatives, 2020

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$213,645	-$38,618	$175,027
Beverage and tobacco product manufacturing	$1,931,614	-$423,644	$1,507,970
Chemical manufacturing	$6,739,902	$1,829,887	$8,569,789
Computer and electronic product manufacturing	$1,836,413	$2,108,593	$3,945,006
Electrical equipment and appliance manufacturing	$4,378,054	-$128,919	$4,249,135
Fabricated metal product manufacturing	$2,347,909	-$8,334	$2,339,575
Food manufacturing	$34,898,986	-$35,919,825	-$1,020,839
Furniture and related product manufacturing	-$1,245,385	$1,238,741	-$6,644
Machinery manufacturing	$1,222,865	-$1,213,066	$9,799
Miscellaneous manufacturing	$1,214,402	-$1,124,451	$89,951
Motor vehicles, bodies and trailers, and parts manufacturing	$1,463,898	-$1,647,134	-$183,236
Nonmetallic mineral product manufacturing	$1,766,294	$410,368	$2,176,662
Other transportation equipment manufacturing	$1,775,479	-$1,865,199	-$89,720
Paper manufacturing	$520,176	$7,570	$527,746
Petroleum and coal products manufacturing	$2,934,225	-$2,128,244	$805,981
Plastics and rubber product manufacturing	$3,420,268	-$1,553,721	$1,866,547
Primary metal manufacturing	-$53,062	$663,211	$610,149
Printing and related support activities	$1,597,468	$178,777	$1,776,245
Textile mills; Textile product mills	$93,151	-$75,113	$18,038
Wood product manufacturing	$1,238,096	-$2,137,476	-$899,380

Sources: REMI PI+, RESI

Appendix C—Annual Wage Impacts for the Manufacturing Industry

The following tables highlight the wage impacts associated with the GGRA to the Manufacturing industry in Maryland between 2010 and 2020.

Figure 27: Manufacturing Wage Impacts from GGRA Initiatives, 2010

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$31,752	-$795	$30,957
Beverage and tobacco product manufacturing	$83,802	-$2,003	$81,799
Chemical manufacturing	$814,488	$46,336	$860,823
Computer and electronic product manufacturing	$1,049,388	$26,216	$1,075,605
Electrical equipment and appliance manufacturing	$259,106	-$191	$258,915
Fabricated metal product manufacturing	$480,081	-$13,961	$466,120
Food manufacturing	$238,633	-$32,827	$205,806
Furniture and related product manufacturing	$89,403	-$19,512	$69,891
Machinery manufacturing	$30,828	$95,365	$126,193
Miscellaneous manufacturing	$87,557	$7,880	$95,437
Motor vehicles, bodies and trailers, and parts manufacturing	$349,847	-$282,522	$67,325
Nonmetallic mineral product manufacturing	$288,208	-$8,711	$279,497
Other transportation equipment manufacturing	$153,438	-$40,440	$112,998
Paper manufacturing	$104,224	-$5,350	$98,874
Petroleum and coal products manufacturing	$41,244	-$1,708	$39,536
Plastics and rubber product manufacturing	$238,722	-$3,532	$235,190
Primary metal manufacturing	$52,826	$5,895	$58,721
Printing and related support activities	$458,069	-$4,255	$453,814
Textile mills; Textile product mills	$17,083	-$4,494	$12,589
Wood product manufacturing	$80,160	$11,322	$91,483

Sources: REMI PI+, RESI

Figure 28: Manufacturing Wage Impacts from GGRA Initiatives, 2011

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$64,359	-$2,295	$62,064
Beverage and tobacco product manufacturing	$199,135	-$17,359	$181,776
Chemical manufacturing	$1,603,562	$18,648	$1,622,210
Computer and electronic product manufacturing	$641,910	$6,137,928	$6,779,839
Electrical equipment and appliance manufacturing	$2,935,886	-$64,804	$2,871,082
Fabricated metal product manufacturing	$1,021,080	-$21,033	$1,000,047
Food manufacturing	$839,280	-$379,045	$460,236
Furniture and related product manufacturing	$140,174	-$3,684	$136,490
Machinery manufacturing	$231,776	$73,895	$305,670
Miscellaneous manufacturing	$174,238	$18,682	$192,919
Motor vehicles, bodies and trailers, and parts manufacturing	$129,324	$360	$129,683
Nonmetallic mineral product manufacturing	$602,113	-$21,510	$580,603
Other transportation equipment manufacturing	-$45,140	$304,882	$259,742
Paper manufacturing	$187,954	-$13,206	$174,748
Petroleum and coal products manufacturing	$83,397	-$1,965	$81,432
Plastics and rubber product manufacturing	$507,421	-$14,708	$492,713
Primary metal manufacturing	$195,630	-$63,163	$132,467
Printing and related support activities	$761,471	-$19,592	$741,879
Textile mills; Textile product mills	$99,382	-$69,535	$29,848
Wood product manufacturing	$172,940	$13,094	$186,035

Sources: REMI PI+, RESI

Figure 29: Manufacturing Wage Impacts from GGRA Initiatives, 2012

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$92,201	-$4,413	$87,787
Beverage and tobacco product manufacturing	$311,118	-$45,527	$265,591
Chemical manufacturing	$2,109,066	-$60,226	$2,048,840
Computer and electronic product manufacturing	$1,722,385	$2,302,458	$4,024,843
Electrical equipment and appliance manufacturing	$1,203,645	-$15,924	$1,187,720
Fabricated metal product manufacturing	$1,520,733	-$42,919	$1,477,814
Food manufacturing	$1,764,470	-$1,098,482	$665,988
Furniture and related product manufacturing	$220,929	-$21,802	$199,127
Machinery manufacturing	$449,929	-$43,545	$406,383
Miscellaneous manufacturing	$358,362	-$103,245	$255,117
Motor vehicles, bodies and trailers, and parts manufacturing	$175,464	-$6,091	$169,373
Nonmetallic mineral product manufacturing	$976,182	-$36,222	$939,960
Other transportation equipment manufacturing	$422,206	-$40,990	$381,216
Paper manufacturing	$257,729	-$26,235	$231,494
Petroleum and coal products manufacturing	$92,157	-$1,430	$90,727
Plastics and rubber product manufacturing	$765,000	-$37,196	$727,805
Primary metal manufacturing	$293,844	-$96,805	$197,039
Printing and related support activities	$970,864	-$38,938	$931,926
Textile mills; Textile product mills	$88,722	-$43,439	$45,283
Wood product manufacturing	$290,657	$11,004	$301,661

Sources: REMI PI+, RESI

Figure 30: Manufacturing Wage Impacts from GGRA Initiatives, 2013

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$106,737	-$6,850	$99,887
Beverage and tobacco product manufacturing	$387,835	-$73,467	$314,368
Chemical manufacturing	$2,448,878	-$387,237	$2,061,641
Computer and electronic product manufacturing	$2,857,241	$4,366,951	$7,224,192
Electrical equipment and appliance manufacturing	$2,749,000	-$66,157	$2,682,843
Fabricated metal product manufacturing	$1,608,243	-$49,273	$1,558,970
Food manufacturing	-$383,121	$1,091,305	$708,184
Furniture and related product manufacturing	$383,856	-$179,546	$204,310
Machinery manufacturing	$527,382	-$73,750	$453,632
Miscellaneous manufacturing	$1,490,033	-$1,200,321	$289,712
Motor vehicles, bodies and trailers, and parts manufacturing	$188,051	-$16,418	$171,633
Nonmetallic mineral product manufacturing	$1,029,939	-$48,020	$981,919
Other transportation equipment manufacturing	-$302,310	$734,632	$432,322
Paper manufacturing	$316,737	-$47,027	$269,710
Petroleum and coal products manufacturing	$100,578	-$3,826	$96,752
Plastics and rubber product manufacturing	$825,178	-$48,105	$777,073
Primary metal manufacturing	$112,662	$125,801	$238,463
Printing and related support activities	$1,100,932	-$54,790	$1,046,142
Textile mills; Textile product mills	$175,818	-$125,176	$50,642
Wood product manufacturing	$297,513	-$26,262	$271,251

Sources: REMI PI+, RESI

Figure 31: Manufacturing Wage Impacts from GGRA Initiatives, 2014

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$106,349	-$9,232	$97,118
Beverage and tobacco product manufacturing	$505,962	-$209,843	$296,119
Chemical manufacturing	$3,418,328	-$1,397,168	$2,021,161
Computer and electronic product manufacturing	$1,019,198	$4,274,849	$5,294,047
Electrical equipment and appliance manufacturing	$1,587,013	-$4,494	$1,582,520
Fabricated metal product manufacturing	$1,342,349	-$56,843	$1,285,506
Food manufacturing	$1,718,509	-$1,225,305	$493,204
Furniture and related product manufacturing	$302,418	-$106,144	$196,274
Machinery manufacturing	$594,195	-$193,904	$400,291
Miscellaneous manufacturing	$19,434	$211,600	$231,034
Motor vehicles, bodies and trailers, and parts manufacturing	$173,974	-$18,667	$155,307
Nonmetallic mineral product manufacturing	$1,068,040	-$55,146	$1,012,893
Other transportation equipment manufacturing	-$33,623	$451,464	$417,841
Paper manufacturing	$290,903	-$62,464	$228,439
Petroleum and coal products manufacturing	$85,647	-$4,268	$81,379
Plastics and rubber product manufacturing	$803,884	-$78,018	$725,866
Primary metal manufacturing	$364,144	-$130,554	$233,589
Printing and related support activities	$1,118,724	-$92,237	$1,026,486
Textile mills; Textile product mills	-$170,856	$218,552	$47,696
Wood product manufacturing	$305,658	-$61,100	$244,558

Sources: REMI PI+, RESI

Figure 32: Manufacturing Wage Impacts from GGRA Initiatives, 2015

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$124,804	-$11,574	$113,230
Beverage and tobacco product manufacturing	$30,042	$305,639	$335,680
Chemical manufacturing	$332,876	$2,113,835	$2,446,711
Computer and electronic product manufacturing	$7,477,982	$2,738,498	$10,216,481
Electrical equipment and appliance manufacturing	$3,526,396	-$87,249	$3,439,147
Fabricated metal product manufacturing	$1,614,689	-$80,532	$1,534,156
Food manufacturing	-$3,118,075	$3,624,845	$506,770
Furniture and related product manufacturing	$457,740	-$238,171	$219,570
Machinery manufacturing	$1,449,639	-$1,042,140	$407,499
Miscellaneous manufacturing	$229,597	$37,771	$267,368
Motor vehicles, bodies and trailers, and parts manufacturing	$212,601	-$40,342	$172,259
Nonmetallic mineral product manufacturing	$1,266,581	-$79,868	$1,186,713
Other transportation equipment manufacturing	-$101,389	$588,141	$486,752
Paper manufacturing	$370,471	-$97,694	$272,777
Petroleum and coal products manufacturing	$115,520	-$9,440	$106,080
Plastics and rubber product manufacturing	$990,006	-$146,413	$843,593
Primary metal manufacturing	$208,227	$57,343	$265,570
Printing and related support activities	$1,273,313	-$86,342	$1,186,971
Textile mills; Textile product mills	-$54,213	$105,942	$51,729
Wood product manufacturing	$294,595	-$92,612	$201,982

Sources: REMI PI+, RESI

Figure 33: Manufacturing Wage Impacts from GGRA Initiatives, 2016

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$124,331	-$20,503	$103,828
Beverage and tobacco product manufacturing	$317,091	-$8,093	$308,998
Chemical manufacturing	$1,192,499	$306,794	$1,499,293
Computer and electronic product manufacturing	$2,385,912	$4,483,764	$6,869,676
Electrical equipment and appliance manufacturing	$1,978,879	-$15,403	$1,963,476
Fabricated metal product manufacturing	$1,396,050	-$162,590	$1,233,459
Food manufacturing	-$1,038,027	$1,384,149	$346,122
Furniture and related product manufacturing	-$972,187	$1,122,941	$150,754
Machinery manufacturing	$355,852	-$36,040	$319,812
Miscellaneous manufacturing	-$1,081,302	$1,286,830	$205,528
Motor vehicles, bodies and trailers, and parts manufacturing	$63,431	$51,299	$114,730
Nonmetallic mineral product manufacturing	$919,502	-$116,847	$802,655
Other transportation equipment manufacturing	$72,820	$314,831	$387,651
Paper manufacturing	$364,107	-$169,172	$194,935
Petroleum and coal products manufacturing	$91,412	-$18,107	$73,306
Plastics and rubber product manufacturing	$580,696	$175,869	$756,565
Primary metal manufacturing	$58,837	$136,284	$195,121
Printing and related support activities	$757,136	$229,042	$986,178
Textile mills; Textile product mills	-$864	$43,809	$42,945
Wood product manufacturing	$289,822	-$132,844	$156,978

Sources: REMI PI+, RESI

Figure 34: Manufacturing Wage Impacts from GGRA Initiatives, 2017

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$131,969	-$30,523	$101,445
Beverage and tobacco product manufacturing	$376,986	-$71,920	$305,067
Chemical manufacturing	-$1,343,875	$2,772,524	$1,428,649
Computer and electronic product manufacturing	$15,191,860	$19,468,494	$34,660,353
Electrical equipment and appliance manufacturing	$10,234,696	-$262,523	$9,972,173
Fabricated metal product manufacturing	$1,408,095	-$135,992	$1,272,103
Food manufacturing	-$225,199	$394,257	$169,058
Furniture and related product manufacturing	$214,010	-$123,043	$90,967
Machinery manufacturing	$1,759,791	-$1,694,346	$65,445
Miscellaneous manufacturing	$1,809,360	-$1,702,714	$106,646
Motor vehicles, bodies and trailers, and parts manufacturing	$374,788	-$342,461	$32,328
Nonmetallic mineral product manufacturing	$961,687	-$170,015	$791,672
Other transportation equipment manufacturing	-$87,697	$354,217	$266,519
Paper manufacturing	$563,713	-$361,925	$201,788
Petroleum and coal products manufacturing	$96,682	-$28,808	$67,874
Plastics and rubber product manufacturing	$877,685	-$149,252	$728,433
Primary metal manufacturing	$274,622	-$100,232	$174,390
Printing and related support activities	$943,180	$149,102	$1,092,282
Textile mills; Textile product mills	-$10,725	$40,876	$30,152
Wood product manufacturing	$218,977	-$166,301	$52,675

Sources: REMI PI+, RESI

Figure 35: Manufacturing Wage Impacts from GGRA Initiatives, 2018

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$83,577	$284	$83,861
Beverage and tobacco product manufacturing	$459,797	-$203,421	$256,375
Chemical manufacturing	-$14,341	$1,214,995	$1,200,654
Computer and electronic product manufacturing	$15,625,723	$21,405,361	$37,031,084
Electrical equipment and appliance manufacturing	$11,619,208	-$280,979	$11,338,229
Fabricated metal product manufacturing	$157,290	$912,446	$1,069,736
Food manufacturing	$568,696	-$557,249	$11,447
Furniture and related product manufacturing	$2,832,442	-$2,808,608	$23,834
Machinery manufacturing	-$24,052,933	$23,970,090	-$82,843
Miscellaneous manufacturing	-$26,803,351	$26,815,836	$12,485
Motor vehicles, bodies and trailers, and parts manufacturing	-$1,836,745	$1,844,798	$8,053
Nonmetallic mineral product manufacturing	$1,594,329	-$922,408	$671,921
Other transportation equipment manufacturing	-$232,763	$416,471	$183,708
Paper manufacturing	$58,451	$116,360	$174,811
Petroleum and coal products manufacturing	$98,266	-$44,091	$54,175
Plastics and rubber product manufacturing	$580,499	$40,301	$620,800
Primary metal manufacturing	$11,762	$131,162	$142,924
Printing and related support activities	$395,754	$584,606	$980,360
Textile mills; Textile product mills	-$5,992	$24,579	$18,587
Wood product manufacturing	$157,413	-$142,374	$15,039

Sources: REMI PI+, RESI

Figure 36: Manufacturing Wage Impacts from GGRA Initiatives, 2019

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$75,067	-$8,216	$66,850
Beverage and tobacco product manufacturing	$87,359	$110,338	$197,697
Chemical manufacturing	$9,378,203	-$8,610,795	$767,409
Computer and electronic product manufacturing	$4,089,844	$7,439,774	$11,529,618
Electrical equipment and appliance manufacturing	$3,657,725	-$115,540	$3,542,185
Fabricated metal product manufacturing	$807,662	$262,704	$1,070,366
Food manufacturing	-$167,261	-$45,717	-$212,978
Furniture and related product manufacturing	-$43,186	$72,353	$29,167
Machinery manufacturing	$483,898	-$416,258	$67,640
Miscellaneous manufacturing	$356,165	-$300,913	$55,252
Motor vehicles, bodies and trailers, and parts manufacturing	$142,040	-$92,235	$49,805
Nonmetallic mineral product manufacturing	$594,689	$116,894	$711,583
Other transportation equipment manufacturing	$151,113	-$6,566	$144,547
Paper manufacturing	-$75,143	$190,334	$115,192
Petroleum and coal products manufacturing	$178,536	-$145,228	$33,308
Plastics and rubber product manufacturing	$1,208,731	-$817,855	$390,876
Primary metal manufacturing	-$66,626	$135,495	$68,869
Printing and related support activities	$474,823	$137,616	$612,439
Textile mills; Textile product mills	$10,272	$2,947	$13,219
Wood product manufacturing	$170,706	-$202,718	-$32,012

Sources: REMI PI+, RESI

Figure 37: Manufacturing Wage Impacts from GGRA Initiatives, 2020

Manufacturing Sector	Direct	Indirect/Induced	Total
Apparel manufacturing; Leather and allied product manufacturing	$67,541	-$7,935	$59,606
Beverage and tobacco product manufacturing	$130,895	$25,425	$156,321
Chemical manufacturing	$443,825	$139,011	$582,837
Computer and electronic product manufacturing	$1,685,521	$3,862,656	$5,548,178
Electrical equipment and appliance manufacturing	$1,825,196	-$59,269	$1,765,927
Fabricated metal product manufacturing	$1,057,189	-$59,759	$997,431
Food manufacturing	$663,109	-$1,018,840	-$355,731
Furniture and related product manufacturing	-$262,103	$284,368	$22,265
Machinery manufacturing	$268,869	-$178,872	$89,997
Miscellaneous manufacturing	-$188,135	$220,202	$32,067
Motor vehicles, bodies and trailers, and parts manufacturing	$83,647	-$44,139	$39,508
Nonmetallic mineral product manufacturing	$604,918	$72,718	$677,636
Other transportation equipment manufacturing	$277,546	-$166,669	$110,877
Paper manufacturing	$508,840	-$420,837	$88,003
Petroleum and coal products manufacturing	$101,596	-$79,035	$22,561
Plastics and rubber product manufacturing	-$228,819	$536,758	$307,939
Primary metal manufacturing	-$41,682	$74,578	$32,896
Printing and related support activities	$284,661	$212,314	$496,975
Textile mills; Textile product mills	-$116,148	$124,413	$8,266
Wood product manufacturing	$277,286	-$352,867	-$75,581

Sources: REMI PI+, RESI

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Appendix I

Just Transition

2030 GGRA Plan

Chapter 2: Just Transition

Commissioned by
Maryland Department of the Environment

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2.0 Executive Summary

As Maryland considers transitioning its energy mix away from fossil fuels and towards less carbon-intensive fuel sources, it is important to consider the impact of this transition on workers in fossil-fuel reliant industries. Some workers involved in aspects of the fossil fuel supply chain may lose their job and find it difficult to switch industries or occupations. The Maryland Department of the Environment (MDE) tasked the Regional Economic Studies Institute of Towson University (RESI) with evaluating economic dislocations resulting from potential carbon mitigation strategies. These economic dislocations included direct impacts to fossil-fuel-reliant workers, fiscal impacts resulting from industry changes at the local level, and other related disparities associated with the State's efforts to reduce GHG emissions. Additionally, to meet objectives set in the State's 40 by 30 Plan, MDE requested strategies for transitioning impacted fossil-fuel-reliant workers and mitigating other economic dislocations resulting associated with greenhouse gas reduction efforts. To meet the project objectives, RESI utilized a five-fold methodology:

- Identified major fossil-fuel-reliant industries within the state, focusing on industries related to the fossil-fuel supply chain;
- Estimated fiscal impacts to state and local governments resulting from a single firm closure within each major industry of focus;
- Determined key threatened occupations within the industries of focus;
- Analyzed related job opportunities for displaced employees; and
- Researched typical employment requirements and training opportunities within the state.

Major findings for each aspect are summarized below.

The fossil-fuel-reliant industries of focus identified through the analysis are illustrated in Figure 1 below. Data reflect 2017 annual averages.

Figure 1: Industries of Focus

NAICS	Industry	Maryland Employment	Total Wages
221112	Fossil Fuel Electric Power Generation	2,298	$388,125,553
4471	Gasoline Stations	11,476	$261,048,950
3241	Petroleum and Coal Products Manufacturing	848	$70,113,044
2212	Natural Gas Distribution	587	$50,083,767
3312	Steel Product Manufacturing from Purchased Steel	169	$10,645,755
2121	Coal Mining	80	$5,145,469

Sources: RESI, U.S. Bureau of Labor Statistics

As shown above, total Maryland employment in the industries of focus ranged from 80 to 11,476 workers. In sum, these six industries employ over 15,000 Maryland residents who earn just over $397 million in wages each year. However, as a proportion of total employment in the state, these six industries are relatively small, constituting 0.7 percent of the state's workforce.

Figure 2 below shows a summary of annual fiscal revenue losses estimated if a single Maryland firm in each industry of focus were to close. Inputs were based on the most recently available 2017 data, while impacts are shown in 2019 dollars.

Figure 2: Summary of Fiscal Impacts per Average Industry Firm

Industry	State Taxes	Local Taxes	Total
Fossil Fuel Electric Power Generation	$7,203,040	$6,288,787	$13,491,826
Gasoline Stations	$57,020	$47,939	$104,959
Petroleum and Coal Products Manufacturing	$147,973	$116,210	$264,181
Natural Gas Distribution	$1,036,774	$906,343	$1,943,118
Steel Product Manufacturing from Purchased Steel	$314,372	$249,786	$564,160
Coal Mining	$1,123,723	$988,172	$2,111,896

Sources: IMPLAN, RESI, U.S. Bureau of Labor Statistics, U.S. Census

Estimated total annual fiscal losses to state and local governments had a considerable range, with a low of $104,959/year per Gasoline Station to $13,491,826/year per Fossil Fuel Electric Power Generation firm.

Figure 3 below shows five key threatened occupations identified within the six industries of focus. Threatened occupations are those with the most workers in fossil-fuel-reliant industries. Employment figures include both total Maryland employment and the proportion of workers in these occupations who work in fossil-fuel-reliant industries. For example, of the 79,000 cashiers employed across Maryland, an estimated 10 percent work in fossil fuel reliant industries.

Figure 3: Key Threatened Occupations in Maryland

Occupation	SOC Code	Total Maryland Employment	Employment in Fossil-Fuel-Reliant Industries
Cashiers	41-2011	79,000	7,545
Machinists	51-4041	2,820	626
First-Line Supervisors of Production and Operating Workers	51-1011	6,780	257
Petroleum Pump System Operators, Refinery Operators, and Gaugers	51-8093	140	140
Inspectors, Testers, Sorters, Samplers, and Weighers	51-9061	4,060	168

Sources: RESI, U.S. Bureau of Labor Statistics

As detailed above, the occupation with greatest number of workers in fossil-fuel-reliant industries are cashiers, with 7,545 workers. The greatest proportion of potentially affected employees were in the petroleum pump system operators, refinery operators, and gaugers occupation with all employees working in fossil-fuel-reliant industries.

For each threatened occupation, related occupations were identified based on skill transfers, existing patterns of employment changes, growth projections, and salary expectations. The related occupations identified are listed in Figure 4 below.

Figure 4: Related Occupations

Related Occupation	Associated Threatened Occupation
Nursing Assistants	Cashiers
Receptionists and Information Clerks	Cashiers
Computer Numerically Controlled Machine Tool Programmers of Metal and Plastic	Machinists
Heavy and Tractor-trailer Truck Drivers	Machinists; Petroleum Pump System Operators, Refinery Operators, and Gaugers
First-line Supervisors of Construction Trades and Extraction Workers	First-Line Supervisors of Production and Operating Workers
First-line Supervisors of Mechanics, Installers, and Repairers	First-Line Supervisors of Production and Operating Workers
Engineering Technicians, Except Drafters	First-Line Supervisors of Production and Operating Workers and Machinists; Petroleum Pump System Operators, Refinery Operators, and Gaugers
Operating Engineers and Other Construction Equipment	Petroleum Pump System Operators, Refinery Operators, and Gaugers
Life, Physical, and Social Science Technicians, All Other	Inspectors, Testers, Sorters, Samplers, and Weighers
Stationary Engineers and Boiler Operators	Inspectors, Testers, Sorters, Samplers, and Weighers; Petroleum Pump System Operators, Refinery Operators, and Gaugers

Sources: Maryland Workforce Exchange, O*Net, RESI, U.S. Bureau of Labor Statistics

For each related occupation above, typical requirements for entry into the profession were researched including educational attainment and on-the-job training needed. Additionally, a survey of available training opportunities within the state was conducted.

For example, cashiers, the occupation with the most jobs within a fossil-fuel-reliant industry, could be transitioned to become nursing assistants or receptionists and information clerks. Both alternative occupations have strong projected growth and higher median wages than cashiers. Becoming a nursing assistant typically requires a postsecondary nondegree award, and there are over 100 certified CNA (certified nursing assistant) training programs offered in colleges, nursing homes, and freestanding institutions in the state.

Certification and degree opportunities exist at Maryland's colleges and universities for most of the occupations examined in greater detail in this report. Additionally, apprenticeship and less formal training programs exist to help prepare workers for new careers in the absence of formal programs. Partnering with local institutions and private employers can help to ensure workers in fossil-fuel-reliant occupations statewide find high-quality, high-paying jobs to help support their families and their communities.

While the industries and occupations evaluated do not represent an exhaustive list of all those that may be affected by the State's 40 by 30 Plan, they provide a solid framework for evaluating potential economic and regional dislocations that may be incurred. Given the flexibility of job training and certification programs, scaling initiatives to respond to economic conditions is viable. Understanding the impacts and challenges related to greenhouse gas reduction policies enables the State to be better equipped when addressing these changes and taking steps to ensure an equitable and fair outcome for those affected.

2.1 Introduction

As Maryland considers transitioning its energy mix away from fossil fuels and towards less carbon-intensive fuel sources, it is important to consider the impact of this transition on workers in fossil-fuel reliant industries. Some workers involved in aspects of the fossil fuel supply chain may lose their job and find it difficult to switch industries or occupations. The Maryland Department of the Environment (MDE) tasked the Regional Economic Studies Institute of Towson University (RESI) with evaluating economic dislocations resulting from potential carbon mitigation strategies. These economic dislocations included direct impacts to fossil-fuel-reliant workers, fiscal impacts resulting from industry changes at the local level, and other related disparities associated with the State's efforts to reduce GHG emissions. Additionally, to meet objectives set in the State's 40 by 30 Plan, MDE requested strategies for transitioning impacted fossil-fuel-reliant workers and mitigating other economic dislocations resulting associated with greenhouse gas reduction efforts. To meet the project objectives, RESI utilized a five-fold methodology:

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- Analyzed related job opportunities for displaced employees; and
- Researched typical employment requirements and training opportunities within the state.

This report will continue as follows. Section 2.2 provides a brief overview of Just Transition models and best practices observed in other regions. Section 2.3 outlines the methodology used to determine the industries of focus, threatened occupations, related occupations, estimated fiscal impacts, and available training opportunities in the state. Section 2.4 provides an overview of each industry of focus and a summary of the estimated fiscal losses that would be incurred by state and local governments resulting from a single firm closure in each industry. Section 2.5 highlights the threatened occupations identified within the industries of focus. This section also provides information on more stable positions related to the threatened occupations into which workers could transfer, typical employment requirements, and available job training opportunities in the state. Additionally, this section presents anecdotal evidence of alternative employment strategies that have been pursued to transition workers from fossil-fuel-reliant industries (primary coal mining) into alternative occupations. Section 2.6 concludes the report.

2.2 Just Transition Overview and Best Practices

The following section will provide an overview of the Just Transition framework, including how the model has been implemented in several countries as they move away from reliance on fossil-fuel-reliant power generation. Additionally, this section will outline several best practice strategies that have emerged from evaluations of transition efforts in other areas.

2.2.1 Overview of Just Transition

Just Transition is a developmental model that is intended to guide the phasing out of high-pollutant industries, while simultaneously introducing and utilizing new and alternative sources (i.e., green/clean/renewable) of energy production.[1] Just Transition approaches are also expected to provide job opportunities and job security to those workers affected by new environmental strategies and policies. In the United States, a transition to alternative energy sources has the potential to significantly impact traditional energy sector workers. The Just Transition framework stresses that that policies should be implemented in advance of major transitions to cushion the impacts and support these workers by providing them with new skills and job opportunities.[2]

The term Just Transition was first used in the late 1990s when North American unions began developing a program to support workers that had lost their jobs due to environmental protection policies.[3] Over time, the meaning of the term has broadened and is used to describe a "deliberate effort to plan for and invest in a transition to environmentally and socially sustainable jobs, sectors and economies."[4] Later, the phrase Just Transition was used again, this time by the International Trade Union Confederation (ITUC) during the 2015 Paris Climate Agreement Conference.[5]

After the Paris Agreement, the UN's International Labor Organization (ILO) produced a definitive definition and implementation plan for Just Transition. According to the ILO, Just Transition is a "bridge from where we are today to a future where all jobs are green and decent, poverty is eradicated, and communities are thriving and resilient."[6] Their approach to Just Transition includes "measures to reduce the impact of job losses and industry phase-out on workers and communities, and measure to produce new, green and decent jobs, sectors and healthy communities."[7]

The Just Transition model will be a crucial component in supporting both existing and developing industries as a new, cleaner energy future is realized. However, these adjustments in energy production will inevitably have an impact on existing industries. In 2017 there were 1.1 million U.S. workers directly employed in the traditional (i.e. coal, oil, gas) Electric Power

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[1] Samantha Smith, "Just Transition: A Report for the OECD," Just Transition Centre (May 2017): 1, accessed October 25, 2018, https://www.oecd.org/environment/cc/g20-climate/collapsecontents/Just-Transition-Centre-report-just-transition.pdf.
[2] Robert Pollin and Brian Callaci, "A Just Transition for U.S. Fossil Fuel Industry Workers," *American Prospect*, July 6, 2016, accessed October 25, 2018, http://prospect.org/article/just-transition-us-fossil-fuel-industry-workers.
[3] Smith, "Just Transition: A Report for the OECD,"2.
[4] Ibid.
[5] Sean Sweeney and John Treat, "Trade Unions and Just Transition," Trade Unions for Energy Democracy (April 2018): 1, accessed October 25, 2018, http://www.rosalux-nyc.org/wp-content/files_mf/tuedworkingpaper11_web.pdf.
[6] Smith, "Just Transition: A Report for the OECD,"3.
[7] Ibid.

Generation and Fuels technologies.[8] The cost for the Just Transition framework in the U.S. has been estimated to be around $500 million per year—only about 1 percent of the total annual investment needed to support climate stabilization policies.[9] The costs includes income subsidies, retraining, and relocation support for fossil-fuel impacted workers and should coincide with the growth of the clean energy industry.[10] Two major components of the Just Transition framework will be the guarantee of clean energy-related jobs for younger workers in affected industries and an expansion of employment opportunities through clean energy investments for individuals and communities that will face the brunt of the transition.[11]

2.2.2 Just Transition Best Practices

As countries around the world have begun to transition away from reliance on fossil fuels, examples of Just Transition models have emerged. These transitions vary in size and scope, depending upon the degree to which fossil fuels are integrated into the economy and the size of the industry. In a review of multiple case studies from economies transitioning away from coal, the IDDRI, an independent policy institute, noted several best practices when undertaking Just Transition initiatives.[12] These insights included aspects involving employee transitions, building successful policies to support Just Transition, and regional strategies for areas that are heavily fossil-fuel reliant. The following subsection highlights several best practice suggestions for each of these factors.

Employees of fossil-fuel-reliant industries are a central focus of Just Transition efforts. A fair transition into new employment opportunities for individuals and their families is crucial to a successful Just Transition effort. The IDDRI notes several aspects that should be considered when formulating a transition effort, including:

- Receiving input from workers early in planning stages,[13]
- Responding to questions from workers,
- Providing a timeline for the phase-out of activities, and
- Creating worker training programs that facilitate the transfer of employees to new jobs.[14]

The actions listed above help to ensure that employees are heard during the planning and transition, and also provide a framework for expectations around the process. Questions that

[8] National Association of State Energy Officials and Energy Futures Initiative, “2018 U.S. Energy and Employment Report,” 13, accessed February 8, 2019, https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5afb0ce4575d1f3cdf9ebe36/1526402279839/2018+U.S.+Energy+and+Employment+Report.pdf.
[9] Pollin and Callaci, “A Just Transition for U.S. Fossil Industry Workers.”
[10] Ibid.
[11] Ibid.
[12] “IDDRI, A Think Tank to Facilitate the Transition Towards Sustainable Development,” IDDRI, accessed January 12, 2019, https://www.iddri.org/en/about-iddri.
[13] O. Sartor, “Insights from Case Studies of Major Coal-Consuming Economies,” IDDRI and Climate Strategies (2018): 27, accessed January 4, 2019, https://coaltransitions.files.wordpress.com/2018/09/coal_synthesis_final.pdf.
[14] Ibid., 27-29.

should be addressed from workers include how they will be ensured a transition to a new career or retirement, how their compensation will be impacted during this transition period, and how the efforts will be funded.[15] Additionally, it is important to gain input through social dialogue from community members who are also impacted by the transition process.[16,17] The provision of a timeline surrounding activities allows workers to determine whether they will likely be transferring to a new career, or whether they are close enough to retirement that they would be exiting the workforce.[18] For those who will be seeking new employment, job retraining programs should match the existing skills of workers with local employment alternatives.[19] Additionally, job training programs with a focus on direct job placement have been found to be more effective than more general retraining initiatives.[20]

Policies surrounding Just Transition plans should also be designed to consider the needs of a successful program. These factors include:

- Providing a transition oversight body,
- Funding of the transition, and
- Facilitating the creating of a job retraining program.[21]

To ensure that the Just Transition framework is implemented more smoothly, a dedicated oversight body should be created that contains stakeholders in the process.[22] This group would be involved in outlining the timeline associated with the transition, creating plans for the implementation and monitoring of the transition, and providing policy suggestions to support a successful transition.[23] Plans to adequately finance the Just Transition effort should also be considered when developing supporting policies.[24,25,26] These may include the creation of a dedicated fund to provide workforce retraining or transition out of the labor force, or potentially involving companies directly involved in the funding of a labor transition.[27] The structure of the job retraining program should be considered in conjunction with how the program would be funded.[28] As previously mentioned, ideally, the program will focus on direct worker placement into alternative industries rather than providing a more generic or general

[15] Sartor, "Insights from Case Studies of Major Coal-Consuming Economies," 27.
[16] Smith, "Just Transition A Report for the OECD," 7.
[17] United Nations, "Just Transition of the Workforce, and the Creation of Decent Work and Quality Jobs," 50, accessed January 11, 2019, https://unfccc.int/sites/default/files/resource/Just%20transition.pdf.
[18] Sartor, "Insights from Case Studies of Major Coal-Consuming Economies," 28.
[19] Ibid., 29.
[20] Ibid.
[21] Ibid., 29-30.
[22] Ibid., 29.
[23] Ibid.
[24] Ibid., 30.
[25] United Nations, "Just Transition of the Workforce, and the Creation of Decent Work and Quality Jobs," 55.
[26] Smith, "Just Transition A Report for the OECD," 17-18.
[27] Sartor, "Insights from Case Studies of Major Coal-Consuming Economies," 30.
[28] Ibid.

skill training program.[29] This may involve providing subsidies for on-the-job (OTJ) training once an appropriate employment opportunity is found for affected workers.[30]

The economies of areas in which Just Transition strategies are implemented can vary significantly. For this reason, the unique attributes of the regional economy should be considered when designing a plan for transitioning away from fossil-fuel reliance. According to findings from the IDDRI, these regional strategies should include:

- Expanding regional industries that are not fossil-fuel reliant,
- Leveraging the area's advantages when diversifying industries,
- Supporting local entrepreneurial networks, and
- Strengthening regional expansion of alternative clean energy.[31]

Economic planning for Just Transition efforts should evaluate the area's existing related activities which are not directly reliant upon fossil-fuel industries, known as "related diversification."[32] Similarly, these diversification efforts should consider the region's unique strengths and leverage these attributes when determining which industries to expand upon.[33] This concept of "smart [specialization]" could include aspects of infrastructure, skills of the existing workforce, local growth industries, property availability, or other comparative advantages within the affected region.[34] If the strengths of an area affected by the transition away from fossil fuels are not clear, partnerships with regional higher educational institutions can be used to help identify these attributes.[35] Entrepreneurial networks can also be a useful tool to start or expand industries with growth potential, and can be facilitated and supported through higher education institutions and their partners, including local businesses and governmental organizations.[36] Through these measures, existing industries in the area with growth potential, or industries that could utilize the region's unique attributes to their advantage, can be identified and bolstered to diversify the local economy.

For regions with significant ties to energy production, and that also have the required infrastructure to support these projects, the expansion of renewable energy in the area may be a strong option in a Just Transition plan.[37][38] The nature of the project—wind, solar, hydropower, or other pilot projects—would depend in part upon the region's available resources.[39] Additionally, these projects would require a business plan that shows a sustainable

[29] Sartor, "Insights from Case Studies of Major Coal-Consuming Economies," 30.
[30] Ibid., 30.
[31] Ibid, 31.
[32] Ibid.
[33] Ibid.
[34] Ibid.
[35] Ibid.
[36] Ibid.
[37] Anna Zinecker, et al., "Real People, Real Change: Strategies for Just Energy Transitions," International Institute for Sustainable Development and Global Subsidies Initiative (December 2018): 7, accessed January 11, 2019, https://www.iisd.org/sites/default/files/publications/real-people-change-strategies-just-energy-transitions.pdf.
[38] Sartor, "Insights from Case Studies of Major Coal-Consuming Economies," 31.
[39] Sartor, "Insights from Case Studies of Major Coal-Consuming Economies," 31.

model for long-term and commercial-scale activity to be used as a substitute for fossil-fuel-reliant power generation.[40]

The best practices outlined above provide multiple examples of how Just Transition models can be designed to bolster a successful shift away from fossil-fuel-reliant industries. While the transition to cleaner energy has numerous societal, economic, and environmental benefits, the impact to existing industries and communities must not be overlooked.[41] By incorporating affected employees and stakeholders into program planning, providing clear policy guidance and funding, and considering unique regional and economic attributes that impact a program's success, Just Transition framework can be strengthened and increase the likelihood of a smooth transition. Successful execution of a Just Transition model can be an integral step in not only mitigating climate change opposition, but also ensuring that all share in the economic benefits of the transition.[42]

2.3 Methodology

This section will outline the methodology used to identify industries that would likely be impacted by the State's plan to reduce GHG emissions, as well as the identification of the specific threatened occupations within these industries. The process of identifying alternative occupations related to these threatened occupations is also discussed, as well as the methods of estimating potential fiscal impacts resulting from reduced activity in fossil-fuel-reliant industries. Lastly, the process by which training opportunities in the state were obtained is also reviewed.

2.3.1 Identification of Industries of Focus

To determine which industries would be most impacted by the State's GHG reduction strategies, RESI first identified industries related to the supply chain for energy derived from coal, oil, and gas. Broadly, these core industries were coal mining, power plant operation, heavy manufacturing, pipeline transport, coal transport (rail), and gas stations. RESI defined these industries using North American Industry Classification System (NAICS) codes. For two industries of interest—Pipeline Transportation of Crude Oil (NAICS 4861) and Pipeline Transportation of Natural Gas (NAICS 4862)—industry data were suppressed and unavailable at the state level. Data suppression often occurs when there are a limited number of establishments in the industry and data disclosure could enable identification of unique companies. For Rail Transportation (NAICS 4821), data were not available due to reporting limitations related to the railroad unemployment insurance system.[43] After evaluating data

[40] Ibid.
[41] Arjin Makhijani, "Beyond a Band-Aid: A Discussion Paper on Protecting Workers and Communities in the Great Energy Transition," Institute for Energy and Environmental Research (June 10, 2016): 2-3, accessed October 2, 2018, https://ieer.org/wp/wp-content/uploads/2016/06/beyond-a-band-aid-just-energy-transition_2016_LNS-IEER.pdf.
[42] Makhijani, "Beyond a Band-Aid: A Discussion Paper on Protecting Workers and Communities in the Great Energy Transition," 2-3.
[43] "QCEW Overview," U.S. Bureau of Labor Statistics, last modified July 18, 2018, accessed October 15, 2018, https://www.bls.gov/cew/cewover.htm.

availability and relevance for detailed industries within the broader coal supply chain industries, six industries for further evaluation were determined:

- Fossil Fuel Electric Power Generation,
- Gasoline Stations,
- Petroleum and Coal Products Manufacturing,
- Natural Gas Distribution,
- Steel Product Manufacturing from Purchased Steel, and
- Coal Mining.

In addition to the six core industries of focus that were identified, RESI also utilized 2016 input-output tables from the U.S. Bureau of Economic Analysis (BEA) to identify additional related industries. The BEA's input-output tables show the interactions of industries through the inputs to, and outputs from, one another.[44] RESI used these tables to consider additional industries that would likely be negatively impacted by decreased operations. After evaluating these relationships, detailed NAICS within the industries of nonmetallic mineral products, primary metals, fabricated metal products, and chemical products were also included in the data analysis to identify threatened occupations.

2.3.2 Identification of Threatened Occupations

RESI then utilized an industry to occupation crosswalk obtained from the U.S. Bureau of Labor Statistics (BLS).[45] This file shows the national-level distribution of specific occupations by industry, allowing for an estimation of an approximate industry-specific occupational proportion. Because standard occupational codes (SOCs) are spread across numerous industries in varying concentrations, RESI needed to more specifically identify the proportion of employees in each occupation that work in the identified threatened industries. As a hypothetical example, although there may be a total of 100 workers within the human resources managers occupation for a specific geographical area, these managers could be spread throughout a number of industries such as retail trade, manufacturing, or healthcare.

Using these national-level proportions, RESI then applied the estimated employment percentage for each occupation to 2017 Maryland-level industry data from the BLS Quarterly Census of Employment of Wages (QCEW).[46] This resulted in a file that estimated the number of employees by occupation for each industry within Maryland. The file was subsequently restricted to those industries which were identified to be fossil-fuel dependent. Employment figures relevant to each threatened industry of focus were then aggregated and sorted, which produced a list of key threatened occupations in the state. To avoid only focusing on only a small subgroup of occupations, jobs with common three-and four-digit SOCs were grouped together. Occupations of focus were selected from these groups based on the number of

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[44] "Input-Output Accounts Data," U.S. Bureau of Economic Analysis, accessed October 15, 2018, https://www.bea.gov/industry/input-output-accounts-data.
[45] "May 2017 National Industry-Specific Occupational Employment and Wage Estimates," U.S. Bureau of Labor Statistics, accessed October 15, 2018, https://www.bls.gov/oes/2017/may/oessrci.htm#00.
[46] "Quarterly Census of Employment and Wages: Private, All Industry Aggregations, Maryland," U.S. Bureau of Labor Statistics, accessed October 15, 2018, http://www.bls.gov/cew/data/api/2017/a/area/24000.csv.

employees within the profession, relevance to the threatened industry, and to represent a broad mix of occupations. A full list of considered occupations can be found in Appendix A.

2.3.3 Identification of Related Occupations

After identifying the threatened occupations of focus, RESI evaluated alternative options for individuals currently working in these jobs. The related occupations were chosen based on several factors, including skill transfers, existing patterns of employment changes, growth projections, and salary expectations.

RESI created an occupational matrix that included employment changes obtained from resume and occupational data through Maryland Workforce Exchange (MWE).[47] Resume data included jobs which workers had moved to or from, and the number of individuals making this job change. In addition to identifying related occupations through resume data, the Occupational Information Network (O*Net) database was also utilized to determine related jobs based on employment characteristics.[48] Occupational data through MWE included skills, certifications, and technologies associated with job postings. These data were merged with occupational growth projections from the BLS, as well as typical education and training requirements needed for entry into the occupation.[49,50] State-level wage data were also obtained from the BLS; for most occupations the most recent year available was 2017.[51] For several occupations, however, 2016 figures were the most recently available at the state level.[52]

For each threatened occupation, the related professions were sorted based on projected growth levels. Those jobs with projected negative growth were eliminated, as well as those with significantly lower median annual wages compared to the threatened occupation or that were also in fossil-fuel-reliant industries. Education and training requirements were considered, with those jobs requiring education levels close to that of the threatened occupation, or slightly above, being the most desirable. Using these criteria, the most relevant jobs were retained and focused on as potential alternative employment opportunities for each threatened occupation.

2.3.4 Estimating Fiscal Impacts

In order to estimate the potential fiscal impacts resulting from industry closures, RESI first collected data on each industry of interest within the state of Maryland. Using 2017 annual averages from BLS QCEW, RESI evaluated the number of firms in each industry of focus, as well

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[47] "Occupational Summary," Maryland Workforce Exchange, accessed November 19, 2018, https://mwejobs.maryland.gov/vosnet/lmi/default.aspx?pu=1&plang=E.
[48] "About O*Net," O*Net Resource Center, accessed November 19, 2018, https://www.onetcenter.org/overview.html.
[49] "Employment Projections," U.S. Bureau of Labor Statistics, last modified January 30, 2018, accessed October 16, 2018, https://www.bls.gov/emp/tables/emp-by-detailed-occupation.htm.
[50] "Education and Training Assignments by Detailed Occupation," U.S. Bureau of Labor Statistics, last modified October 24, 2017, accessed October 16, 2018, https://www.bls.gov/emp/tables/education-and-training-by-occupation.htm.
[51] "May 2017 State Occupational Employment and Wage Estimates: Maryland," U.S. Bureau of Labor Statistics, last modified March 30, 2018, accessed October 16, 2018, https://www.bls.gov/oes/current/oes_md.htm.
[52] "May 2016 State Occupational Employment and Wage Estimates: Maryland," U.S. Bureau of Labor Statistics, last modified March 31, 2017, accessed October 16, 2018, https://www.bls.gov/oes/2016/may/oes_md.htm#19-0000.

as the number of employees and total wages.[53] The average figures per firm were then calculated to provide an approximate reference for the size of each establishment.

The IMPLAN input/output model was then used to calculate the expected fiscal impacts resulting from a closure of an 'average' firm for each industry type within the state of Maryland. The IMPLAN model has the ability to enumerate the economic and fiscal impact of each dollar earned and spent by the following: employees of the firm, other supporting vendors (business services, retail, etc.), each dollar spent by these vendors on other firms, and each dollar spent by the households of the firm's employees, other vendors' employees, and other businesses' economic impacts that result from households increasing their purchases at local businesses.

Economists measure three types of economic impacts: direct, indirect, and induced impacts. The direct economic effects are generated as the event creates jobs and hires workers to support the event's activities. The indirect economic impacts occur as vendors purchase goods and services from other firms. In either case, the increases in employment generate an increase in household income, as new job opportunities are created and income levels rise. This drives the induced economic impacts that result from households increasing their purchases at local businesses.

The fiscal impacts generated by IMPLAN include direct, indirect, and induced impacts. As noted in Section 2.4, fiscal impacts for each standalone industry cannot be combined due to the potential for double counting.[54] To more clearly differentiate state and local taxes, beyond the categories provided (e.g., property taxes, payroll taxes, etc.) RESI evaluated tax structures from the U.S. Census, to obtain approximate breakdowns between state and local tax revenues.[55] Using these approximations, RESI applied ratios to the fiscal impacts estimated by IMPLAN for each industry.

RESI's analysis includes the following modeling assumptions.

- Economic impact multipliers are developed from IMPLAN input/output software.
- IMPLAN data are based on the North American Industrial Classification System (NAICS).
- IMPLAN employment multipliers are adjusted for inflation using the Bureau of Labor Statistic's CPI-U.
- Impacts are based on 2016 IMPLAN data for the state of Maryland.
- Impacts are represented in 2019 dollars.

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[53] "Quarterly Census of Employment and Wages: 2017, Annual Averages," U.S. Bureau of Labor Statistics, last modified March 7, 2017, accessed December 19, 2018, https://data.bls.gov/cew/apps/data_views/data_views.htm#tab=Tables.

[54] Fiscal impacts include not only direct effects, but also indirect and induced effects which often overlap over different industries. For example, a coal mining firm may be considered an input or supplier to a fossil fuel electric power generation firm. The fiscal impacts resulting from the closure of a fossil fuel electric power generation firm would include impacts from the coal mining firm. Because of this, fiscal impacts should be interpreted independently by industry and not combined, because doing so could show impacts that are artificially large.

[55] "State and Local Government Finances by Level of Government and by State: 2015," U.S. Census Bureau, American Factfinder, last updated October 19, 2017, accessed January 10, 2019, https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk.

2.3.5 Training Opportunities

RESI utilized a number of sources to gain information on job training for related occupations. Sources included career planning websites, local training finder websites, industry group information pages, and occupational databases such as O*Net. More specific information on programs and courses was obtained through college or training institution websites. For some occupations, such as nursing assistants, State requirements were also considered in training research. To provide additional employment context, data were also obtained on the number of job postings through Maryland Workforce Exchange to specify the areas within the state where positions were available as of November 2018.

2.4 Industries of Focus

As described in Section 2.3, six fossil-fuel-reliant industries were chosen for further analysis, based on relevance to the coal, oil, and gas supply chains. The following section will briefly describe each industry within Maryland and the estimated state and local fiscal impacts associated with potential firm reductions. Note that fiscal impacts presented for each industry include direct, indirect, and induced impacts. Because of this, fiscal impacts for standalone industries cannot be combined due to the potential for double counting.[56]

A summary of each fossil-fuel-reliant industry of focus is shown below in Figure 5 below. Data reflect 2017 annual averages.

Figure 5: Industries of Focus

NAICS	Industry	Maryland Employment	Total Wages
221112	Fossil Fuel Electric Power Generation	2,298	$388,125,553
4471	Gasoline Stations	11,476	$261,048,950
3241	Petroleum and Coal Products Manufacturing	848	$70,113,044
2212	Natural Gas Distribution	587	$50,083,767
3312	Steel Product Manufacturing from Purchased Steel	169	$10,645,755
2121	Coal Mining	80	$5,145,469

Sources: RESI, U.S. Bureau of Labor Statistics

As detailed above, the six industries of focus vary considerably in both employment and total wages. The following subsections provide a more detailed breakdown of each industry, including the total number of firms, average employment per firm, and wages per firm.

[56] Fiscal impacts include not only direct effects, but also indirect and induced effects which often overlap over different industries. For example, a coal mining firm may be considered an input or supplier to a fossil fuel electric power generation firm. The fiscal impacts resulting from the closure of a fossil fuel electric power generation firm would include impacts from the coal mining firm. Because of this, fiscal impacts should be interpreted independently by industry and not combined, because doing so could show impacts that are artificially large.

Additionally, estimated fiscal losses associated with the closure of an average firm are shown for each industry.

2.4.1 Fossil Fuel Electric Power Generation

Figure 6 below shows the industry summary for Fossil Fuel Electric Power Generation in Maryland during 2017.

Figure 6: Fossil Fuel Electric Power Generation, 2017 Maryland Industry Summary

Metric	Total
Total Firms	27 Firms
Total Workers	2,298 Employees
Total Wages	$388,125,553
Average Workers Per Firm	85 Employees
Average Wages Per Firm	$14,375,020

Sources: RESI, U.S. Bureau of Labor Statistics

As detailed above, a total of 2,298 employees worked in the industry in 2017 with total Maryland wages of $388.1 million. There were approximately 27 firms in the state within the Fossil Fuel Electric Power Generation industry, having an average of 85 employees per firm. Of the six industries evaluated, fossil fuel electric power plants have the most average employees per firm. This reflects the nature of modern power plants (and utility companies in general) which possess economies of scale—larger facilities with high entry costs and a relatively limited number of firms.

Figure 7 below provides an estimated fiscal impact summary for a Fossil Fuel Electric Power Generation firm in Maryland. These figures provide a hypothetical example of fiscal losses that would be attributed to the closing of a single firm within the industry. While input data reflects the most recently available 2017 figures from the BLS, impact dollars are represented in 2019 dollars.

Figure 7: Fossil Fuel Electric Power Generation – Fiscal Impacts, Average Firm

Type	State	Local	Total
Property	$426,054	$4,966,037	$5,392,091
Income	$548,419	$320,046	$868,465
Sales	$5,092,518	$517,129	$5,609,647
Payroll	$32,027	$6,589	$38,616
Other	$1,104,023	$478,985	$1,583,007
Total	**$7,203,040**	**$6,288,787**	**$13,491,826**

Sources: IMPLAN, RESI, U.S. Bureau of Labor Statistics, U.S. Census

Of the total $13.5 million in estimated annual taxes paid by each firm, approximately $7.2 million would be allocated to the State while $6.3 million would be paid to local governments.

Combined, State sales tax and Local property tax account for $10.1 million—roughly 75 percent of all taxes paid by each Maryland Fossil Fuel Electric Power Generation firm. Individual plant closures would have the most significant effect on tax revenue of any of the industries evaluated—total fiscal impacts from the closing of one Fossil Fuel Electric Power Generation plant are equivalent to the closure of roughly 133 gas stations for example.

2.4.2 Gasoline Stations

Figure 8 below shows the industry summary for Gasoline Stations in Maryland during 2017.

Figure 8: Gasoline Stations, 2017 Maryland Industry Summary

Metric	Total
Total Firms	1,397 Firms
Total Workers	11,476 Employees
Total Wages	$261,048,950
Average Workers Per Firm	8 Employees
Average Wages Per Firm	$186,864

Sources: RESI, U.S. Bureau of Labor Statistics

As illustrated above, a total of 11,476 employees worked in Gasoline Stations in 2017 with total Maryland wages of $261.0 million. There were approximately 1,397 firms in the state within the industry, having an average of eight employees per firm. Of the six industries evaluated, Gasoline Stations had the fewest average employees and, by far, the lowest average wages per firm. Further, while the five other industries evaluated each had less than 100 firms each, there were 1,397 Gasoline Stations within the state.

Figure 9 below provides an estimated fiscal impact summary for an average Gasoline Station in Maryland. These figures represent the estimated revenue losses to state and local governments resulting from the closure of a single station.

Figure 9: Gasoline Stations – Fiscal Impacts, Average Firm

Type	State	Local	Total
Property	$2,831	$32,999	$35,830
Income	$12,280	$7,166	$19,446
Sales	$33,689	$3,421	$37,110
Payroll	$469	$97	$566
Other	$7,751	$4,256	$12,007
Total	**$57,020**	**$47,939**	**$104,959**

Sources: IMPLAN, RESI, U.S. Bureau of Labor Statistics, U.S. Census

Of the total $0.1 million in estimated annual taxes paid by each firm, approximately $57,020 would be allocated to the State while $47,939 would be paid to local governments. Sales and property taxes comprise the largest components of total fiscal revenues, at $37,110 and

$35,830, respectively. Although an individual firm closure will have notably less-pronounced economic consequences with regard to taxes compared to the other industries examined, there are significantly more total firms across the state.

2.4.3 Petroleum and Coal Products Manufacturing

Figure 10 below illustrates the industry summary for Petroleum and Coal Products Manufacturing in Maryland during 2017.

Figure 10: Petroleum and Coal Products Manufacturing, 2017 Maryland Industry Summary

Metric	Total
Total Firms	55 Firms
Total Workers	848 Employees
Total Wages	$70,113,044
Average Workers Per Firm	15 Employees
Average Wages Per Firm	$1,274,783

Sources: RESI, U.S. Bureau of Labor Statistics

As detailed above, a total of 848 employees worked in the industry in 2017 with total Maryland wages of $70.1 million. There were approximately 55 firms in the state within the Petroleum and Coal Products Manufacturing industry, having an average of 15 employees per firm. Compared to the other five industries examined, this industry had both the second-lowest wages per firm and second-lowest average workers per firm.

Figure 11 below shows an estimated fiscal impact summary for the average Petroleum and Coal Products Manufacturing firm in Maryland.

Figure 11: Petroleum and Coal Products Manufacturing – Fiscal Impacts, Average Firm

Type	State	Local	Total
Property	$6,005	$69,999	$76,004
Income	$46,028	$26,861	$72,889
Sales	$71,112	$7,221	$78,333
Payroll	$2,749	$566	$3,315
Other	$22,078	$11,564	$33,640
Total	**$147,973**	**$116,210**	**$264,181**

Sources: IMPLAN, RESI, U.S. Bureau of Labor Statistics, U.S. Census

Of the nearly $0.3 million in total estimated annual taxes paid by an average firm, over $0.1 million each would be allocated to both the state and local governments, respectively. Sales, property, and income taxes comprise the largest components of total fiscal revenues, respectively. Overall, the Petroleum and Coal Products Manufacturing industry would represent the second-lowest revenue losses to state and local governments, per firm, compared to the other industries evaluated.

2.4.4 Natural Gas Distribution

Figure 12 below details the industry summary for Natural Gas Distribution in Maryland during 2017.

Figure 12: Natural Gas Distribution, 2017 Maryland Industry Summary

Metric	Total
Total Firms	19 Firms
Total Workers	587 Employees
Total Wages	$50,083,767
Average Workers Per Firm	31 Employees
Average Wages Per Firm	$2,635,988

Sources: RESI, U.S. Bureau of Labor Statistics

As shown above, a total of 587 employees worked in the industry in 2017 with total Maryland wages of $50.1 million. There were approximately 19 firms in the state within the Natural Gas Distribution industry, having an average of 31 employees per firm.

Figure 13 below provides an estimated fiscal impact summary for an average Natural Gas Distribution firm in Maryland. These figures represent the estimated losses that would be incurred by state and local governments resulting from the closure of a single firm.

Figure 13: Natural Gas Distribution – Fiscal Impacts, Average Firm

Type	State	Local	Total
Property	$58,270	$679,195	$737,465
Income	$139,992	$81,697	$221,689
Sales	$695,357	$70,611	$765,968
Payroll	$7,009	$1,442	$8,451
Other	$136,146	$73,398	$209,545
Total	**$1,036,774**	**$906,343**	**$1,943,118**

Sources: IMPLAN, RESI, U.S. Bureau of Labor Statistics, U.S. Census

Of the more than $1.9 million in total estimated annual taxes paid by each firm, approximately $1.0 million would be received by the State while $0.9 million would be paid to local governments. Sales and property taxes comprise the largest components of total fiscal revenues, at approximately $0.8 million and $0.7 million, respectively.

2.4.5 Steel Product Manufacturing from Purchased Steel

Figure 14 below shows the industry summary for Steel Product Manufacturing from Purchased Steel in Maryland during 2017.

Figure 14: Steel Product Manufacturing, 2017 Maryland Industry Summary

Metric	Total
Total Firms	5 Firms
Total Workers	169 Employees
Total Wages	$10,645,755
Average Workers Per Firm	34 Employees
Average Wages Per Firm	$2,129,151

Sources: RESI, U.S. Bureau of Labor Statistics

As detailed above, a total of 169 employees worked in the industry in 2017 with total Maryland wages of $10.7 million. There were approximately five firms in the state within the Steel Product Manufacturing industry, having an average of 34 employees per firm. This industry accounted for the second-lowest total wages of those industries evaluated and was tied with the Coal Mining industry as having the fewest number of firms in the state.

Figure 15 below shows a summary of the estimated fiscal losses from the closure of an average Steel Product Manufacturing firm in Maryland.

Figure 15: Steel Product Manufacturing – Fiscal Impacts, Average Firm

Type	State	Local	Total
Property	$13,691	$159,579	$173,270
Income	$83,773	$48,888	$132,661
Sales	$162,486	$16,500	$178,986
Payroll	$5,300	$1,091	$6,391
Other	$49,122	$23,728	$72,852
Total	**$314,372**	**$249,786**	**$564,160**

Sources: IMPLAN, RESI, U.S. Census

Of the nearly $0.6 million in total estimated annual taxes paid by each firm, over $0.3 million would be allocated to the State while more than $0.2 million would be paid to local governments. Sales and property taxes comprise the largest components of total fiscal revenues, at roughly $0.2 million each.

2.4.6 Coal Mining

Figure 16 below shows the industry summary for Coal Mining in Maryland during 2017.

Figure 16: Coal Mining, 2017 Maryland Industry Summary

Metric	Total

Total Firms	5 Firms
Total Workers	80 Employees
Total Wages	$5,145,469
Average Workers Per Firm	16 Employees
Average Wages Per Firm	$1,029,094

Sources: RESI, U.S. Bureau of Labor Statistics

In 2017, a total of 80 employees worked in the Coal Mining industry in Maryland with combined wages of $5.1 million. There were approximately five firms in the state within this industry, having an average of 16 employees per firm. Among the six industries evaluated, the Coal Mining industry in Maryland had the lowest total wages, and was tied with Steel Product Manufacturing as having the fewest number of firms.

Figure 17 below shows the estimated fiscal impact summary for an average Coal Mining firm in Maryland. These results represent the estimated revenue losses to state and local governments resulting from the closure of a single firm.

Figure 17: Coal Mining – State and Local Fiscal Impacts, Average Firm

Type	State	Local	Total
Property	$68,110	$793,886	$861,996
Income	$63,832	$37,251	$101,083
Sales	$814,523	$82,712	$897,235
Payroll	$3,560	$733	$4,293
Other	$173,698	$73,590	$247,289
Total	**$1,123,723**	**$988,172**	**$2,111,896**

Sources: IMPLAN, RESI, U.S. Bureau of Labor Statistics, U.S. Census

A total of $2.1 million in estimated annual taxes is generated by each firm, with approximately $1.1 million allocated to the State and $1.0 million paid to local governments. Sales and property taxes comprise the largest components of total fiscal revenues, at approximately $0.9 million each. The revenue losses from a single coal mining firm represent the second-highest of the industries evaluated.

As shown throughout this section, the size and scope of the evaluated industries vary substantially, with total Maryland employment ranging from 80 to 11,476. Estimated fiscal losses to state and local governments also had a considerable range, with a low of $0.1 million per Gasoline Station to $13.5 million per Fossil Fuel Electric Power Generation firm. These figures provide an estimate of the employment and fiscal impacts that would result from decreased operations within these industries of focus.

2.5 Occupational Transitions

RESI evaluated key threatened occupations resulting from State climate change mitigation strategies, as determined in the methodology outlined in Section 2.3. This section will provide a summary of these occupations, as well as related professions to each threatened occupation. For several of these related occupations, the requirements and opportunities for entry are discussed in greater detail. In addition, alternative strategies for transitioning fossil-fuel-reliant workers that have been explored are also described.

These five key threatened occupations are summarized in Figure 18 below.

Figure 18: Key Threatened Occupations

Occupation	SOC Code	Total Maryland Employment	Employment in Fossil-Fuel-Reliant Industries
Cashiers	41-2011	79,000	7,545
Machinists	51-4041	2,820	626
First-Line Supervisors of Production and Operating Workers	51-1011	6,780	257
Petroleum Pump System Operators, Refinery Operators, and Gaugers	51-8093	140	140
Inspectors, Testers, Sorters, Samplers, and Weighers	51-9061	4,060	168

Sources: RESI, U.S. Bureau of Labor Statistics

As detailed above, of the five key threatened occupations, four fall under major SOC code 51, Production Occupations. The most-heavily impacted of these professions is petroleum pump system operators, refinery operators, and gaugers, for which all Maryland positions are estimated to be affected. While the greatest number of employees potentially displaced from fossil-fuel-reliant occupations are cashiers, the number of affected workers represents approximately 9.6 percent of all workers in Maryland within this position.

The following subsection will detail occupations that are related to each of the threatened occupations shown in Figure 18 above.

2.5.1 Related Occupations

In 2017, there were approximately 79,000 cashiers in Maryland; of these, an estimated 7,545 would potentially be impacted by State climate change mitigation strategies. Figure 19 below outlines occupations related to cashiers, as well as entry requirements, growth projections, and 2017 median wages. Please note that in the following tables abbreviations are used for high school diploma or equivalent (HS/Equivalent) and on-the-job (OTJ) training.

Figure 19: Related Occupations, Cashiers

Occupation	Code	Minimum Education	On-the-Job Training	Projected Growth 2016-2026	Maryland Employment	Median Maryland Wage
Cashiers	**41-2011**	**No formal credential**	**Short-term OTJ**	**-0.9%**	**79,000**	**$20,363**
Combined food preparation and serving workers, including fast food	35-3021	No formal credential	Short-term OTJ	16.8%	53,330	$20,738
Nursing assistants	**31-1014**	**Postsecondary non-degree award**	**None**	**11.5%**	**28,250**	**$29,640**
Receptionists and information clerks	**43-4171**	**HS/Equivalent**	**Short-term OTJ**	**9.1%**	**18,640**	**$35,984**
Laborers and freight, stock, and material movers, hand	53-7062	No formal credential	Short-term OTJ	7.6%	42,370	$27,456
Waiters and waitresses	35-3031	No formal credential	Short-term OTJ	7.0%	41,630	$19,843
Maids and housekeeping cleaners	37-2012	No formal credential	Short-term OTJ	6.1%	16,640	$23,483
Counter and rental clerks	41-2021	No formal credential	Short-term OTJ	5.5%	10,260	$30,326
Stock clerks and order fillers	43-5081	HS/Equivalent	Short-term OTJ	5.0%	38,150	$23,962

Sources: Maryland Workforce Exchange, O*Net, RESI, U.S. Bureau of Labor Statistics

As shown above, the majority of positions related to cashiers require a limited amount of education and training, such as short-term on-the job and a high school diploma or less. One of the highlighted occupations, nursing assistants, does require a postsecondary non-degree award. This position also has a significantly higher median wage than cashiers ($29,738 for nursing assistants vs. $20,363 for cashiers), and a high projected growth rate of 11.5 percent. The other highlighted occupation, receptionists and information clerks, has significant projected growth of 9.1 percent and a median wage in 2017 of $35,984. Training opportunities for each of these professions are discussed in Section 2.5.2.

Figure 20 below details several occupations related to machinists, as well as entry requirements, growth projections, and 2017 median wages. Of the 2,820 machinists in the state, 626 are estimated to be potentially impacted by State climate change mitigation strategies.

Figure 20: Related Occupations, Machinists

Occupation	Code	Minimum Education	On-the-Job Training	Projected Growth 2016-2026	Maryland Employment	Median Maryland Wage
Machinists	**51-4041**	**HS/Equivalent**	**Long-term OTJ**	**2.0%**	2,820	$43,306
Computer numerically controlled machine tool programmers, metal and plastic	**51-4012**	**Postsecondary non-degree award**	**Moderate-term OTJ**	**16.3%**	**270**	**$54,829**
Construction laborers	47-2061	No formal credential	Short-term OTJ	12.4%	19,640	$32,822
Maintenance and repair workers, general	49-9071	HS/Equivalent	Moderate-term OTJ	7.9%	21,590	$41,101
Heavy and tractor-trailer truck drivers	**53-3032**	**Postsecondary non-degree award**	**Short-term OTJ**	**5.8%**	**23,640**	**$45,594**
Computer-controlled machine tool operators, metal and plastic	51-4011	HS/Equivalent	Moderate-term OTJ	1.1%	1,060	$43,306

Sources: Maryland Workforce Exchange, O*Net, RESI, U.S. Bureau of Labor Statistics

Educational requirements for occupations related to machinists have more variation, ranging from no formal education to postsecondary non-degree awards. Similarly, on-the-job training needed for these positions range from short-term to moderate-term. The first highlighted occupation, computer numerically controlled machine tool programmers, metal and plastic, typically requires a postsecondary non-degree award and moderate-term on-the-job training. This position has a substantially higher median wage compared to machinists ($43,306 for machinists vs. $54,829 for computer numerically controlled machine tool programmers), and projected growth of 16.3 percent. The second highlighted occupation, heavy and tractor-trailer truck drivers, also requires a postsecondary non-degree award but only short-term on-the-job training. This occupation has projected growth of 5.8 percent and a median wage in 2017 of $45,594. Training opportunities for each of these professions are discussed in Section 2.5.2.

Figure 21 below details several occupations related to first-line supervisors of production and operating workers. Of the 6,780 individuals employed in this occupation within the state, 257 are estimated to be potentially impacted by State climate change mitigation strategies.

Figure 21: Related Occupations, First-Line Supervisors of Production and Operating Workers[57]

Occupation	Code	Minimum Education	On-the-Job Training	Projected Growth 2016-2026	Maryland Employment	Median Maryland Wage
First-line supervisors of production and operating workers	**51-1011**	**HS/Equivalent**	**None**	**-0.30%**	**6,780**	**$59,946**
First-line supervisors of construction trades and extraction workers	**47-1011**	**HS/Equivalent**	**None**	**12.6%**	**15,520**	**$67,330**
General and operations managers	11-1021	Bachelor's degree	None	9.1%	47,360	$119,434
First-line supervisors of helpers, laborers, and material movers, hand	53-1021	HS/Equivalent	None	8.5%	3,720*	$47,278*
First-line supervisors of mechanics, installers, and repairers	**49-1011**	**HS/Equivalent**	**None**	**7.1%**	**10,180**	**$65,728**
First-line supervisors of transportation and material-moving machine and vehicle operators	53-1031	HS/Equivalent	None	6.6%	4,790*	$60,674*
Aircraft cargo handling supervisors	53-1011	HS/Equivalent	None	5.9%	190	$42,827
Engineering technicians, except drafters, all other	**17-3029**	**Associate degree**	**None**	**5.2%**	**1,730**	**$86,445**

Sources: Maryland Workforce Exchange, O*Net, RESI, U.S. Bureau of Labor Statistics

[57] Note that figures marked with an asterisk (*) represent employment and wage estimates from 2016, the most recent available at the state level.

For the occupations related to first-line supervisors of production and operating workers, all are estimated by the BLS to require no on-the-job training. This is likely because supervisors will have knowledge of the requirements for their supervisees due to prior experience. Educational requirements for these positions vary, however, ranging from a high school diploma to bachelor's degree. Two highlighted occupations, first-line supervisors of construction trades and extraction workers, and first-line supervisors of mechanics, installers, and repairers, typically require a high school diploma or equivalent and no on-the-job training. These positions both have higher median wages compared to first-line supervisors of production and operating workers ($67,330 and $65,728 vs. $59,946 for first-line supervisors of production and operating workers), and have projected growth rates of 12.6 percent and 7.1 percent, respectively. The third highlighted occupation, engineering technicians, except drafters, typically requires an associate degree yet has a substantially higher median wage of $86,445. Moderate growth is projected for engineering technicians at 5.2 percent. Training opportunities for each of these professions are discussed in Section 2.5.2.

Figure 22 outlines several occupations related to petroleum pump system operators, refinery operators, and gaugers. This occupation is estimated to have the greatest proportion of workers potentially impacted by State climate change mitigation strategies, with all 140 individuals in the position potentially affected.

Figure 22: Related Occupations, Petroleum Pump System Operators, Refinery Operators, and Gaugers

Occupation	Code	Minimum Education	On-the-Job Training	Projected Growth 2016-2026	Maryland Employment	Median Maryland Wage
Petroleum pump system operators, refinery operators, and gaugers	**51-8093**	**HS/Equivalent**	**Moderate-term OTJ**	**2.8%**	**140**	**$48,838**
Pile-driver operators	47-2072	HS/Equivalent	Moderate-term OTJ	14.6%	90	$49,317
Operating engineers and other construction equipment operators	**47-2073**	**HS/Equivalent**	**Moderate-term OTJ**	**12.3%**	**4,610**	**$47,070**
Transportation vehicle, equipment and systems inspectors, except aviation	53-6051	HS/Equivalent	Moderate-term OTJ	5.9%	290	$53,102
Heavy and tractor-trailer truck drivers	**53-3032**	**Postsecondary non-degree award**	**Short-term OTJ**	**5.8%**	**23,640**	**$45,594**
Engineering technicians, except drafters, all other	**17-3029**	**Associate degree**	**None**	**5.2%**	**1,730**	**$86,445**
Mechanical engineering technicians	17-3027	Associate degree	None	5.0%	670	$57,366
Stationary engineers and boiler operators	**51-8021**	**HS/Equivalent**	**Long-term OTJ**	**5.0%**	**1,160**	**$56,410**
Control and valve installers and repairers, except mechanical door	49-9012	HS/Equivalent	Moderate-term OTJ	4.9%	1,280	$56,035

Sources: Maryland Workforce Exchange, O*Net, RESI, U.S. Bureau of Labor Statistics

Occupations related to petroleum pump system operators, refinery operators, and gaugers show significant variation in estimated training and educational requirements for entry. The first highlighted occupation, Operating engineers and other construction equipment operators, generally requires a high school diploma or equivalent for entry and moderate-term on-the-job training. This profession has the highest projected growth rate of the three highlighted positions, at 12.3 percent, and a median wage comparable to that of petroleum pump system operators, refinery operators, and gaugers. Heavy and tractor-trailer truck drivers is again highlighted, requiring a postsecondary non-degree award and short-term on-the-job training. This occupation had a slightly lower median wage than petroleum pump system operators in 2017 ($45,594 and $48,838, respectively), though also has substantial employment opportunities in the state with 23,640 workers in 2017. Engineering technicians, except drafters are also highlighted again, which typically requires an associate degree. This position does offer a substantially higher median wage compared to petroleum pump system operators. Moderate growth is projected for both heavy and tractor-trailer truck drivers and engineering technicians at 5.8 percent and 5.2 percent, respectively. The final highlighted occupation, stationary engineers and boiler operators, most often requires a high school diploma only but long-term on-the-job training. This occupation has projected growth of 4.8 percent and had a median wage of $56,410 in 2017. Training opportunities for each of these highlighted professions are discussed in Section 2.5.2.

Positions related to the final threatened occupation, inspectors, testers, sorters, samplers, and weighers, are shown in Figure 23. Of the 4,060 individuals employed in this profession in Maryland, 168 workers are estimated to potentially be impacted by State climate change mitigation strategies.

Figure 23: Related Occupations, Inspectors, Testers, Sorters, Samplers, and Weighers

Occupation	Code	Minimum Education	On-the-Job Training	Projected Growth 2016-2026	Maryland Employment	Median Maryland Wage
Inspectors, Testers, Sorters, Samplers, and Weighers	**51-9061**	**HS/Equivalent**	**Moderate-term OTJ training**	**-10.7%**	**4,060**	**$46,363**
Life, physical, and social science technicians, all other	**19-4099**	**Associate degree**	**None**	**9.7%**	**3,150**	**$55,598**
Aviation/Transportation Inspectors	53-6051	HS/Equivalent	Moderate-term OTJ training	5.9%	290	$53,102
Welders, cutters, solderers, and brazers	51-4121	HS/Equivalent	Moderate-term OTJ training	5.6%	2,080	$45,885
Stationary engineers and boiler operators	**51-8021**	**HS/Equivalent**	**Long-term OTJ training**	**4.8%**	**1,160**	**$56,410**

Sources: Maryland Workforce Exchange, O*Net, RESI, U.S. Bureau of Labor Statistics

For most of the occupations related to inspectors, testers, sorters, samplers, and weighers, a high school diploma plus moderate-term to long-term on-the-job training is required for entry. However, for the first highlighted occupation, life, physical, and social science technicians (all other), an associate degree is typically needed. Jobs in this field include quality control analysts, precision agriculture technicians, and remote sensing technicians.[58] These occupations have strong projected growth of 9.7 percent and a median annual wage of $55,598, higher than that of inspectors, testers, sorters, samplers, and weighers ($46,363). The second highlighted occupation, stationary engineers and boiler operators, requires a high school diploma only but long-term on-the-job training. This occupation has projected growth of 4.8 percent and had a median wage of $56,410 in 2017. Training opportunities for each of these professions are discussed in Section 2.5.2.

While the threatened occupations discussed in this subsection represent a cross section of those likely to be affected by the State's climate change mitigation strategies, they are not an exhaustive list. Rather, identifying these threatened occupations and related occupations into which workers could transition show examples of how displaced individuals could transfer skills and knowledge into new occupations with a more positive outlook. Often, these transitions could be facilitated with very feasible training, such as obtaining a postsecondary non-degree award or associate degree, and result in higher wages.

The following subsection will detail specific training and apprenticeship programs within the state for each of the related occupations that have been highlighted.

2.5.2 Job Training Programs

The following subsection outlines training requirements and opportunities in Maryland for the highlighted occupations in Section 2.5.4. These career preparation opportunities include apprenticeships, training programs, and formal degree programs. While other pathways to these professions exist, this section offers potential entry strategies for those seeking to transition from fossil-fuel-dependent jobs.

Nursing Assistants (31-1014)

Becoming a nursing assistant typically requires a postsecondary nondegree award.[59] To obtain this position in Maryland, the State requires a minimum of 100 training hours and 40 clinical hours for certified nursing assistant (CNA) certification.[60] In general, most CNA programs take approximately four to twelve weeks to complete.[61] Courses typically cover a broad range of patient care including taking vital signs, personal care, nutrition requirements, promotion of exercise and activity, identification of respiratory issues, basic diabetes management, and

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[58] "19-4099," My Next Move, accessed December 27, 2018, https://www.mynextmove.org/find/search?s=19-4099.
[59] "Education and Training Assignments by Detailed Occupation," U.S. Bureau of Labor Statistics.
[60] "Nursing Assistant Training Requirements by State," PHI, accessed December 27, 2018, https://phinational.org/advocacy/nurse-aide-training-requirements-state-2016/.
[61] "Here's What You'll Study in a CNA Degree Program," All Nursing Schools, accessed February 7, 2019, https://www.allnursingschools.com/certified-nursing-assistant/degrees/.

caring for individuals with cognitive impairment.[62] Over 100 certified CNA training programs are offered in colleges, nursing homes, and freestanding institutions in the state.[63] These include community colleges located in 16 Maryland counties, serving a broad area within Maryland.[64]

Advertised skills for individuals in this profession include customer service, providing personal care, flexibility, and recording vital signs.[65] The most-common certifications requested in job postings on Maryland Workforce Exchange (MWE) for nursing assistants include Certification in Cardiopulmonary Resuscitation (CPR), CNA, Basic Life Support (CPR), Emergency Medical Technician (EMT), and Advanced Cardiac Life Support Certification (ACLS). There are also a number of certifications beyond a CNA certification. Some of these require a CNA certification as a base, but others, such as the Certified Patient Care Technician certificate, do not have this prerequisite. These additional certifications include Certified Wound Care Associate, National Nurse Aide Assessment Program, Certified Hospice and Palliative Nursing Assistant, and Certified Alzheimer Caregiver.[66]

In November of 2018, the Maryland counties with the highest numbers of job postings for nursing assistants were Baltimore City (107), Anne Arundel County (100), Montgomery County (84), Howard County (53), Baltimore County (52), and Prince George's County (52).[67]

Receptionists and Information Clerks (43-4171)

Entry into the profession of receptionists and information clerks usually requires short-term on-the-job (OTJ) training and possessing a high school diploma or equivalent.[68] To further education, an associate degree in administrative assistant or secretarial science may be obtained.[69] These degree programs typically require one to two years of academic coursework.[70] Maryland has a wide range of degree programs that offer specialty options dependent on occupational field. Program curriculum can be field specific in areas such as healthcare, legal and business, or general for positions in corporate or government offices.[71] These options include but are not limited to software application specialist, executive

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[62] "Online CNA Classes: What You'll Need to Know," All Nursing Schools, accessed February 7, 2019, https://www.allnursingschools.com/certified-nursing-assistant/cna-classes/.
[63] Maryland Board of Nursing, "2018 Approved CNA Training Programs," 1-5, accessed December 27, 2018, https://mbon.maryland.gov/Documents/approved-na-training-programs.pdf.
[64] Maryland Board of Nursing, "2018 Approved CNA Training Programs," 2.
[65] "Occupational Summary," Maryland Workforce Exchange.
[66] "Find Training," CareerOneStop, accessed January 23, 2018, https://www.careeronestop.org/FindTraining/find-training.aspx.
[67] "Job Search," Maryland Workforce Exchange, accessed December 20, 2018, https://mwejobs.maryland.gov/jobbanks/default.asp?p=0&session=jobsearch&geo= .
[68] "Education and Training Assignments by Detailed Occupation," U.S. Bureau of Labor Statistics.
[69] "Local Training Finder – Secretaries and Administrative Assistants," My Next Move, accessed December 27, 2018, https://www.mynextmove.org/profile/ext/training/43-6014.00?s=MD.
[70] Ibid.
[71] "Administrative Professional – A.A.S. Degree (Career), Howard Community College, accessed February 8, 2019, http://howardcc.smartcatalogiq.com/2018-2019/Catalog/Areas-of-Study-By-Academic-Division/Business-and-Computer-Systems-Division-Areas-of-Study/Administrative-Professional-AAS-Degree-Career.

administrative assistant, medical office administration, and legal office administration.[72] Programs may also be located at a local community college or university.[73]

Receptionists must possess strong customer service and time management skills.[74] In addition, knowledge of Microsoft Office programs are typically required.[75] Skills needed for this profession can be built by local courses in office administration and online training for office software.[76] Software skills learned are also dependent upon occupation field. Jobs in the medical field may require skills in medical coding software while jobs in business may require bookkeeping software skills.[77] The Maryland counties with the highest numbers of job postings for receptionist and information clerks in November 2018 were Montgomery County (70), Prince George's County (48) and Anne Arundel County (38).[78]

Computer Numerically Controlled Machine Tool Programmers, Metal and Plastic (51-4012)
Positions as a computer numerically controlled machine tool programmers of metal and plastic typically require a postsecondary non-degree award and moderate OTJ training.[79] Training for this profession can generally be completed in under two years.[80]

The Community College of Baltimore County offers a short-term training program that combines both manual and computer numerical control technology.[81] This program is certified through the National Institute of Metalworking skills (NIMS) and requires six months of educational training.[82] The Community College of Baltimore County also offers two other computer numerical control (CNC) certifications that differ in length and requirements. The CNC machinist certification prepares students for roles as a machine operator, machinist and/or a set-up person and requires 35 credit hours.[83] The CNC programming certificate is the shortest in length as it only requires 24 credit hours.[84] This certification is designed to prepare students

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[72] "Office Administration (Executive Administrative Assistant Option)," Community College of Baltimore County, accessed February 8, 2019, http://catalog.ccbcmd.edu/preview_program.php?catoid=16&poid=7859&returnto=984.
[73] "Local Training Finder – Secretaries and Administrative Assistants," My Next Move.
[74] "Occupational Summary," Maryland Workforce Exchange.
[75] Ibid.
[76] "Become a Receptionist: Educations and Career Roadmap," Study.com, accessed December 27, 2018, https://study.com/become_a_receptionist.html.
[77] "Summary Report for: 43-4171.00," O*Net Online, accessed December 27, 2018, https://www.onetonline.org/link/summary/43-4171.00.
[78] "Job Search," Maryland Workforce Exchange.
[79] "Education and Training Assignments by Detailed Occupation," U.S. Bureau of Labor Statistics.
[80] "Local Training Finder – Computer Numerically Controlled Machine Tool Programmers, Metal and Plastic," My Next Move, accessed December 27, 2018, https://www.mynextmove.org/profile/ext/training/51-4012.00?s=MD&g=Go.
[81] "CNC Machine Tool, Continuing Education Certificate," Community College of Baltimore County, accessed December 27, 2018, http://www.ccbcmd.edu/Programs-and-Courses-Finder/ConED-Program/cnc-machine-tool.
[82] Ibid.
[83] "CNC Machinist Certificate, Credit Certificate," Community College of Baltimore County, accessed December 27, 2018, http://www.ccbcmd.edu/Programs-and-Courses-Finder/program/cnc-machinist-certificate.
[84] "CNC Machinist Certificate, Credit Certificate," Community College of Baltimore County.

for employment as a CNC programmer.[85]

Essential skills for this position include programming, operation monitoring, and complex problem solving.[86] Software programs used by computer numerically controlled machine tool programmers include computer-aided design (CAD), computer-aided manufacturing (CAM), object- or component-oriented software, and Microsoft Excel.[87]

Heavy and Tractor Trailer Truck Drivers (53-3032)

Becoming a heavy and tractor-trailer truck driver typically requires a postsecondary nondegree award and short-term OTJ training.[88] Potential truck drivers may attend a professional truck driving school to gain experience operating large vehicles, learn about federal regulations and laws, and earn the required commercial driver's license (CDL).[89] Additionally, drivers can add endorsements to their CDLs, such as the hazardous materials endorsement, which will enable them to drive a specialized type of vehicle.[90]

In Maryland, CDL programs provide instruction for both the written exam and driving training, and typically take between six to eight weeks for completion.[91] Currently, there are 16 programs in the state with an average tuition of $4,966, though individuals seeking this training may be eligible for federal financial aid.[92] Local schools offering this training include Anne Arundel Community College, College of Southern Maryland, Hagerstown Community College, All-State Career, and North American Trade Schools.[93] Classes are often held on both weekdays and weekends, enabling more flexible training schedules.[94,95,96] Some programs, such as the one offered through Hagerstown Community College, provide students with both job placement assistance through local and national employers.[97]

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[85] Ibid.

[86] "Summary Report for 51-4012.00," O*Net Online, accessed January 4, 2019, https://www.onetonline.org/link/summary/51-4012.00.

[87] "Summary Report for 51-4012.00," O*Net Online.

[88] "Education and Training Assignments by Detailed Occupation," U.S. Bureau of Labor Statistics.

[89] "Occupational Outlook Handbook: Heavy and Tractor-trailer Truck Drivers," U.S. Bureau of Labor Statistics, last modified April 13, 2018, accessed February 7, 2019, https://www.bls.gov/ooh/transportation-and-material-moving/heavy-and-tractor-trailer-truck-drivers.htm.

[90] "Occupational Outlook Handbook: Heavy and Tractor-trailer Truck Drivers," U.S. Bureau of Labor Statistics.

[91] "Truck Driving Schools in Maryland," All Trucking.com, accessed December 27, 2018, http://www.alltrucking.com/schools/maryland/truck-driving/.

[92] Ibid.

[93] Ibid. .

[94] Hagerstown Community College, "Commercial Vehicle Transportation: Truck Driver Training at HCC," 1-2, accessed February 7, 2019, http://www.hagerstowncc.edu/sites/default/files/documents/13619%20B%20Lyle%20CVT%20brochure%20UPDATE.PDF.

[95] "Truck Driving: Commercial Driver's License," Anne Arundel Community College, accessed February 8, 2019, https://www.aacc.edu/programs-and-courses/job-training/truck-driving/.

[96] "Commercial Driver's License (CDL) Class A," College of Southern Maryland, accessed February 8, 2019, https://www.csmd.edu/programs-courses/non-credit/career-development/transportation/CDL-Class-A.

[97] Hagerstown Community College, "Commercial Vehicle Transportation: Truck Driver Training at HCC," 1-2.

Heavy and tractor trailer truck drivers must be in good health.[98] Federal regulations can prohibit those with medical conditions such as high blood pressure or epilepsy from becoming truck drivers.[99] Potential truck drivers will also need to pass vision and hearing tests.[100] Additionally, CDL drivers must have a clean driving record and be willing to take random drug tests.[101]

In Maryland, the number of heavy and tractor-trailer truck driver jobs is expected to grow with an average of 2,440 annual job openings.[102] In November of 2018, the Maryland counties with the highest numbers of job postings for heavy and tractor-trailer truck drivers were Baltimore City (188), Howard County (137), Prince George's County (108), Baltimore County (101), and Anne Arundel County (91).[103]

First-line Supervisors of Construction Trades and Extraction Workers (47-1011)
Jobs for first-line supervisors of construction trades and extraction workers most-often require a high school diploma or equivalent.[104] Many positions also require training from a vocational school, related work experience, or an associate degree.[105] Training is offered in building and construction site management at multiple Maryland colleges, including Community College of Baltimore County, Prince George's Community College, and Frederick Community College.[106] Community College of Baltimore offer programs of varying lengths and required credit hours, such as the Construction Project Controls Certificate (12 credits), Construction Management Certificate (39 credits), First-Line Supervisor Continuing Education Certificate (six months), and an associate of applied science in construction management (60 credits). [107,108,109,110]

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[98] "Occupational Outlook Handbook: Heavy and Tractor-trailer Truck Drivers," U.S. Bureau of Labor Statistics, last modified April 13, 2018, accessed February 7, 2019, https://www.bls.gov/ooh/transportation-and-material-moving/heavy-and-tractor-trailer-truck-drivers.htm.
[99] "Occupational Outlook Handbook: Heavy and Tractor-trailer Truck Drivers," U.S. Bureau of Labor Statistics.
[100] Ibid.
[101] Ibid.
[102] "Long Term Occupational Projections (2016-2026): Maryland, Heavy and Tractor-Trailer Truck Drivers," Projections Central - State Occupational Projections, accessed February 7, 2019, http://www.projectionscentral.com/Projections/LongTerm.
[103] "Job Search," Maryland Workforce Exchange.
[104] "Education and Training Assignments by Detailed Occupation," U.S. Bureau of Labor Statistics.
[105] "Summary Report for: 47-1011.00," My Next Move, accessed February 7, 2019, https://www.mynextmove.org/profile/ext/online/47-1011.00.
[106] "Local Training Finder – First-Line Supervisors of Construction Trades and Extraction Workers," My Next Move, accessed December 27, 2018, https://www.mynextmove.org/profile/ext/training/47-1011.00?s=MD&g=Go.
[107] "Construction Project Controls Certificate, Credit Certificate," Community College of Baltimore County, accessed February 7, 2019, http://www.ccbcmd.edu/Programs-and-Courses-Finder/program/construction-project-controls-certificate.
[108] "Construction Management Certificate, Credit Certificate," Community College of Baltimore County, accessed February 7, 2019, http://www.ccbcmd.edu/Programs-and-Courses-Finder/Program/construction-management-certificate.
[109] "First-Line Supervisor, Continuing Education Certificate," Community College of Baltimore County, accessed February 7, 2019, http://www.ccbcmd.edu/Programs-and-Courses-Finder/program/first-line-supervisor.
[110] "Construction Management, Associate of Applied Science," Community College of Baltimore County, accessed February 7, 2019, http://www.ccbcmd.edu/Programs-and-Courses-Finder/Program/construction-management.

Advertised job skills for this profession include customer service, problem solving, and the ability to stand for long periods of time.[111] Proficiency in project management software, data base user interface and query software, and calendar and scheduling software may be required in this role.[112] Specific programs cited for this profession include Microsoft Project and Oracle Primavera Enterprise Project Portfolio Management.[113] Job postings were most plentiful in November 2018 in Baltimore City (11), Prince George's County (7), Allegany County (4), Howard County (4), and Montgomery County (4).[114]

First-line Supervisors of Mechanics, Installers, and Repairers (49-1011)

To become a first-line supervisor of mechanics, installers, and repairers, individuals typically need a high school diploma or equivalent.[115] According to MWE, employees also typically need about two years of training, consisting of both on the job and informal training.[116,117] Operations management and supervision programs are offered by Johns Hopkins University, Morgan State University, and the University of Maryland-University College.[118] These programs can be completed in less than one year.[119] Other job titles associated with this occupation include facilities manager, facility maintenance supervisor, and maintenance manager.[120] The International Facility Management Association (IFMA) is an association of facility management professionals which offers a number of facility-related credential and professional qualifications, and may be useful in obtaining training.[121,122] In Maryland, Prince George's

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111 "First-Line Supervisors of Construction Trades and Extraction Workers," Maryland Workforce Exchange, accessed February 7, 2019, https://mwejobs.maryland.gov/vosnet/lmi/profiles/profileSummary.aspx?session=occdetail&valueName=occupation.

112 "First-Line Supervisors of Construction Trades & Extraction Workers," My Next Move, accessed February 7, 2019, https://www.mynextmove.org/profile/summary/47-1011.00.

113 Ibid.

114 "Job Search," Maryland Workforce Exchange.

115 "Education and Training Assignments by Detailed Occupation," U.S. Bureau of Labor Statistics.

116 "First-Line Supervisors of Mechanics, Installers, and Repairers: Description," Maryland Workforce Exchange, accessed February 7, 2019, https://mwejobs.maryland.gov/vosnet/lmi/profiles/profileDetails.aspx?session=occdetail&valueName=occupation&section=description.

117 This OTJ varies from the minimum requirements provided by the U.S. BLS, which indicates that no OTJ training is required.

118 "Local Training Finder: First-Line Supervisors of Mechanics, Installers, and Repairers, Maryland," CareerOneStop, accessed on February 8, 2019, https://www.careeronestop.org/Credentials/Toolkit/find-local-training.aspx?keyword=First-Line%20Supervisors%20of%20Mechanics%2C%20Installers%2C%20and%20Repairers&location=maryland&ajax=occ&post=y.

119 "Local Training Finder: First-Line Supervisors of Mechanics, Installers, and Repairers, Maryland," CareerOneStop.

120 "Summary Report for: 49-1011.00," O*Net Online, accessed February 8, 2019, https://www.onetonline.org/link/summary/49-1011.00.

121 "Empowering Facility Professionals Worldwide," International Facility Management Association, accessed February 8, 2019, http://www.ifma.org/.

122 "Credentials and Continuing Education," International Facility Management Association, accessed February 7, 2019, https://www.ifma.org/professional-development/credentials.

Community College and Community College of Baltimore County have partnered with the Chesapeake chapter of IFMA to offer the Facilities Management Professional certification program.[123,124] At Community College of Baltimore, it is a four-month program with day classes that are typically held on Fridays and Saturdays.[125]

These positions may utilize project management software, data base user interface and query software, and enterprise resource planning software.[126] Advertised job skills include (but are not limited to) customer service, welding, and preventative, general, building, and grounds maintenance.[127]

As recently as November 2018, Baltimore City (31), Prince George's County (21), Montgomery County (19), Howard County (14), and Baltimore County (13) were among the leaders in the most positions offered.[128]

Engineering Technicians, Except Drafters, All Other (17-3029)

Those seeking positions as engineering technicians, except drafters, would typically need to acquire an associate degree.[129] Associate degree programs in engineering are offered through multiple Maryland community colleges including Carroll Community College, College of Southern Maryland, Community College of Baltimore County, Howard Community College, and Prince George's Community College.[130,131,132] Along with others, Howard Community College offers engineering degrees with various specializations, such as computer, electrical, and biomedical.[133] Additionally, programs in energy management and systems technology;

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[123] "Facility Management Credential Programs (FMP)," Prince George's Community College, accessed February 7, 2019, http://www.pgcc.edu/Programs_and_Courses/Noncredit/Continuing_Education_Program_Detail.aspx?id=6442462730.

[124] "Facility Management Professional, Continuing Education Certificate," Community College of Baltimore County, accessed February 7, 2019, http://www.ccbcmd.edu/Programs-and-Courses-Finder/ConED-Program/facility-management-professional.

[125] "Facility Management Professional, Continuing Education Certificate," Community College of Baltimore County.

[126] "First-Line Supervisors of Mechanics, Installers, & Repairers," Federal Student Aid, accessed February 7, 2019, https://studentaid.ed.gov/sa/prepare-for-college/students/career-search/profile/summary/49-1011.00.

[127] "First-Line Supervisors of Mechanics, Installers, and Repairers: Skills," Maryland Workforce Exchange, accessed February 7, 2019, https://mwejobs.maryland.gov/vosnet/lmi/profiles/profileDetails.aspx?session=occdetail&valueName=occupation&section=skillstools.

[128] "Job Search," Maryland Workforce Exchange.

[129] "Education and Training Assignments by Detailed Occupation," U.S. Bureau of Labor Statistics.

[130] "Electronic Engineering Technology Courses in Maryland," Study.com, accessed December 27, 2018, https://study.com/electronic_engineering_technology_courses_in_maryland.html.

[131] "Engineering Technology," Community College of Baltimore County, accessed December 27, 2018, http://www.ccbcmd.edu/Programs-and-Courses/Schools-and-Academic-Departments/School-of-Technology-Art-and-Design/Engineering-Department/Engineering-Technology.aspx.

[132] "Engineering Associate of Science," Prince George's Community College, accessed February 8, 2019, https://www.pgcc.edu/Programs_and_Courses/Program_Detail.aspx?programID=6442462394.

[133] "Search Results: Engineering," Howard Community College, accessed February 8, 2019, https://www.howardcc.edu/search-results.html?q=engineering.

hydraulics and fluid power technology; and heating, ventilation, air conditioning, and refrigeration engineering offer technician career preparation and are available at Maryland colleges.[134] Vocational and technical schools also offer programs for engineering technicians, such as the Lincoln College of Technology in Columbia, MD.[135,136] A certification through the National Institute for Certification in Engineering Technologies, though not required, may make prospective employees more competitive.[137]

It may be important to learn C++ programming, either through coursework or a certificate program.[138] Since many employers look for candidates with previous work experience, when starting off in the field individuals often pursue entry-level jobs.[139] If a candidate has difficulty obtaining one, he or she may consider a job involving electrical equipment, programming, or power systems to gain the experience they need to break into the field.[140] Counties hiring the most engineering technicians in late 2018 were St. Mary's County (15), Montgomery County (3), Harford County (2), and Washington County (2).[141]

Operating Engineers and Other Construction Equipment Operators (47-2073)

Entry into the profession of operating engineers and other construction equipment operators typically requires a high school diploma or equivalent and moderate-term OTJ training.[142] OTJ training can be facilitated through apprenticeships, which typically take several years to complete.[143] Many apprenticeship programs take four years to complete and include 6,000 hours of on the job training.[144] Local apprenticeship programs include Operating Engineers Local 37 Apprentice Training School and International Union of Operating Engineers Local 99.[145,146] The Operating Engineers Local 37 Apprenticeship is approximately a two-year

[134] "Local Training Finder: 17-3029.00, MD," CareerOneStop, accessed February 8, 2019, https://www.careeronestop.org/Credentials/Toolkit/find-local-training.aspx?keyword=17-3029.00&persist=true&location=MD&ajax=0&post=y.
[135] Beatrice Harrison, "How To Become an Engineering Technician," College Mouse, August 4, 2014, accessed February 8, 2019, https://www.collegemouse.com/how-to-become-an-engineering-technician/.
[136] "Local Training Finder: 17-3029.00, MD," CareerOneStop.
[137] Dawn Rosenberg Mckay, "Engineering Technician Career," The Balance Careers, updated February 6, 2019, accessed February 8, 2019, https://www.thebalancecareers.com/engineering-technician-526012.
[138] "How To Become an Electronics Engineering Technician: Career Roadmap," Study.com, accessed February 8, 2019,
https://study.com/articles/How_to_Become_an_Electronics_Engineering_Technician_Career_Roadmap.html.
[139] "How To Become an Electronics Engineering Technician: Career Roadmap," Study.com.
[140] Ibid.
[141] "Job Search," Maryland Workforce Exchange.
[142] "Education and Training Assignments by Detailed Occupation," U.S. Bureau of Labor Statistics.
[143] "Be an Operating Engineer: Education and Career Roadmap," Study.com, accessed December 27, 2018, `https://study.com/be_an_operating_engineer.html.
[144] "Operating Engineer Training Programs and Requirements," Study.com, accessed February 8, 2019, https://study.com/operating_engineer_training.html.
[145] "Operating Engineer Apprenticeship," Train Baltimore, accessed December 27, 2018, http://trainbaltimore.org/Training/Program-Details.aspx?pid=89&pn=0.
[146] "Welcome," International Union of Operating Engineers Local 99, accessed December 27, 2018, http://www.iuoelocal99.org/.

program, comprised of 40-hour work weeks for a total length of 4,500 hours.[147] This apprenticeship is based in Sparrows Point, requires a high school diploma or GED, and offers a starting wage of $14.38 per hour.[148,149] The apprenticeship offered by Miller & Long lasts 8,000 hours, also requires a high school diploma or GED, and has a starting wage of $24.86 an hour.[150]

The International Union of Operating Engineers offers a four-year apprenticeship program consisting of 8,000 hours of OTJ experience and 576 classroom hours.[151] The Maryland Apprenticeship and Training Program (MATP) also lists operating engineers on their website, and directs applicants to available apprenticeship opportunities.[152] For individuals seeking jobs with certain skills such as operation of heavy construction equipment, certifications are offered.[153] For example, numerous crane certifications are offered through the National Commission for the Certification of Crane Operators.[154,155]

License requirements vary by state, but may be required to operate large machinery such as cranes and bulldozers.[156] Knowledge of Microsoft Office is frequently mentioned in job postings.[157] Facilities management software may also be necessary.[158]
The best Maryland counties for operating engineers and other construction equipment operators opportunities are Prince George's County, which posted 19 job openings in November 2018, followed by eight in Baltimore City and seven in Anne Arundel County.[159]

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[147] "Maryland Apprenticeship Locator: Operating Engineers: Operating Engineer Details," Maryland Department of Labor, Licensing and Regulation, accessed February 8, 2019, http://www.dllr.state.md.us/Apprenticeship/Details.aspx?user=A&access=1&results=1&details=1&sessionGUID=94cd4cd4-cda2-405e-8b80-687c8f61146a.
[148] "Maryland Apprenticeship Locator: Operating Engineers: Operating Engineer Details," Maryland Department of Labor, Licensing and Regulation.
[149] "Operating Engineer Apprenticeship," Train Baltimore.
[150] "Maryland Apprenticeship Locator: Miller & Long Concrete Construction: Operating Engineer Details," Maryland Department of Labor, Licensing and Regulation, accessed February 8, 2019, http://www.dllr.state.md.us/Apprenticeship/Details.aspx?user=A&access=1&results=1&details=1&sessionGUID=94cd4cd4-cda2-405e-8b80-687c8f61146a.
[151] "Our Apprenticeship Program," International Union of Operating Engineers, accessed February 8, 2019, http://www.iuoelocal99.org/apprenticeships.htm#one.
[152] "Explore Registered Occupations - Maryland Apprenticeship and Training Program (MATP)," Maryland Department of Labor, Licensing, and Regulation, accessed December 27, 2018, https://www.dllr.state.md.us/employment/approcc/approcc.shtml.
[153] "Be an Operating Engineer: Education and Career Roadmap," Study.com, accessed December 27, 2018, https://study.com/be_an_operating_engineer.html.
[154] "Be an Operating Engineer: Education and Career Roadmap," Study.com.
[155] "News Headlines," National Commission for the Certification of Crane Operators (NCCCO), accessed February 8, 2019, http://nccco.org/.
[156] "Be an Operating Engineer: Education and Career Roadmap," Study.com.
[157] "Summary Report for: 47-2073.00," O*Net Online, accessed February 8, 2019, https://www.onetonline.org/link/summary/47-2073.00.
[158] "Operating Engineers & Other Construction Equipment Operators," My Next Move, accessed February 8, 2019, https://www.mynextmove.org/profile/summary/47-2073.00.
[159] "Job Search," Maryland Workforce Exchange.

Life, Physical, and Social Science Technicians, All Other (19-4099)
Jobs falling under life, physical, and social science technicians, all other, most often require obtaining an associate degree.[160] As noted in the previous subsection, occupations in this field include quality control analysts, precision agriculture technicians, and remote sensing technicians.[161] Several Maryland community colleges offer related associate degrees, including Baltimore City Community College, Community College of Baltimore County, and Harford Community College.[162]

Life, physical, and social science technicians positions usually require knowledge of analytical or scientific software.[163,164,165] Specifically, quality control analyst positions may use additional program testing software and data base user interface and query software such as Selenium and Structured Query Language (SQL).[166] Precision agriculture technicians and remote sensing technicians may also need knowledge of map creation software such as ESRI ArcGIS software.[167,168]

The counties offering the most job postings in November of 2018 were Montgomery County (116), Frederick County (37), Howard County (31), and Baltimore City (13).[169]

Stationary Engineers and Boiler Operators (51-8021)
To become a stationary engineers and boiler operator, individuals typically need a high school diploma or equivalent combined with long-term OTJ training.[170] Training for becoming a stationary engineer or boiler operator is often completed through an apprenticeship program.[171] These apprenticeship programs are typically completed over a four-year period though work with experienced operators, as well as supplemental classroom instruction.[172] Certification preparation courses are offered through Maryland community colleges including

[160] "Education and Training Assignments by Detailed Occupation," U.S. Bureau of Labor Statistics.
[161] "19-4099," My Next Move, accessed December 27, 2018, https://www.mynextmove.org/find/search?s=19-4099.
[162] "Local Training Finder – Life, Physical, and Social Science Technicians, All Other," My Next Move, accessed December 27, 2018, https://www.mynextmove.org.
[163] "Quality Control Analysts," My Next Move, accessed February 8, 2019, https://www.mynextmove.org/profile/summary/19-4099.01.
[164] "Precision Agriculture Technicians," My Next Move, accessed February 8, 2019, https://www.mynextmove.org/profile/summary/19-4099.02.
[165] "Remote Sensing Technicians," My Next Move, accessed February 8, 2019, https://www.mynextmove.org/profile/summary/19-4099.03.
[166] "Quality Control Analysts," My Next Move.
[167] "Precision Agriculture Technicians," My Next Move.
[168] "Remote Sensing Technicians," My Next Move.
[169] "Job Search," Maryland Workforce Exchange.
[170] "Education and Training Assignments by Detailed Occupation," U.S. Bureau of Labor Statistics.
[171] "Stationary Engineer Training," International Union of Operating Engineers, accessed December 27, 2018, https://www.iuoe.org/training/stationary-engineer-training.
[172] Ibid.

Anne Arundel Community College, College of Southern Maryland, Community College of Baltimore County, and Prince George's Community College.[173,174,175,176]

At Anne Arundel Community College (AACC), a Maryland Stationary Engineer Certification consists of two courses and in addition to earning an AACC certificate, it will prepare students for the Maryland Board of Stationary Engineers licensing exam.[177] Courses include training in boiler construction, care, and operations; hydronic heating systems; refrigeration and HVAC systems, and basic electrical knowledge.[178]

Commonly cited skills for this occupation include preventative maintenance, customer service, building maintenance, maintenance mechanics, and problem solving.[179] Use of technologies such as facilities management software or database user interface and query software may also be required in this role.[180] Baltimore City had the most job openings posted for stationary engineers and boiler operators in November of 2018 (11), followed by Harford and Prince George's County (three each).[181] Anne Arundel County, Dorchester County, Frederick County, Howard County, and Montgomery County also each had two positions listed during this time.[182]

2.5.3 Alternative Strategies

While this report has largely focused on retraining efforts through matching of education and skills between occupations through occupational crosswalks, alternative strategies have been pursued in other areas. A significant number of these efforts have focused on teaching former fossil-fuel-reliant workers to write code, for applications including software and web design, in order to gain employment in the technology field.[183] These programs are more prominent in states including West Virginia and Kentucky, which have historically had substantial coal mining

[173] "Maryland Stationary Engineer Certification," Anne Arundel Community College, accessed December 27, 2018, https://www.aacc.edu/programs-and-courses/job-training/stationary-engineer/.
[174] "Stationary Engineer," College of Southern Maryland, accessed December 27, 2018, https://www.csmd.edu/programs-courses/non-credit/career-development/construction-and-skilled-trades/Stationary-Engineer.
[175] "VOC 042 – Preparation for Maryland Stationary Engineer's Certificate," Community College of Baltimore County, accessed December 27, 2018, https://www.ccbcmd.edu/Migrate/ceed/syllabus/voc.html.
[176] "OCU-359-Stationary Engineering I," Prince George's Community College, accessed December 27, 2018, http://www.pgcc.edu/Programs_and_Courses/course_detail.aspx?courseID=6442455530&programID=6442462358.
[177] "Maryland Stationary Engineer Certification," Anne Arundel Community College, accessed February 8, 2019, https://www.aacc.edu/programs-and-courses/job-training/stationary-engineer/.
[178] Ibid.
[179] "Occupational Summary," Maryland Workforce Exchange.
[180] "Summary Report for 51-8021.00," O*Net Online, accessed February 8, 2019, https://www.onetonline.org/link/summary/51-8021.00.
[181] "Job Search," Maryland Workforce Exchange.
[182] "Job Search," Maryland Workforce Exchange.
[183] ABC Radio, "Coal Miners in West Virginia Learn HTML Coding as Second Career," *WTOP*, May 7, 2018, accessed November 15, 2018, https://wtop.com/national/2018/05/coal-miners-being-taught-html-coding-as-a-second-career/.

industries.[184,185] Although this transition may initially seem incongruent with mining skillsets, some individuals leading transition efforts have stated that technologies used in mining, such as robotics, facilitate entry into the coding field.[186]

In eastern Kentucky, a startup company called Bit Source offered 22-week training in coding to laid-off coal miners.[187] Although the company hired only a fraction of the applicants for the training positions, local leaders have stressed the importance of small companies in diversifying the area's economic landscape.[188] One significant challenge the project has encountered is internet infrastructure, though there is a project currently underway to increase broadband availability in the state.[189] Internet speeds in the area lower than many other regions, with a 2017 ranking placing the state 47th in the nation for broadband speed and capacity.[190]

The Louisville, Kentucky-based startup Interapt provides another example of an organization that was created to increase economic activity through 'insourcing' of technology jobs.[191] The company initially trained 35 of 800 applicants to program completion, with plans to expand training over the next two sessions to 90 and over 150 individuals, respectively.[192] Interapt received funding from the Appalachia Regional Commission to launch the training program, which also provides trainees with a $400 weekly stipend. [193] Additionally, the company's founder currently investing $4 million in a local warehouse renovation to house the organization.[194]

While none of the programs listed above are sufficient to completely offset the impacts from fossil-fuel industry employment losses, they do offer examples of alternative strategies to create economic opportunities for displaced workers. Software and application positions often have the benefit of being amenable to working remotely, enabling these displaced employees to work in a new profession yet stay in their current geographic location and generate economic activity. In addition to the related occupations generated though the occupational crosswalks, these in-demand technology jobs can also be considered as potential alternatives to fossil-fuel reliant positions as the State plans Just Transition strategies.

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[184] ABC Radio, "Coal Miners in West Virginia Learn HTML Coding as Second Career."
[185] Sheryl Gay Stolberg, "Beyond Coal: Imagining Appalachia's Future," *New York Times*, August 17, 2016, accessed November 16, 2018, https://www.nytimes.com/2016/08/18/us/beyond-coal-imagining-appalachias-future.html.
[186] Erica Peterson, "From Coal to Code: A New Path for Laid-off Miners in Kentucky," *NPR*, May 6, 2016, accessed November 15, 2018, https://www.npr.org/sections/alltechconsidered/2016/05/06/477033781/from-coal-to-code-a-new-path-for-laid-off-miners-in-kentucky.
[187] Peterson, "From Coal to Code: A New Path for Laid-off Miners in Kentucky."
[188] Ibid.."
[189] Ibid.
[190] "KentuckyWired FAQs," Kentucky Communications Network Authority, accessed February 8, 2019, https://kentuckywired.ky.gov/about/Pages/faq.aspx.
[191] Arlie Hochschild, "The Coders of Kentucky," *New York Times*, September 21, 2018, accessed November 15, 2018, https://www.nytimes.com/2018/09/21/opinion/sunday/silicon-valley-tech.html.
[192] Hochschild, "The Coders of Kentucky."
[193] Ibid.
[194] Ibid.

2.6 Conclusion

Throughout this report, RESI has addressed a broad range of topics related to the State's climate change mitigation strategies. These efforts include providing an overview of Just Transition models and how they have been successfully implemented in other regions, and a comprehensive evaluation of the predicted effects to Maryland's workforce and economy resulting from the State's 40 by 30 Plan. RESI completed this analysis by studying the industries of focus and their economic and fiscal footprints within the state, identifying key occupations likely to be impacted, and determining related occupations that provide alternative employment opportunities as the State transitions from fossil-fuel-reliant industries. The educational requirements for highlighted related occupations and training opportunities within the state of Maryland were also explored to provide greater transitional guidance. Additionally, the report provides strategies for mitigating these impacts though Just Transition models that have been successfully implemented in other regions, as well as alternative strategies that have been used in areas with declining coal mining industries.

While the industries and occupations evaluated throughout this report do not represent an exhaustive list of all those that may be affected by the State's 40 by 30 Plan, they provide a solid framework for evaluating potential economic and regional dislocations that may be incurred with this effort. Understanding the impacts and challenges related to greenhouse gas reduction policies enables the State to be better equipped when addressing these changes and taking steps to ensure an equitable and fair outcome for those affected.

It is clear that the transition to cleaner energy has numerous societal, economic, and environmental benefits—but it is also crucial to anticipate the impacts to existing industries, employees, communities, and regions that will be affected through this process. Through the information provided in this report, the State can take actions to build and strengthen policies that increase the likelihood of a smoother transition to Maryland's future of increased clean energy.

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Appendix A—Industries of Consideration

Figure 24: Occupations within Fossil-Fuel-Reliant Industries

Six-Digit SOC Code	Six-Digit SOC Title	Maryland Jobs in Fossil Fuel Dependent Industries	Occupation of Focus
41-2011	Cashiers	7,545	X
41-1011	First-Line Supervisors of Retail Sales Workers	1,127	
51-4041	Machinists	626	X
35-3021	Combined Food Preparation and Serving Workers, Including Fast Food	586	
11-1021	General and Operations Managers	314	
53-6031	Automotive and Watercraft Service Attendants	275	
41-2031	Retail Salespersons	258	
51-1011	First-Line Supervisors of Production and Operating Workers	257	X
43-9061	Office Clerks, General	199	
49-3023	Automotive Service Technicians and Mechanics	191	
51-4011	Computer-Controlled Machine Tool Operators, Metal and Plastic	186	
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	168	X
43-5081	Stock Clerks and Order Fillers	167	
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	162	X
35-2021	Food Preparation Workers	148	
51-9011	Chemical Equipment Operators and Tenders	141	
49-9071	Maintenance and Repair Workers, General	134	
49-9041	Industrial Machinery Mechanics	132	
51-4121	Welders, Cutters, Solderers, and Brazers	115	
43-3031	Bookkeeping, Accounting, and Auditing Clerks	114	

Sources: RESI, U.S. Bureau of Labor Statistics

END OF DOCUMENT

Maryland Department of the Environment

Appendix J

2020 MDOT GGRA Plan

2030 GGRA Plan

2020 Maryland Department of Transportation
Greenhouse Gas Reduction Act Plan

MARYLAND DEPARTMENT OF TRANSPORTATION

Executive Summary

The Greenhouse Gas Reduction Act (GGRA) Plan presents the Maryland Department of Transportation's (MDOT) approach to meet the requirements of the GGRA. The GGRA requires the Maryland Department of Environment (MDE) to submit a plan that reduces statewide greenhouse gas (GHG) emissions by 40 percent from 2006 levels by 2030 ("40 by 30"). MDOT worked in coordination with MDE, other agencies, and partners to develop and test strategies for the transportation sector to achieve the "40 by 30" goal.

The current statewide emissions inventory, developed for 2017, shows that on-road transportation is the single largest GHG emissions generator in Maryland, representing 36 percent of total GHG emissions. Off-road transportation (aviation, marine, and rail) represents another 4 percent.

A steady increase in transportation demand indicators including growth in population, vehicle miles traveled (VMT), and congestion combined with limited revenue relative to needs creates a major challenge. Based on MDOT analysis accounting for these challenges and by harnessing new opportunities, it is possible for Maryland's transportation sector to meet the "40 by 30" goal. The analysis considered two policy scenarios built from the Maryland Transportation Plan (MTP), the Consolidated Transportation Program (CTP), and Maryland's two major Metropolitan Planning Organizations' (MPO) plans and programs (Baltimore and Washington D.C. regions). Achieving the goal will not be easy and requires an innovative and cost-effective approach that includes:

- An aggressive investment in transportation beyond current levels of projected funding,
- Supportive policy and new and additional resources enabling MDOT to fund and advance these needed investments,
- A shared commitment and coordinated approach between MDOT and its partners to advance reliable, low-cost, and low-carbon technologies, and
- A best-case scenario for the roll-out and adoption of transportation technology, including market penetration of electric vehicles (EVs) into public and private fleets in Maryland.

Statewide VMT, which is a major indicator of transportation sector GHG emissions, has been steadily increasing in Maryland since 2014, with over 60 billion VMT in 2019. VMT growth has been consistent with population growth as VMT per capita has remained stable. While population increase is expected to create additional demand for the State's transportation systems, VMT in Maryland dropped dramatically in 2020 due to the COVID-19 pandemic. Based on MDOT's estimates of VMT trends, 2020 annual VMT is expected to drop to an estimated 51.1 billion VMT statewide. While MDOT anticipates that VMT will rebound back to 2019 levels over the next five years, there is uncertainty regarding the exact timeline and pace of the recovery.

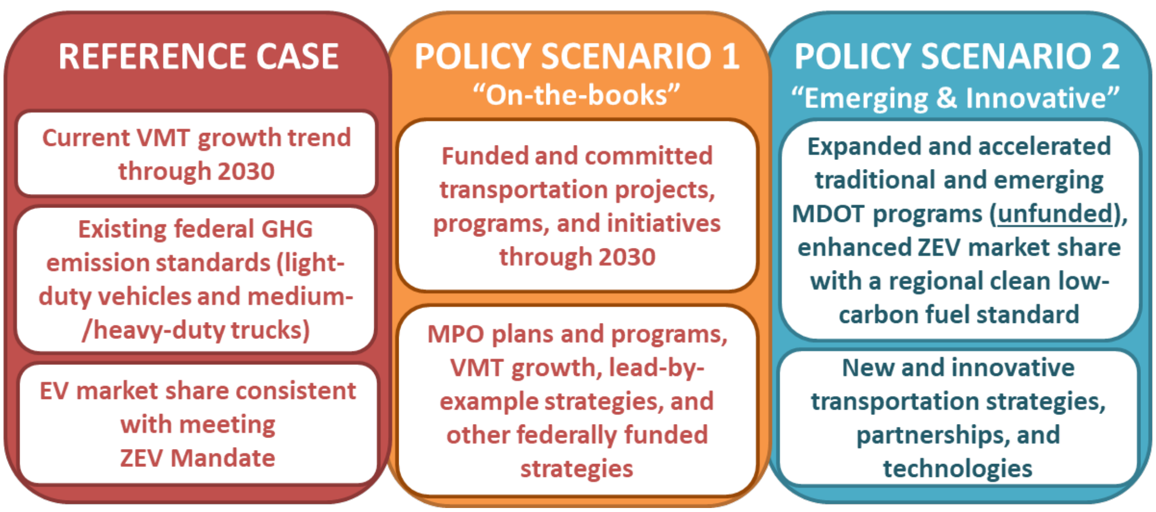
According to projections by the Maryland Department of Planning (MDP), Maryland may grow to over 6.5 million people by 2030. Coupled with economic expansion and land use change, VMT could increase to over 69 billion by 2030. Reducing emissions from this projected travel activity rests on the four pillars of emission reduction (as shown in **Figure ES 1**). These pillars rely on behavioral change and innovation among all the stakeholders of the State's transportation system, as we transition to a low-carbon emissions pathway to achieve the 2030 goal.

Figure ES 1 The Four Pillars of Emission Reductions in the Transportation Sector

Construct of Scenarios and Strategy Development

While the GGRA goal is "40 by 30" across all economic sectors in Maryland, MDOT's analysis applies the same goal for the transportation sector as the current and projected largest contributor of GHG emissions in Maryland by 2030. The policy scenarios and results are presented in **Figure ES 2**.

Figure ES 2 MDOT GGRA Plan – Scenario Construct



The 2006 Baseline Inventory established the base conditions for the GHG reduction goals in the GGRA (25 percent by 2020 and 40 percent by 2030). The on-road portion of the emissions inventory represents a "bottom-up" approach to estimating statewide GHG emissions based on roadway congestion levels, traffic volumes, and vehicle fleet data. GHG emission estimates for on-road transportation in 2014 and 2017 baselines reflect an alignment with actual conditions based upon the process for developing the U.S. Environmental Protection Agency's (EPA) National Emissions Inventory (NEI).

Reference Case – This scenario assumes a constant 1.2 percent annual VMT growth rate (the annual average since 1990) through 2030 combined with full implementation of current federal emission and fuel standards. With the full implementation of final federal vehicle and fuel standards through 2030, total on-road GHG emissions could decrease by 6.35 mmt CO_2e[1], bringing 2030 emissions 20 percent below 2006 emissions. Maryland meeting the Zero Emissions Vehicle Memorandum of Understanding (ZEV MOU) target of 535,000 ZEVs registered in Maryland by 2030 (9.9 percent of the light-duty vehicle fleet) will result in an additional 1.66 mmt CO_2e reductions. **This results in a reduction to 22.71 mmt CO_2e from on-road mobile sources in 2030, a 26 percent reduction from 2006.**

Policy Scenario 1 "On-the-Books" – As its name indicates, this scenario evaluates the emission reductions from funded projects and programs. This includes projects and programs in the CTP, land development assumptions consistent with local plans and MDP's goals, and GHG reducing projects included in fiscally constrained MPO metropolitan transportation plans. This scenario represents a best-case outcome for implementation of all currently funded programs through 2030. The total estimated statewide reduction as a result of implementing Policy Scenario 1 in 2030 is 2.19 mmt CO_2e. **The result is a reduction to 20.53 mmt CO_2e from on-road mobile sources in 2030, a 33 percent reduction from 2006.**

Policy Scenario 2 "Emerging and Innovative" – This scenario acknowledges that attaining the 2030 goal will require additional investments to expand or accelerate deployment of previously planned strategies. This could include expanding their scope of application, deployment of new best-practice strategies, and capitalizing on the opportunities created by new transportation technologies by enabling policies and providing incentives.

All the strategies in Policy Scenario 2 require additional funding and, in some cases, private sector commitment. The 22 strategies in this scenario (16 emerging and 6 innovative) represent a combination of approaches to reduce GHG emissions with varying levels of confidence and MDOT responsibility. The total estimated statewide reduction in 2030 under Policy Scenario 2 is estimated between 4.539 and 6.417 mmt CO_2e. **The result is a reduction to 15.70 mmt CO_2e from on-road mobile sources in 2030, a 49 percent reduction from 2006.**

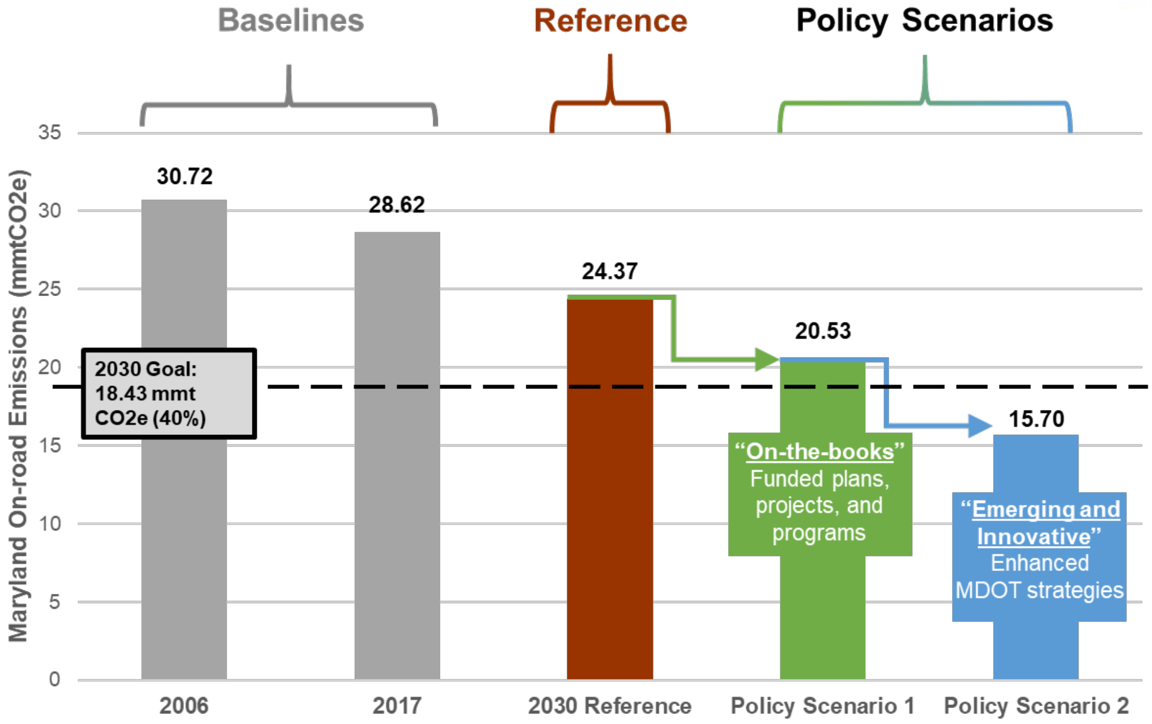
This scenario suggests that achieving the 40 percent reduction is possible; however, the transportation sector will need a new infusion of revenues and partnerships to make this a reality. The strategies in both scenarios create opportunities for significant co-benefits beyond reduced fuel consumption and GHG emissions, including improved air and water quality, public health benefits, more equitable transportation options and access to opportunity, and direct and indirect economic impacts for current and future Maryland workers and employers.

The COVID-19 pandemic resulted in a decrease in VMT and congestion on Maryland roadways as many employers switched to telework. This, coupled with advancement in transportation technology, will result in lower GHG emissions in Maryland. Nonetheless, as long-term national trends continue to show an increase in VMT and decrease in transit ridership as an externality resulting from social-distancing measures, it is important that the State continue to develop solutions that address modern preferences, such as mobile applications that offer riders real-time bus tracking, or investment in travel time reduction and facility-wide comfort.

Figure ES 3 shows how far the transportation sector in Maryland can get in terms of emission reductions by 2030 as a result of implementing the two policy scenarios.

[1] Note: CO_2e represents CO_2 equivalents, which is a measure of GHG emissions that considers the global warming potential of each GHG, including CO_2, methane, and nitrous oxides. More information is available through US EPA here.

Figure ES 3 MDOT GGRA Plan – Scenarios and Potential Emissions Reductions



Implementation Costs

A majority of the strategies require an influx of capital funding for implementation. These include facility construction costs, the cost of acquiring right-of-way, purchasing rolling stock or vehicles for transit, and technology costs for equipment and infrastructure.

Policy Scenario 1 total estimated cost is $14.091 billion. These costs are based on CTP outlays, ongoing investments in current MDOT programs from 2026 to 2030, and funded projects and programs in MPO MTPs planned for implementation by 2030. These programs are included within fiscally constrained plans based on projected revenue sources available to fund the programs for implementation.

Policy Scenario 2 total estimated cost, *not including potential investments in MAGLEV or Loop*, ranges from $11.593 billion up to $15.585 billion (total funding levels of around 80 to 110 percent above current fiscally constrained plans). A balanced investment approach is needed to identify and prioritize strategies for funding based on cost effectiveness, reduction potential, and overall feasibility including readiness of policy adoption, public acceptance, and a supportive regulatory environment for rolling out new technologies.

The path to "40 by 30" for the transportation sector is beset with implementation challenges and uncertainties, while also having the potential to capitalize on known and unknown opportunities. MDOT's approach takes a careful, fact and research-driven approach to gauge what is realistic by 2030. Given the vitality of the transportation sector for maintaining and enhancing the economic prosperity of Maryland's citizens and its contribution as the largest source of GHG emissions in Maryland, a firm commitment to fulfilling the sector's resource and implementation challenges will enable the state to meet the GGRA goals.

1. Background and Approach

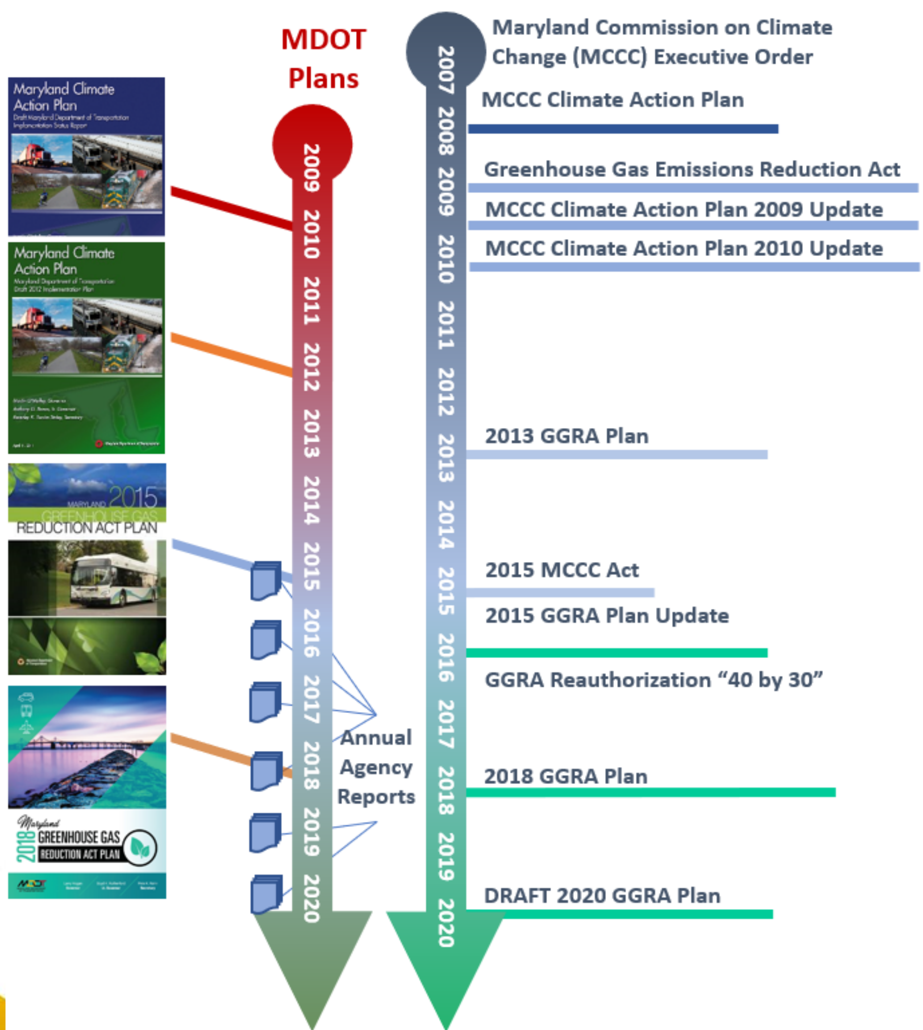
The Greenhouse Gas Reduction Act (GGRA) Plan presents the Maryland Department of Transportation's (MDOT) blueprint for reducing greenhouse gas (GHG) emissions from the transportation sector through 2030. The Plan includes information on emission reductions, co-benefits, implementation considerations, and costs of a diverse set of strategies and scenarios developed in coordination with the Maryland Department of Environment (MDE), other State agencies, and regional and local partners.

Greenhouse Gas Reduction Act and Maryland Commission on Climate Change

Maryland adopted the 2009 GGRA in June 2009. MDOT began working with stakeholders to develop a comprehensive approach to reduce GHG emissions from the transportation sector through 2020 and beyond.

In 2016, Maryland reauthorized the 2009 GGRA, refocusing efforts on a new goal of reducing GHG by 40 percent of 2006 emissions by 2030 ("40 by 30"). This plan represents MDOT's draft approach toward achieving the 2030 goal, which will be finalized through development of the required 2020 GGRA Plan. An overview of the history, showing MDOT's role relative to the activities of the Maryland Commission on Climate Change (MCCC), is highlighted in **Figure 1.1**.

Figure 1.1 MDOT's Contribution to Climate Change Planning in Maryland



Purpose of the Plan

The Plan presents the progress made by the transportation sector in reducing GHG emissions, the trends affecting GHG emissions through 2030, and the anticipated benefits of planned MDOT strategies to support achieving the “40 by 30” goal. The Plan’s purpose is to:

- Present transportation sector accomplishments since 2009;
- Discuss broad trends impacting vehicle miles traveled (VMT), vehicle technology, and fuel use, as well as the associated emission outcomes of these trends;
- Identify specific actions, including costs and benefits, for implementation through 2030; and
- Assess the transportation sector’s contribution to the overall 2030 emission reduction goal.

Recent and Ongoing MDOT Actions

MDOT, through annual status reports to the Governor’s Office and General Assembly, provides a review of recent, ongoing, and planned activities aimed toward meeting the GGRA goals across three different implementation tiers: policy, programs, and data. These plans are available for review here.

Transportation Technology

As a leader in implementing emerging transportation technologies, MDOT is leading various initiatives including the Maryland Zero Emission Electric Vehicle Infrastructure Council (ZEEVIC), connected and automated vehicle (CAV) technology, and renewable energy.

- Total registered Electric Vehicles (EVs) in Maryland stands at 29,268 as of December 31, 2020.
- MDOT is completing its Fleet Innovation Plan which will support the conversion of MDOT’s light-duty and bus fleet to Zero Emission Vehicles (ZEVs).

Congestion Mitigation

MDOT continues its comprehensive and innovative approach to mitigating congestion and improving travel and freight reliability through various initiatives, including those within Transportation Systems Management and Operations (TSMO).

- In 2019, the Coordinated Highways Action Response Team (CHART) Program cleared 31,750 traffic incidents and assisted 39,500 motorists on Maryland highways. The program saved drivers $1.4 billion in delay and fuel costs through effective traffic incident management, traveler information, and emergency services.

VMT Reduction

MDOT invests in low-emissions travel modes (transit, bicycle, and pedestrian) and provides commuting incentives and information under the Commuter Choice Maryland Travel Demand Management Program.

- MDOT Maryland Transit Administration (MTA) continues its railcar replacement program, replacing 78 railcars to improve passenger comfort and travel time reliability, and enhancing safety components on the Metro SubwayLink system.
- MDOT MTA launched real-time tracking for MARC Train service in August 2020 to improve traveler information and system management.

Infrastructure Design

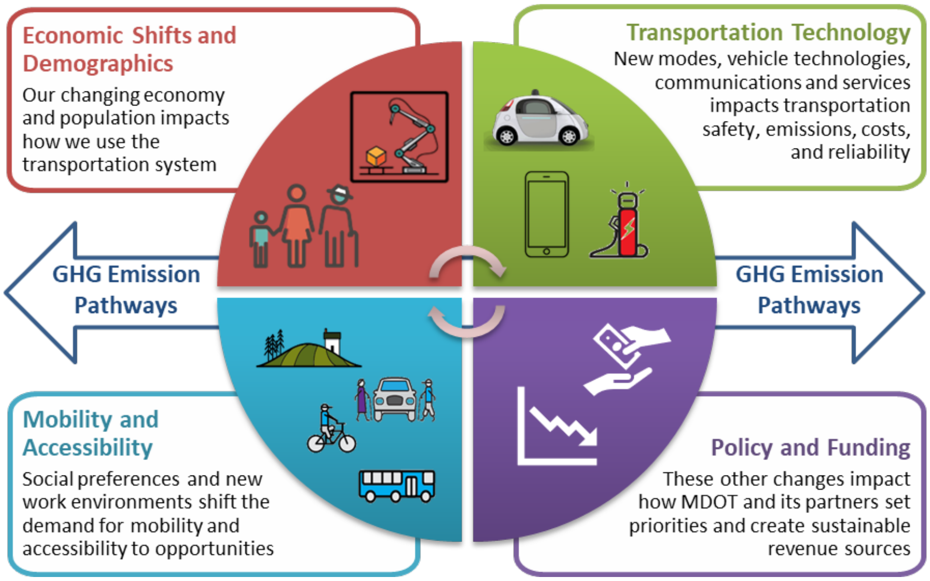
MDOT continues to emphasize the importance of reducing emissions through design principles including practical and innovative project implementation.

- MDOT Transportation Secretary's Office (TSO) published design guidance for projects applying for MDOT Kim Lamphier Bicycle Program funding.
- Maryland Transportation Authority (MDTA) implemented permanent full-time all-electronic (cashless) tolling at all of its facilities across Maryland.

Setting the Context for 2030: Drivers and Trends

Maryland continues to witness significant shifts in the factors impacting transportation demand. The Maryland Transportation Plan (MTP) establishes a 20-year vision for multimodal transportation and outlines the State's transportation policies and priorities to proactively address these shifts. The MTP outlines strategies that support a new framework for transportation investments. **Figure 1.2** shows the four broad drivers which shape the State's transportation emissions pathways through 2030 and beyond.

Figure 1.2 Drivers and Trends

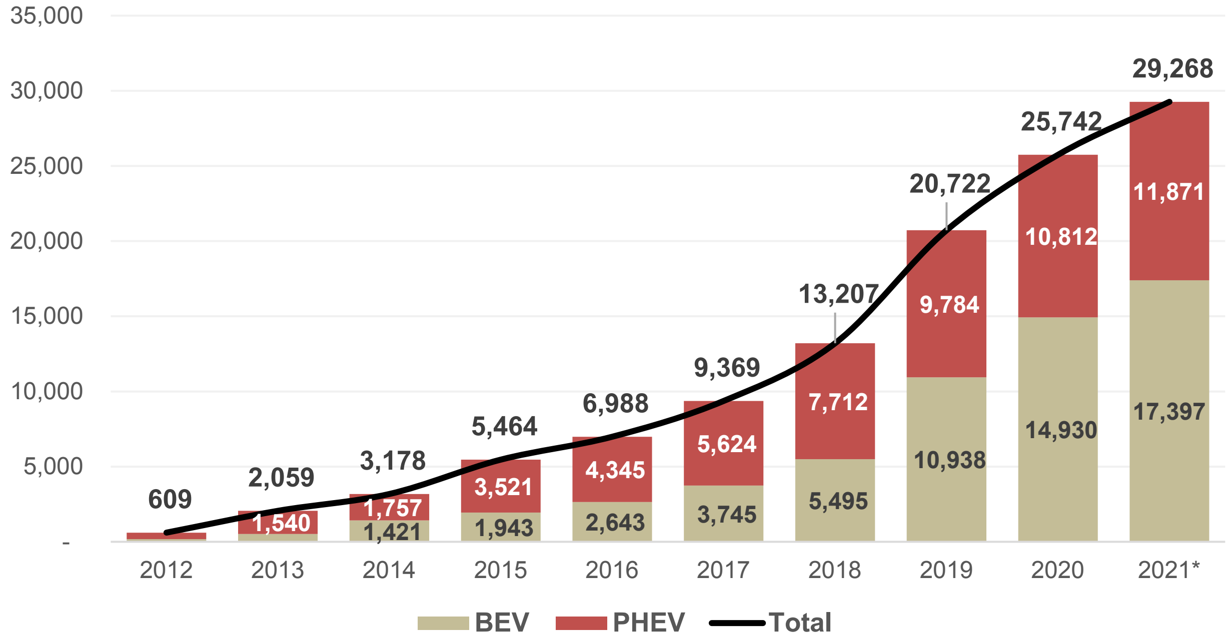


Economic shifts and changing demographics are the key drivers of demand for travel in Maryland. MDOT's balanced transportation system connects system users and customers to life's opportunities. In areas of the state with high population density, residents tend to rely more on mass transit and non-motorized transportation modes, while those living in rural, ex-urban, and less populated areas rely on motor vehicles for connectivity and access.

Emerging **mobility and accessibility** trends toward a "sharing economy" in transportation and changing logistics and supply chain patterns will influence the use of the transportation system. Given the expansive scope of the origins and drivers of these trends, MDOT has very limited control in how they will play out. Through the MTP and other long-range planning activities, MDOT and its partners will balance demand and available resources to accommodate current needs and create the 2030 and beyond transportation network.

Maryland is a leader in adopting **transportation technologies**. Through the Clean Cars Program, Maryland adopted more stringent standards for vehicles purchased in the State. **Figure 1.3** shows the number of EVs registered by fiscal year since the start of the Clean Cars Program in 2011. MDOT also leads a workgroup dedicated to ensuring that CAV technology is deployed safely and thoughtfully on Maryland's roads. Through facilitation of enabling policies for innovative and low-emissions transportation technologies, MDOT is positioning Maryland to achieve the full potential GHG emission benefits afforded by new vehicle technologies.

Figure 1.3 Registered Electric Vehicles in Maryland by Fiscal Year



* FY 2021 registrations as of Dec 31, 2020

MDOT supports strategies across every mode of transportation – improving the customer experience on the transportation network by improving safety, reducing congestion, providing more convenient travel options, increasing connections between modes, and improving the flow of goods. MDOT's multimodal transportation investment **policy and funding** priorities demonstrate commitment to reducing emissions in the transportation sector.

MDOT tracks the total share of Consolidated Transportation Program (CTP) funding dedicated to projects that will help Maryland meet its climate change goals. In the FY 2020–2025 CTP, 65 percent (approximately $7.05 billion) of Maryland's $10.85 billion six-year major capital program are investments that will reduce GHG emissions. These investments range from connecting Maryland with expanded transit options to addressing highway congestion to optimizing waterways and intermodal facilities for trade.

The economic challenges and uncertainty surrounding the COVID-19 global pandemic have impacted virtually all MDOT operations and revenues. In response, MDOT has reduced its revenue projections. Estimated State revenues for the Draft FY2021 – FY2026 CTP are $2.6 billion less than the estimates for the FY2020 – FY2025 CTP (reducing total projected capital spending by almost 18 percent).

2. 2030 Modeling Approach and Considerations

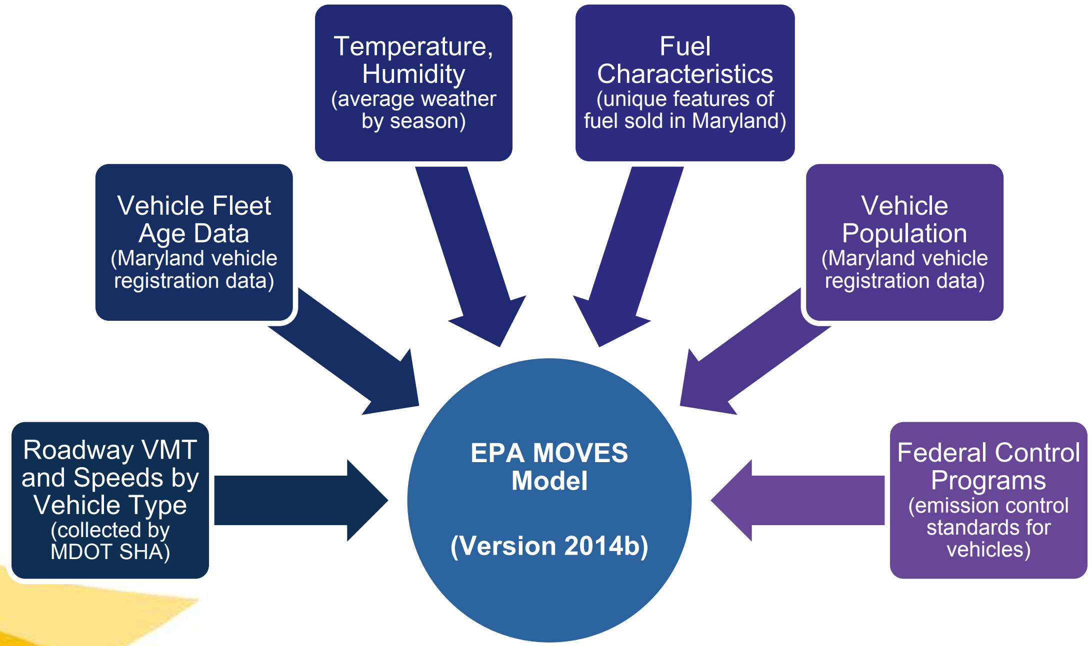
Emission reduction strategies and scenarios in this Plan pivot from the 2006 Base Year GHG emissions inventory. MDOT refers to 2006, 2014, and 2017 inventories as "Baseline Scenarios."

- The 2006 Baseline Inventory established the base conditions for the GHG reduction goals in the GGRA (25 percent by 2020 and 40 percent by 2030). The on-road portion of the emissions inventory represents a "bottom-up" approach to estimating statewide GHG emissions based on travel speeds and traffic volumes. This approach utilizes emission rates from the U.S. Environmental Protection Agency's (EPA) MOVES (Motor Vehicle Emissions Simulator) model and Maryland reported VMT.
- GHG emission estimates for on-road transportation in 2014 and 2017 baselines reflect an update to actual conditions based on the process for developing EPA's National Emissions Inventory (NEI). The statewide inventories represent traffic conditions based on roadway segment counts, reported speed data from MDOT State Highway Administration (SHA), and the vehicle technology standards in place for each inventory.

Technical Approach

MDOT's technical approach to analyzing GHG emission outcomes and co-benefits continues to evolve with new and updated tools. In addition, there are new assumptions for consideration with each iteration of inventory development, including economic growth, socioeconomics, vehicle and fuel technology, and transportation funding trends. As in prior analysis, the EPA's MOVES model remains the primary tool for estimating on-road GHG emissions. This model has improved from previous MDOT analyses, as have the inputs from MPO metropolitan transportation plans and statewide planning forecasts. **Figure 2.1** highlights the primary inputs into the MOVES model for each emissions inventory.

Figure 2.1 Emissions Inventory Modeling and Inputs



2030 Reference Case

The 2030 Reference Scenario includes the Maryland Clean Cars Program and federal vehicle technology and fuel economy standards, and federal renewable fuels standards in place in 2020 (at the time of emissions modeling). Implementation of these state and federal vehicle and fuel standards yields a substantial GHG emissions reduction for on-road emissions from cars and trucks through 2030. The technology advances are designed to improve vehicle fuel economy and reduce average GHG emissions per mile. The benefits will increase over time as older vehicles are replaced with newer vehicles. A summary of these standards is presented in **Table 2.1**.

Table 2.1 2030 Approach Overview – Standards and Programs

Light-Duty Vehicle (passenger cars and trucks) Standards

- ***The Maryland Clean Car Program (Model Year 2011)*** – Implements California's Low-Emission Vehicle (LEV) standards to vehicles purchased in Maryland. The California LEV program also includes goals for the sale of EVs (adopted 2007).
- ***Corporate Average Fuel Economy (CAFE) Standards (Model Years 2008-2011)*** – Vehicle model years through 2011 are covered under CAFE standards. These remain intact under the National Program.
- ***National Program (Model Years 2012-2016)*** – The light-duty vehicle fuel economy standards for model years between 2012 and 2016. The fuel economy improvements increase over time until an average 250 gram/mile CO_2 standard is met in 2016. This equates to an average fuel economy near 35 mpg (published May 2010).
- ***National Program Phase 2 (Model Years 2017-2020)*** – The light-duty vehicle fuel economy standards for model years between 2017 and 2020. These standards were projected through model year 2025 but were replaced by the SAFE Vehicle Rule. (The National Program Phase 2 was originally published October 2012.)
- ***Safer Affordable Fuel-Efficient (SAFE) Vehicle Rule (Model Years (2021-2026)*** – The light-duty fuel economy standards for model years 2021-2026. SAFE replaces the Phase 2 National Fuel Economy Program. Under SAFE, the rollback to standards equate to an estimated miles per gallon efficiency of 40.4 mpg compared to the previous rule that would have achieved 54.5 mpg (published April 2020). Note, this rule is currently under review per Executive Order by the Biden Administration on January 20, 2021.

Medium-/Heavy-Duty Vehicle (trucks and buses) Standards

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

Fuel Standards

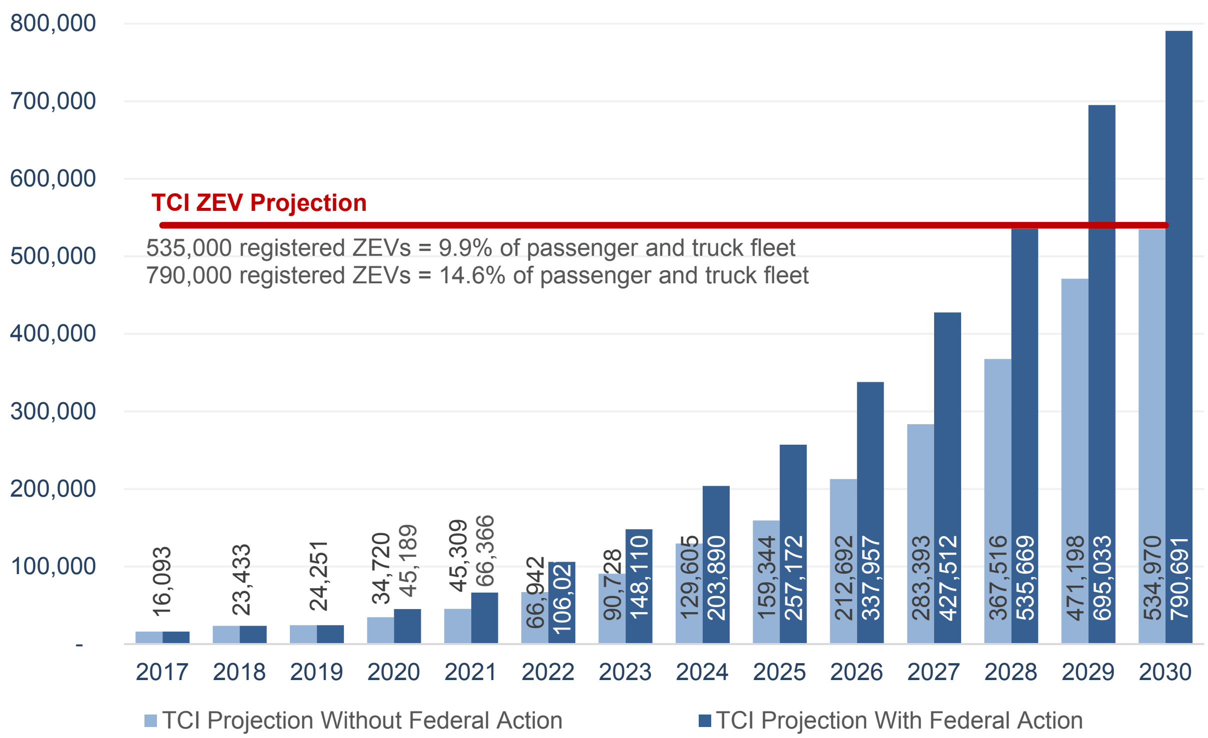
- ***Tier 3 vehicle and fuel standards*** – The rule establishes more stringent vehicle emissions standards and will reduce the sulfur content of gasoline from current average level of 30 ppm to 10 ppm beginning in 2017. The gasoline sulfur standard will make emission control systems more effective for both existing and new vehicles and will enable more stringent vehicle emission standards. The vehicle standards will reduce both tailpipe and evaporative emissions from gasoline powered vehicles (published April 28, 2014).
- ***The Federal Renewable Fuel Standard Program (RFS2)*** – Mandates the use of 36 billion gallons of renewable fuel annually by 2022 (published March 2010). Based on an approach utilized by the Metropolitan Washington Council of Governments (MWCOG), the use of renewable fuels will represent a 2 percent reduction in total on-road gasoline CO_2 emissions in 2030.

Electric Vehicles

Initiatives to encourage the purchase and use of electric and other low and ZEVs are part of Maryland's efforts to reduce emissions from mobile sources by providing alternatives to conventional internal combustion engine vehicles. EVs include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). Achieving the goals as part of Maryland's participation within the ZEV Memorandum of Understanding (ZEV MOU) reflects a commitment to a low-emissions fleet that goes beyond what the federal standards require. The path from nearly 30,000 PHEVs and BEVs registered in Maryland in December 2020 to between 535,000 vehicles (without Federal action) and 790,000 vehicles (with Federal action) by 2030—as estimated by the Transportation and Climate Initiative (TCI)—will require a combination of opportunities to come together. Maryland is striving to meet this goal through aggressive deployment of EVs and the charging stations necessary to support their adoption.

Figure 2.2 presents the projected ZEV deployment curve through 2030 starting from 2017. Costs to Maryland to facilitate this level of deployment includes up to $1.2 million annually through 2030 for the Electric Vehicle Recharging Equipment Rebate Program and other capital costs associated with matching federal grants to expand public EV charging infrastructure throughout Maryland.

Figure 2.2 ZEV Deployment Projections Through 2030



Multi-State Medium- and Heavy-Duty Zero Emission Vehicle MOU

In July 2020, Maryland signed the Multi-State Medium-and Heavy-Duty Zero Emission Vehicle (MHDV) MOU, joining 14 other states and the District of Columbia, to address GHG pollution from medium-and heavy-duty vehicles through the electrification of large pick-up trucks and vans, delivery trucks, box trucks, school and transit buses, and long-haul delivery trucks.

The Multi-State MHDV MOU will identify barriers to the electrification of medium- and heavy-duty vehicles and will develop solutions to support the deployment of zero emission medium-and heavy-duty vehicles. The MHDV MOU identifies a target of 30 percent of all medium- and heavy-duty vehicle sales will by ZEVs by 2030. Maryland has outlined a Maryland Clean Truck Planning Framework that engages stakeholders and communities to collaboratively develop an action plan to reduce air pollution and GHG emissions from the trucking industry, while preserving existing jobs and creating new jobs.

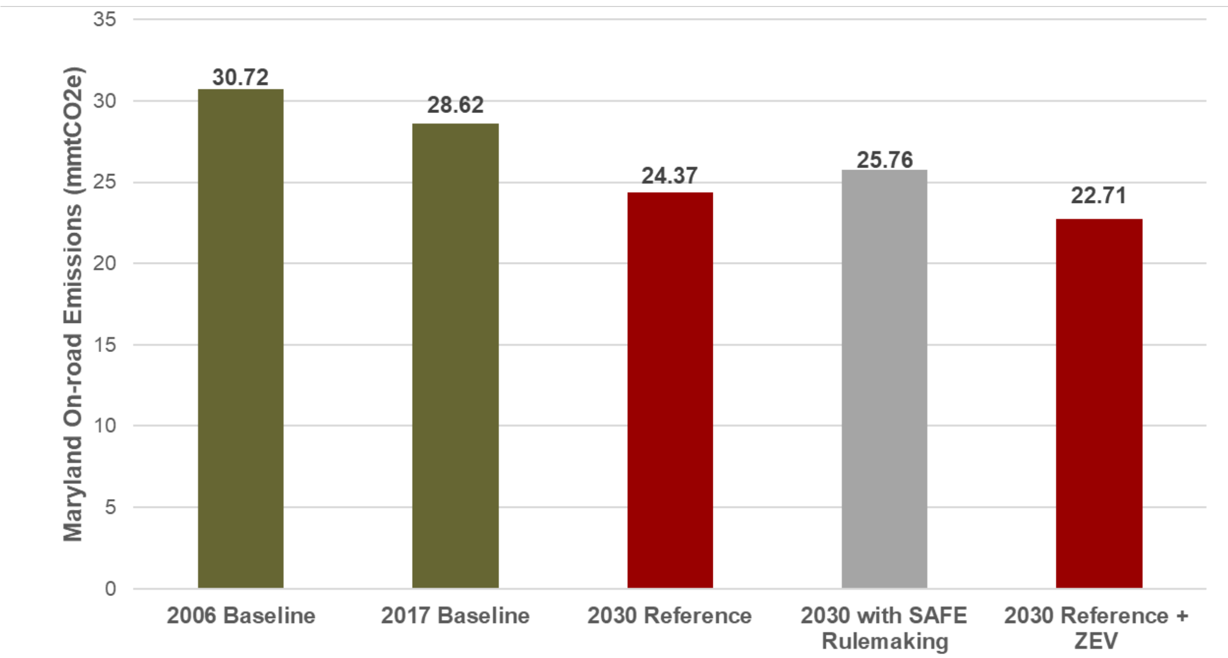
2030 Reference Scenarios Emission Outcomes

With the full implementation of federal standards through 2030, total on-road GHG emissions could decrease by 6.35 mmt CO_2e compared to 2006, bringing 2030 emissions to 20 percent below 2006 emissions.

The impact of the SAFE Vehicles Rule through 2026 model year is forecast to increase GHG emissions by 1.39 mmt CO_2e. This result represents a potential worst-case scenario associated with implementation of the SAFE Vehicles Rule. Ultimately, the emissions impact of this standard change is uncertain given the executive action noted in **Table 2.1** and that auto manufacturers may choose to exceed federal standards, particularly in state's like Maryland that are committed to the California standards. **Figure 2.3** presents each component of the Baseline Scenarios and the Reference Scenario.

If fuel economy standards continue to increase by five percent per year from 2026 through 2030, an additional decrease of 0.80 mmt CO_2e would result from the vehicle technology standards. This assumption has been included under Policy Scenario 2 given the uncertain standards beyond 2025.

Figure 2.3 Baseline and Reference Scenarios



Presuming the current federal vehicle standards are fully implemented, and Maryland meets the 535,000 EV goal by 2030, **total on-road GHG emissions could decrease by another 1.66 mmt CO_2e, bringing 2030 emissions to 26 percent below 2006 emissions.**

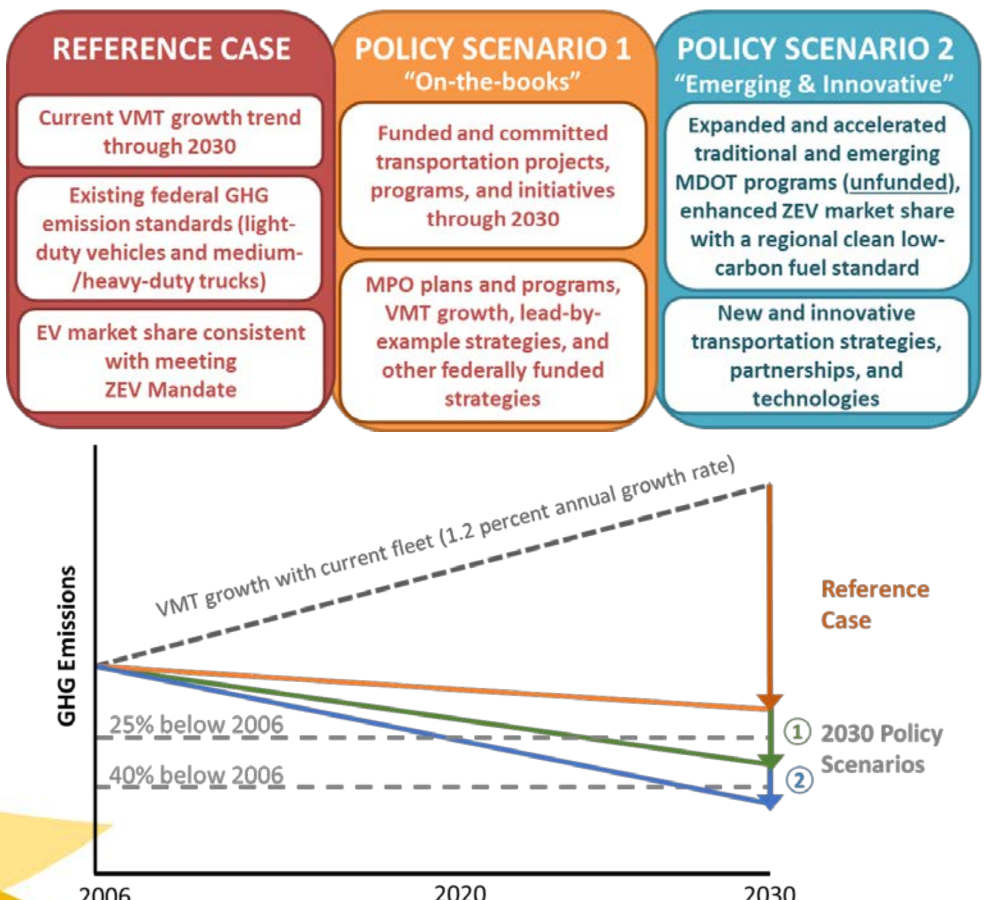
2030 Strategies and Scenarios Development

MDOT has developed scenarios and associated strategies, consistent with the goals, objectives, and strategies in the 2040 MTP, to put Maryland's transportation sector on a path toward the "40 by 30" goal. While there is some certainty established with transportation funding over the next six years (2020 – 2025) through the CTP, there are significant projects and programs in early planning stages, plus other technological changes such as the shift to an electric fleet, automated and connected vehicles, and the rise of mobility-on-demand services that could greatly change the landscape through 2030. **Appendix B** lists each GHG mitigation strategy evaluated under the two policy scenarios, with strategy descriptions and underlying contextual and cost assumptions. MDOT coordinated its scenario organization and strategy assumptions with MDE for maintaining consistency with the Mitigation Work Group (MWG):

- **Policy Scenario 1:** Extension of the current policy and program framework within the Reference Case including funded plans, projects, and programs; and
- **Policy Scenario 2:** New programs and policies beyond Policy Scenario 1 that are not currently funded.

Figure 2.4 depicts the overall strategy and high-level definitions for this scenario approach focused on the on-road transportation sector. Off-road transportation strategies and scenarios (aviation, marine, and rail) are developed and analyzed through a partnership approach between MDOT and MDE and presented separately.

Figure 2.4 2030 Scenarios and Strategies Approach



3. Policy Scenario 1 – On-the-Books

Policy Scenario 1 includes projects and programs funded within MDOT's 2020-2025 CTP, expected investments in continuing MDOT GHG emission reduction strategies included in current (2021-2026) and future CTPs through 2030, as well as projects in fiscally constrained MPO metropolitan transportation plans for implementation by 2030.

2030 Plans and Programs

MDOT continually takes steps to plan, invest in, and evaluate the transportation system to ensure it connects customers to key destinations–enabling a growing economy. MDOT sets a vision for the transportation system through the MTP, which is then implemented through the six-year budget for transportation, projects produced annually as the CTP. In coordination with MDOT, Maryland's MPOs develop federally required metropolitan transportation plans. These plans carefully combine locally driven projections of future land use with stakeholder input on transportation needs to develop fiscally constrained list of long-term transportation investments over the next 25 years. The 2030 Plans and Programs use information from the CTP, each MPO plan, and land use, population, and employment projections from the Maryland Department of Planning (MDP) to estimate the emission trendline through 2030. The plans and programs are also referenced in this report as "on-the-books" (or Policy Scenario 1) to reflect that these actions are programmed for implementation by MDOT.

The primary benefit of the plans and programs relative to the Reference Scenario is the reduction in VMT and improved operational efficiency of the multimodal transportation system. **Figure 3.1** presents Maryland's VMT trend since 2006 and the alternative VMT projections (Reference Case compared to Policy Scenario 1) for 2030.

Other "On-the-Books" Strategies

Along with the traditionally funded transportation programs and investments assumed within the 2030 Plans and Programs, Policy Scenario 1 also assumes other "on-the-books" strategies that have been implemented with funding from Federal agencies (like the Department of Energy, EPA, and others) for improving air quality and reducing GHG emissions. Examples include Diesel Emissions Reduction Act (DERA) funding to replace or repower diesel engines, marine vessels, and cargo handling equipment. One such strategy includes MDOT MPA's support to replace dray trucks, which results in air quality benefits within the Port of Baltimore area where they operate. Policy Scenario 1 also estimates the emissions impacts of current diesel transit bus replacement policies toward clean diesel and compressed natural gas for MDOT MTA, locally operated transit systems (LOTS), Washington Metropolitan Area Transit Authority (WMATA), and Baltimore/Washington International Thurgood Marshall (BWI) Airport shuttle buses.

Strategy, Emissions, and Cost Summary

Table 3.1 lists the Policy Scenario 1 strategies, GHG reduction potential, and estimated costs for implementation. For example, investments in MPO plans and programs yield the highest emission reduction, but also have the highest cost ($10.1 billion).

Figure 3.1 VMT and VMT per Capita Trends, including Policy Scenario 1

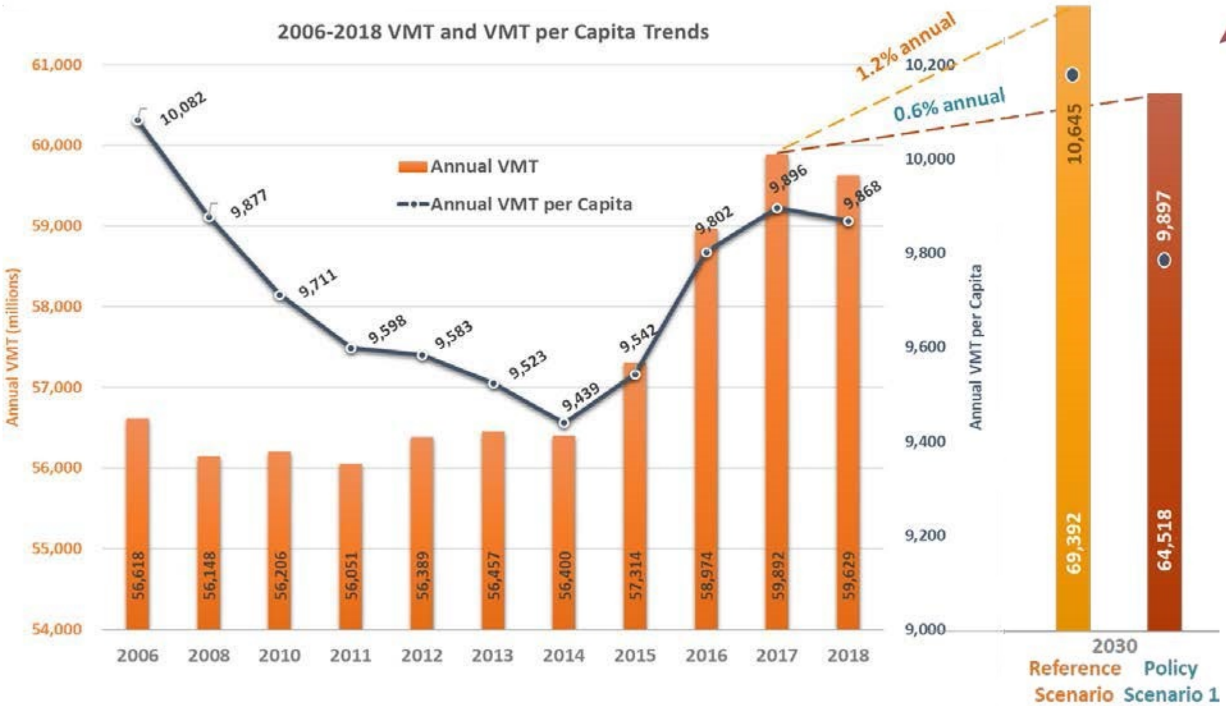


Table 3.1 Policy Scenario 1 Strategies Summary Table

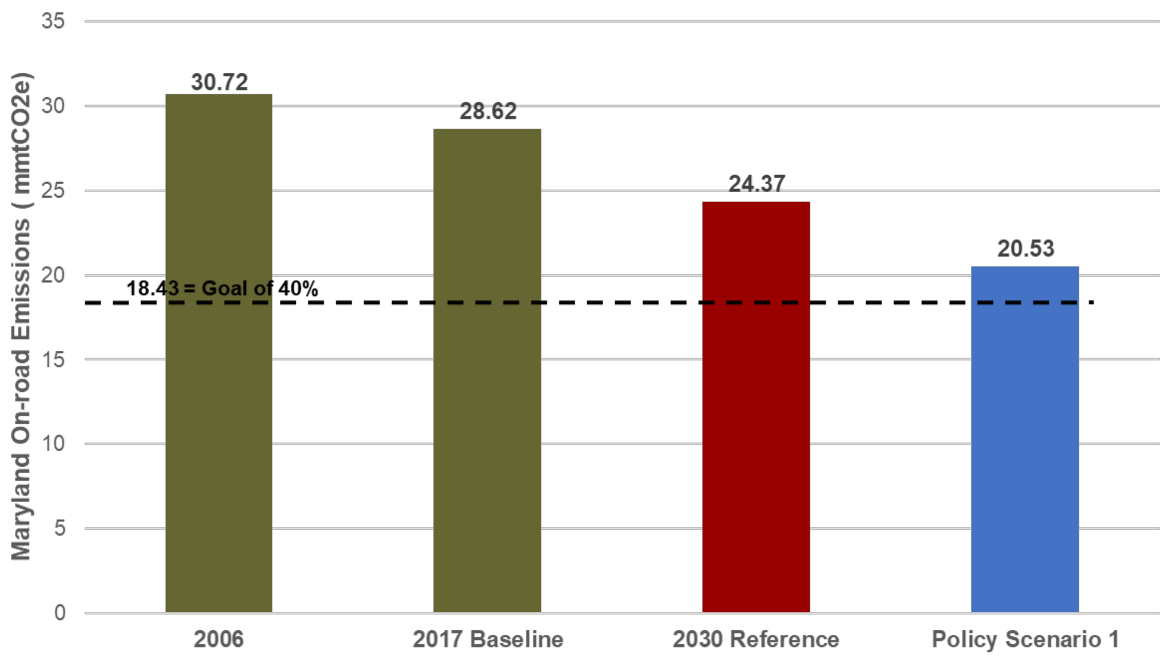
Strategies (Funded)	GHG Emission Reduction (mmt CO_2e)	Estimated Costs ($M)
2018/2019 MPO Plans & Programs yield lower annual VMT growth (estimated at 0.6% per year growth)	1.712	$10,146.5
On-Road Technology (CHART, Traveler Information)	0.142	$247.0
Freight and Freight Rail Programs (National Gateway, Howard Street Tunnel, MTA rail projects)	0.037	$503.2
Public Transportation (New rail or bus capacity or frequency, improved operations)	0.011	$2,009.8
Public Transportation (50% EV transit bus fleet)	0.074	$625.1
Intercity Transportation Initiatives (Amtrak NE Corridor, Intercity bus)	0.006	$0.0
Transportation Demand Management	0.146	$63.9
Pricing Initiatives (Electronic Tolling)	0.022	$188.5
Bicycle and Pedestrian Strategies (current program continuation and expansion through 2030)	0.024	$263.8
Port of Baltimore Drayage Track Replacements	0.005	$18.0
BWI Airport parking shuttle bus replacements	<0.001	$26.1
MDOT Vehicle Fleet (Fleet Innovation Plan)	0.006	n/a
Total Policy Scenario #1	**2.19**	**$14,091.9**

Emissions Outcomes

Figure 3.2 presents the emission outcomes from Policy Scenario 1, compared to the 2030 Reference and the 2006 and 2017 Baselines.

- **The total estimated statewide reduction in 2030 is 2.19 mmt CO_2e. This brings the emissions levels to 20.53, resulting in 2030 emissions at 33.2 percent below 2006 emissions (*2.10 mmt CO_2e short of the 18.43 mmt CO_2e goal*).**
- Strategies that reduce VMT, including the plans and programs and other on-the-books strategies, result in a total reduction of **5.585 billion VMT in Maryland by 2030, equivalent to an 8 percent VMT reduction** relative to business-as-usual VMT growth.

Figure 3.2 Policy Scenario 1 Emission Outcomes



Implementation

Strategies listed as part of Policy Scenario 1 are funded in the six-year MDOT CTP (FY 2020-FY 2025), MPO metropolitan transportation plans, or through federal grants and funding sources. The total cost of Policy Scenario 1 is $14.092 billion in capital investment through 2030. This does not include additional operating costs for expanded transit or other services implemented by 2030. The objective of constructing Policy Scenario 1 is to group programs and strategies that are completely funded or expected to be funded based on current funding levels and assumptions, and thereby have a high certainty of successful implementation by 2030.

The challenges for Policy Scenario 1 strategies include widely acknowledged concerns such as diminishing fuel tax revenue relative to infrastructure costs, which is a primary funding mechanism for the Maryland Transportation Trust Fund (TTF). Another related challenge is continued diminishing returns relative to needs from federal sources, particularly formula funds provided through Federal Highway Administration (FHWA) and Federal Transit Administration (FTA). MDOT and its partners also have to deliver this program, while at the same time prioritizing funds to support maintaining and operating Maryland's multimodal transportation system.

4. Policy Scenario 2: Emerging and Innovative

This scenario envisions implementing two distinct categories of GHG mitigating strategies—emerging and innovative strategies. The key distinction between the Policy Scenario 1 strategies and these strategies is the potential funding available for implementation. Funding sources for emerging and innovative strategies have not been finalized in any planning documents by federal, State, local or private agencies. For a number of these strategies, MDOT has limited control in their execution. Some of these strategies are driven by market forces that require MDOT to play the role of a facilitator enabling supportive policy and regulatory framework for their implementation.

Emerging Strategies

Emerging strategies can be defined as logical next steps for strategies that are currently funded in Policy Scenario 1, whose implementation requires one or more of the following:

- Full implementation of a strategy where current fiscally constrained plans have not identified the complete funding approach.
- Expanded application of the strategy by enhancing its geographic scope, accelerated implementation of a strategy that would otherwise not be implemented before 2030, and implementation ramp-up of a strategy involving its intensity of application.
- Strategies that have been implemented in peer states that could work in Maryland.
- Expanded policy impetus and partnerships for a regional scale strategy application.

Emerging strategies have a demonstrable record of mitigating emissions based on practice. However, there is still some uncertainty, especially as it relates to the rate of adoption of new technologies by policymakers and the general public. Examples of such strategies include adoption of EVs by the public and transition to an electric bus fleet by transit agencies.

Innovative Strategies

Among the strategies grouped under innovative strategies in Policy Scenario 2 are those that are “disruptive” or undergoing breakthroughs in innovation, having impact on a significant user base and broad market reach, and having the potential to alter status quo in the way people make and execute their travel choices. These strategies are also characterized by uncertainty in the technological and policy maturity that is required for widespread adoption. Examples of strategies that require policy and technological maturity are CAV technologies, zero emission truck corridors, and SCMAGLEV or Loop. Some strategies have been implemented on a controlled or limited scale by pioneering jurisdictions—for example, freight consolidation centers and variable speed management corridors. MDOT’s role in implementing some of these strategies is by playing the role of a facilitator and a policy regulator. MDOT can facilitate by providing a safe and conducive environment for Maryland residents and businesses to adopt these new technologies. Challenges to implementing some of these strategies include public funding availability, technological maturity, MDOT’s limited role in strategy facilitation or rolling out an enabling regulatory framework, partnerships with the private sector, transportation safety and data security and privacy, and concerns surrounding public acceptance (for example, speed management on freeways).

Strategy, Emissions, and Cost Summary

Table 4.1 shows a breakdown of estimated GHG reductions between emerging and innovative solutions as well as the estimated cost presented as ranges. The reason for presenting this information in ranges has to do with uncertainty due to scope and intensity of implementation and other externalities that determine their effectiveness by the year 2030.

Table 4.1 Policy Scenario 2 Strategies Summary Table

Strategies (Unfunded)	GHG Emission Reduction (mmt CO_2e)	Estimated Costs ($M)
Emerging Strategies		
TSMO/Integrated Corridor Management (Limited Access System)	0.08 to 0.14	$108 to $152
TSMO//Integrated Corridor Management (Arterial System)	0.10 to 0.18	$453 to $680
Variable Speeds/Speed Management	0.01 to 0.02	$108 to $152
Intermodal Freight Centers Access Improvement	0.02	$2,240 to $3,136
Commercial Vehicle Technologies (Idle Reduction, Low-Carbon Fleet, Dynamic Routing)	0.03 to 0.05	Uncertain §
Regional Clean Fuel Standard	0.895	$148
Eco-Driving (informal implementation underway)	0.042	$3 to $5
EV Market Share Ramp-up of an additional 255,000 vehicles	0.88	$140
Extended CAFE Standards (Model Years 2026-2030)	0.80	$0
Transit capacity/service expansion (fiscally unconstrained)	0.019 to 0.039	$2,307 to $2,659
MARC Growth and Investment Plan / Cornerstone Plan	0.038 to 0.054	$1,078
Transit-Oriented Development (TOD) Build-Out (20 zones)	0.033	$4 to $8
50% to 75% EV Transit Bus Fleet	0.081 to 0.103	$93
Expanded TDM strategies (dynamic)	0.274 to 0.972	$15 to $30
Expanded Telework	0.300 to 0.793	$100 to $200
Expanded bike/pedestrian system development	0.040 to 0.051	$103
Innovative Strategies		
Autonomous/Connected Vehicle Technologies	0.68 to 0.73	$43 to $63
Zero-Emission Truck Corridors	0.03 to 0.06	$34 to $128
Freight Villages/Urban Freight Consolidation Centers	0.03 to 0.04	$4,705 to 6,893
Speed Management on Freeways (increased enforcement)	0.04 to 0.20	$7 to $14
High-Speed Rail/SCMAGLEV	0.011 to 0.021	$45,300 to $47,300
Pay-As-You-Drive Insurance	0.123 to 0.292	n/a §§
Total Policy Scenario #2 "Emerging and Innovative"	**4.539 to 6.417**	**$56,893 to $62,886**

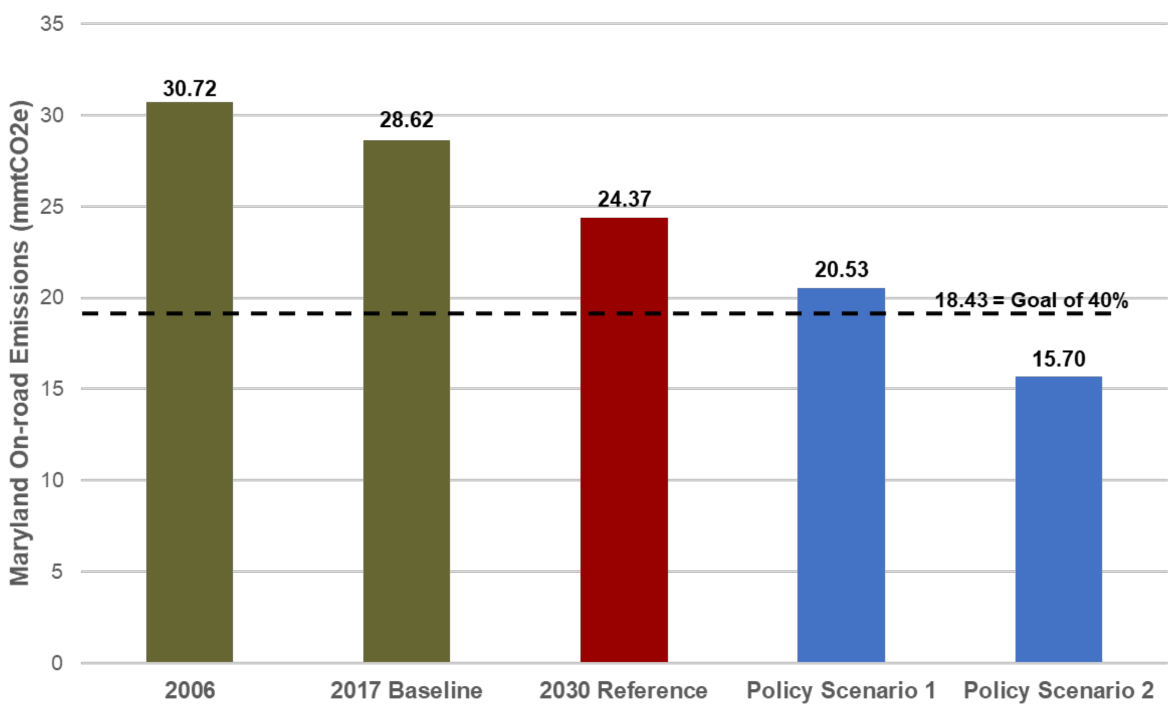
§ Policy change with potential incentive program. Uncertain costs.
§§ Policy action with supportive technology/programs offered by private sector.

Emissions Outcome

Figure 4.2 presents the emission outcomes from Policy Scenario 2, compared to the 2030 Reference and the 2006 and 2017 Baselines.

- The total estimated statewide reduction in 2030 under Policy Scenario 2 is estimated between 4.539 and 6.417 mmt CO_2e. This brings emissions levels to 15.70 mmt CO_2e (low range) to 13.99 mmt CO_2e (high range), demonstrating reduction well beyond the 2030 goal.
- Policy Scenario 2 strategies that reduce VMT result in a total reduction of 4.034 billion VMT (low range) in Maryland by 2030, which is lower compared to the reduction from the Policy Scenario 1. This is due to the majority of Policy Scenario 2 strategies being focused on new technologies and system efficiencies rather than additional transportation capital investments, which are uncertain to be implemented by 2030 given resource realities.

Figure 4.2 Policy Scenario 2 Emissions Outcomes



Implementation

Policy Scenario 2 strategies are currently not funded within MDOT's CTP or the MPO's metropolitan transportation plans for implementation by 2030. Policy Scenario 2 total estimated costs, not including potential investments in SCMAGLEV or Loop, ranges from $11.593 billion up to $15.585 billion.

These strategies require dedicated funding sources outside the current traditional investment sources. It should be noted that some these strategies require significant funding (comparable to the level of the State's entire CTP), which is indicative of challenges to their implementation. MDOT's role in implementation of these strategies is lower than that of the emerging strategies as the driving factors for the successful implementation of many of these strategies involve market forces and require significant share of private funding for execution.

5. Implementation Challenges, Opportunities, and Next Steps

As highlighted by the results presented in this Plan, the on-road transportation sector in Maryland could achieve the “40 by 30” goal. There are a multitude of approaches MDOT and its partners could take to facilitate achievement of the goal. These include substantial investments in multimodal options and financial and policy support of new technologies to push more people and goods toward cleaner and more efficient modes, and to improve the efficiency of transportation system operations. However, many of the most significant GHG reduction strategies are mostly outside the control of MDOT, including notable examples like EV market penetration, CAV technology, and expanded telework.

Maryland’s multimodal transportation network faces a number of challenges including continued need to maintain and modernize infrastructure and ensure the safe and efficient movement of people and goods. MDOT continues to monitor changing transportation needs associated with technological, societal, demographic, land use, climate, and other environmental changes. Opportunities and challenges come hand-in-hand as increasing number of residents and employers in the State will generate additional revenue, but they will also demand services, including transportation services, which could require increased spending. The impact of transportation-related technological changes such as CAVs, EVs, and the shared mobility economy is uncertain, given that the technology maturity and market penetration are yet to play out in the marketplace. MDOT maintains and delivers a transportation system that addresses these challenges to ensure that Maryland remains a great place to live, work, and do business.

Across all of these challenges, Maryland faces the overarching uncertainty associated with the transportation-funding picture through 2030:

- Needs continue to far outweigh available resources and revenues;
- The federal funding picture continues to trend toward a competitive grant program, with less reliance on traditional formula-based funding; and
- Traditional revenue sources are producing less relative to growing demand, particularly as trends continue toward more efficient vehicle and lower ownership rates.

Maryland’s transportation needs are comprised of the costs required to operate and maintain the current transportation system, and to expand services and infrastructure as needed. These costs include operation and maintenance (O&M) expenses, capital needs as provided by MDOT’s six transportation business units (TBUs), and Maryland’s share of financial support form the WMATA system. O&M expenses include the costs of service for more than 100 million annual transit trips, maintenance of highways, bridges and tunnels, dredging for the Port of Baltimore, and operations for the BWI and MTN airports.

Transportation Revenue Sources

Transportation programs and projects in Maryland are primarily funded from an integrated account called the TTF from sources including motor fuel tax, rental car sales tax, titling tax, corporate income tax, operating revenues, federal aid, motor vehicle taxes and fees, and bond sales. The distribution of revenue is subject to a number of federal and state laws that constrain how and for what system revenues can be assigned. More detail on this process is available within documentation in the CTP.

Environmental Co-Benefits

Ensuring environmental protection and sensitivity is a goal of the 2040 MTP. The goal focuses on strategies to deliver sustainable transportation infrastructure improvements that protect and reduce impacts to Maryland’s natural, historic, and cultural resources.

The strategies, policies and programs implemented as part of the two policy scenarios, also achieve substantial reductions of the National Ambient Air Quality Standards (NAAQS) criteria pollutants, including ozone producing volatile organic compounds (VOC) and nitrogen oxides (NOx), and fine particulates (PM2.5). Transportation related control measures and improvements to vehicle technologies that reduce ozone and PM2.5 have been included in State Implementation Plans (SIP) and transportation conformity determinations. These measures are major contributors to meeting the State's air quality goals and have proven to be effective in attaining the NAAQS for ozone and fine particulates.

Advanced vehicle and fuel technologies and the draft GGRA Plan scenarios not only reduce criteria pollutant and GHG emissions, but also indirectly will reduce on-road transportation sources impact on Maryland's water quality and diverse and sensitive ecosystems.

Other Benefits

Public Health. Reductions in emissions could help prevent premature deaths and asthma cases in Maryland, translating to reductions in public health costs. Continued investment in bicycle and pedestrian systems can foster healthier lifestyles for Maryland residents.

Equity. The MTP goals recognize the importance of Maryland's transportation system in facilitating access for the aging population and supporting growth and diversification of economic activity in disadvantaged communities. The increase in older and non-working transportation users could change travel patterns and travel times and affect public transportation agencies, non-profit transportation providers, and/or private providers. While Maryland's largest employment centers are in the Baltimore and Washington regions, other parts of the State require transportation investments to ensure the continued growth of their economies. Striking a balance between congested and growing areas and slower growth areas in need of investment continues to be a key consideration within short- and long-range multimodal planning in Maryland. Many of these communities also lack access to reliable and cost-effective travel choices, which limits access to services, health care, education, and jobs. A number of strategies within this Plan can help address these barriers, especially when they are implemented in a context-sensitive and community supported manner.

Consumer Cost Savings. Adoption and implementation of the two policy scenarios would likely lead to cost increases initially in the form of upfront costs as consumers purchase more advanced clean vehicles. These increases would be more than offset in a short term by cost savings from reduced fuel use (because consumers are driving more fuel-efficient vehicles and driving less as a result of more and improved multimodal options), reduced vehicle maintenance costs (also because they are driving less), and incentives and discounts (to promote clean vehicles).

Business Cost Savings. Adoption and implementation of the two policy scenarios would likely lead to businesses experiencing initial cost increases due to higher vehicle prices and other policies that may be implemented to increase transportation revenue. Over time, savings from reduced fuel use and vehicle maintenance costs, as well as reductions in labor costs due to relieved congestion and the availability of more cost-effective freight options would quickly offset these increases.

Looking Toward 2050

The transportation sector faces unique challenges when considering potential pathways to an 80 percent reduction in 2006 GHG emissions by 2050. These challenges are associated with current and emerging disruptors in multimodal passenger and freight transportation, including CAVs, EVs, smart and shared mobility, evolving manufacturing and logistics patterns, and emerging modes and ownership models. These disruptors are playing out at the same time as an uncertain transportation revenue future is layered over a system facing increasing system preservation and resilience needs. MDOT's MTP, MPO metropolitan transportation plans, and other state and regional plans have identified these needs and uncertainties through 2040 and beyond, however, to date, few, if any have attempted to quantify the potential range of impacts, they may create to Maryland's transportation system, including GHG emissions.

While the current 2030 scenario analysis has been able to project the scope and anticipated levels of implementation for current and planned transportation emission reduction strategies and their anticipated benefits over the next decade, MDOT is considering an approach to 2050 scenario analysis, which would allow for a more comprehensive view of the degree of uncertainty that a 30-year period of forecasting entails, with 2050 scenarios built on macro-indicators (such as technology, VMT growth, freight patterns, socioeconomics, location choices, mode choice). **Figure 5.1** presents some perspectives on the opportunities, challenges, and uncertainty facing the transportation sector through 2050. As further analysis in 2021 begins to look at 2050, these areas will represent a starting point for evaluating GHG emission reduction opportunities.

Figure 5.1 2050 Perspective on Opportunities, Challenges, and Uncertainty

GHG Emissions Opportunity

Trends and drivers that present inherent opportunities to decrease GHG emissions from the transportation sector

- **Federal GHG Emission Standards**
- **ZEV market share growth**
- **Transition to an electric transit fleet**

GHG Emissions Challenge

Trends and drivers that present inherent challenges to mitigating GHG emissions in the transportation sector

- **Population and VMT growth**
- **System delay and reliability**
- **Transportation costs**

Uncertain

Trends and drivers where there are too many uncertainties in transportation sector impacts or extent of relevance through 2030

- **Autonomous and connected vehicles**
- **Mobility as a service**
- **Change in freight logistics patterns**
- **Climate impacts and system resiliency**

Appendix A. 2017 Baseline and 2030 Technology Scenario Emissions Inventory Documentation

This technical analysis report documents the methodology and assumptions used to produce the greenhouse gas (GHG) inventory for Maryland's on-road portion of the transportation sector. Statewide emissions have been estimated for the 2017 baseline and 2030 forecast technology scenario based on the most recent traffic trends. The inventory was calculated by estimating emissions for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Those emissions were then converted to carbon dioxide equivalents that are measured in the units of million metric tons (mmt CO_2e). Carbon dioxide represents about 97 percent of the transportation sector's GHG emissions.

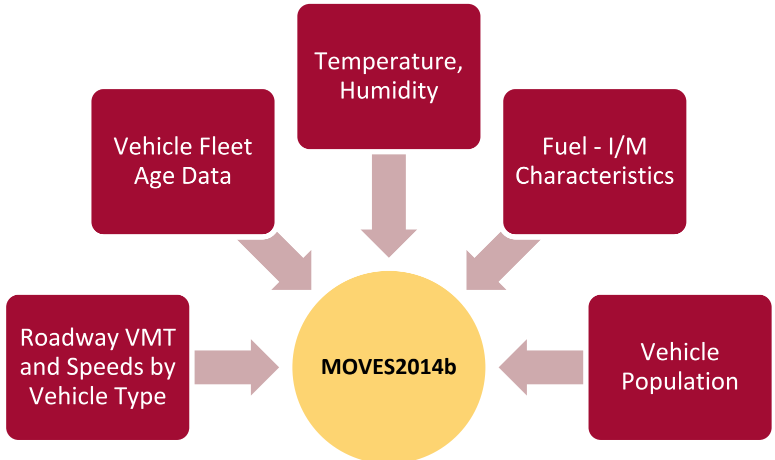
The on-road portion of the inventory was developed using EPA's emissions model MOVES2014b (Motor Vehicle Emissions Simulator) released in August 2018. The MOVES2014b model improves estimates of emissions from nonroad mobile sources and does not change the on-road emissions results of MOVES2014a. With MOVES, greenhouse gases are calculated from vehicle energy consumption rates and vary by vehicle operating characteristics including speed, engine size, and vehicle age.

On-Road Analysis Process

The data, tools and methodologies employed to conduct the on-road vehicle GHG emissions inventory were developed in close consultation with MDE and are consistent with the *MOVES2014, MOVES2014a, and MOVES2014b Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, EPA-420-B-18-039, August 2018*. MOVES2014b incorporates all existing CAFE standards in place in 2017 plus: a) medium/heavy duty greenhouse gas standards for model years 2014-2018, b) light duty greenhouse gas standards for model years 2017-2025, and c) Tier 3 fuel and vehicle standards for model years 2017-2025.

As illustrated in Figure A.1, the MOVES2014b model has been integrated with local traffic, vehicle fleet, environmental, fuel, and control strategy data to estimate statewide emissions.

Figure A.1 Emission Calculation Data Process



The modeling assumptions and data sources were developed in coordination with MDE and are consistent with other SIP-related inventory efforts. The process represents a "bottom-up" approach to estimating statewide GHG emissions based on available roadway and traffic data. A "bottom-up" approach provides several advantages over simplified "top-down" calculations using statewide fuel consumption. These include:

- Addresses potential issues related to the location of purchased fuel. Vehicle trips with trip ends outside of the state (e.g. including "thru" traffic) create complications in estimating GHG emissions. For example, commuters living in Maryland may purchase fuel there but may spend much of their traveling in Washington D.C. The opposite case may include commuters from Pennsylvania working in Maryland. With a "bottom-up" approach, emissions are calculated for all vehicles using the transportation system.
- Allows for a more robust forecasting process based on historic trends of VMT or regional population and employment forecasts and their relationship to future travel. For example, traffic data can be forecasted using growth assumptions determined by the MPO through their analytic (travel model) and interagency consultation processes.

GHG emission values are reported as annual numbers for the 2017 baseline and 2030 technology scenarios. The annual values were calculated based on annual MOVES runs as summarized in Figure A.2. Each annual run used traffic volumes, and speeds that represent an annual average daily traffic (AADT) condition, and temperatures and fuel input parameters representing an average day in each month.

Figure A.2 Calculation of Annual Emissions

For the 2017 and 2030 technology scenario emissions inventories, the traffic data was based on roadway segment data obtained from the Maryland State Highway Administration (SHA). This data does not contain information on congested speeds and the hourly detail needed by MOVES. As a result, post-processing software (PPSUITE) was used to calculate hourly-congested speeds for each roadway link, apply vehicle type fractions, aggregate VMT and VHT, and prepare MOVES traffic-related input files. The PPSUITE software and process methodologies are consistent with that used for state inventories and transportation conformity analyses throughout Maryland.

Other key inputs including vehicle population, temperatures, fuel characteristics and vehicle age were obtained from and/or prepared in close coordination with MDE staff. The following sections summarize the key input data assumptions used for the inventory runs.

Summary of Data Sources

A summary of key input data sources and assumptions were developed in consultation with MDE and are consistent with the *MOVES2014, MOVES2014a, and Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, EPA-420-B-18-039, August 2018* and are provided in Table A.1. Many of these data inputs are consistent to those used for SIP inventories and conformity analyses. Several data items require additional notes:

- Traffic volumes and VMT are forecasted for the 2030 technology scenario analysis. A discussion of forecasted traffic volumes and vehicle miles of travel (VMT) is discussed in more detail in the following section.
- Vehicle population is a key input that has an important impact on start and evaporative emissions. The MOVES Model requires the population of vehicles by the thirteen source type categories. For light duty vehicles, vehicle population inputs were prepared and provided by MDE for base year (2017). For the analysis year 2030, the vehicle population was forecasted based on projected household and population growth obtained from state and MPO sources. For heavy-duty trucks, vehicle population was calculated from VMT using MOVES default estimates for the typical miles per vehicle by source type (e.g. vehicle type). The PPSUITE post processor automatically prepares the vehicle population file under this method.
- The vehicle mixes are another important file that is used to disaggregate total vehicle volumes and VMT to the 13 MOVES source types. The vehicle mix was calculated based on 2017 SHA vehicle type pattern percentages by functional class, which disaggregates volumes to four vehicle types: light-duty vehicles, heavy-duty vehicles, buses, and motorcycles. As illustrated in Figure A.3, from these four vehicle groups, MOVES default Maryland county VMT distributions by source type was used to divide the four groups into each of the MOVES 13 source types.

Figure A.3 Defining Vehicle Types

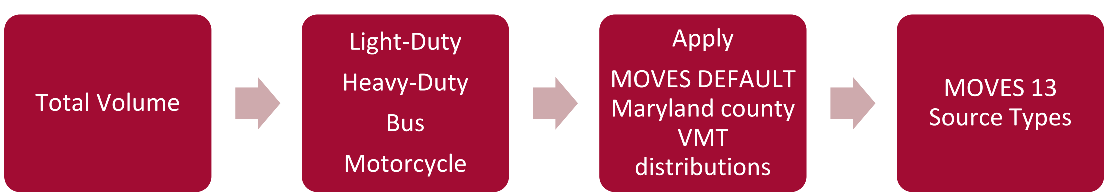


Table A.1 Summary of Key Data Sources

Data Item	Source	Description	Difference between 2017 and 2030Technology
Roadway Characteristics	2017 MDOT SHA Universal Database	Includes lanes, segment distance, facility type, speed limit	*Same Data Source*
Traffic Volumes	2017 MDOT SHA Universal Database	Average Annual Daily Traffic Volumes (AADT)	Volumes forecasted for 2030 technology scenario
Seasonal Adjustments	SHA 2017 *ATR Station Reports in the Traffic Trends System Report Module* from the MDOT SHA website	Used to develop day and month VMT fractions as inputs to MOVES to disaggregate annual VMT to daily and monthly VMT	*Same Data Source*
VMT	Highway Performance Monitoring System 2017	Used to adjust VMT to the reported 2017 HPMS totals by county and functional Class	VMT forecasted for 2030 technology scenario
Hourly Patterns	MDOT SHA 2016 *Traffic Trends System Report Module* from the SHA website	Used to disaggregated volumes and VMT to each hour of the day	*Same Data Source*
Vehicle Type Mix	2017 MDOT SHA vehicle pattern and hourly distribution data; MOVES default Maryland county VMT distributions	Used to split traffic volumes to the 13 MOVES vehicle source types	*Same Data Source*
Ramp Fractions	MOVES Defaults	MOVES Defaults	*Same Data Source*
Vehicle Ages	2017 Maryland Registration data; MOVES national default age distribution data	Provides the percentage of vehicles by each model year age	*Used 2017 registration data for light duty vehicles and MOVES2014 national default data for source types 61 & 62.*
Hourly Speeds	Calculated by PPSUITE Post Processor	Hourly speed distribution file used by MOVES to estimate emission factors	Higher volumes produce lower speeds in 2030
I/M Data	Provided by MDE	Based on current I/M program	Different I/M Program Characteristics
Fuel Characteristics	Provided by MDE	Fuel characteristics vary by year	Different Fuel Characteristics
Temperatures	Provided by MDE	Average Monthly Temperature sets	*Same Data Source*
Vehicle Population	Light duty vehicles: used vehicle population data provided by MDE for 2017 baseline and applied growth rates to forecast population to 2030	Number of vehicles by MOVES source type which impact forecasted start and evaporative emissions	2030 based on projected demographic and VMT growth

	Heavy duty trucks: Calculated by PPSUITE Post Processor; MOVES Default Miles/Vehicle Population Data

Traffic Volume and VMT Forecasts

The traffic volumes and VMT within the MDOT SHA traffic database were forecast to estimate future year emissions. Several alternatives are available to determine forecast growth rates, ranging from historical VMT trends to the use of MPO-based travel models that include forecast demographics for distinct areas in each county. For the 2030 technology scenario, the forecasts were determined based on historic trends of 1990-2017 highway performance monitoring system (HPMS) VMT growth. The average statewide annualized growth rate through 2030 for this scenario is 1.2 percent. Table A.2 summarizes the growth rates by county.

Table A.2 VMT Annual Growth Rates (Per Maryland CAP) for 2030 Technology Scenario

County	2030 Technology (Based on 1990-2017 HPMS)
Allegany	0.6%
Anne Arundel	1.2%
Baltimore	1.0%
Calvert	2.3%
Caroline	1.3%
Carroll	1.3%
Cecil	1.8%
Charles	1.6%
Dorchester	0.9%
Frederick	1.8%
Garrett	1.5%
Harford	1.1%
Howard	2.2%
Kent	0.0%
Montgomery	0.9%
Prince George's	1.1%
Queen Anne's	2.0%
Saint Mary's	1.5%
Somerset	0.8%
Talbot	1.4%
Washington	1.6%
Wicomico	1.7%
Worcester	0.5%
Baltimore City	0.2%
Statewide	**1.2%**

Table A.3 summarizes total 2017 baseline and 2030 forecast VMT by vehicle type.

Table A.3 2017 Baseline and 2030 Technology Scenario - VMT by Vehicle Type

Annual VMT (millions)	2017 Baseline	2030 Technology
Light-Duty	55,799	64,633
Medium/Heavy-Duty Truck & Bus	4,093	4,759
TOTAL VMT (in millions)	**59,892**	**69,392**

The analysis process (e.g. using PPSUITE post processor) re-calculates roadway speeds based on the forecast volumes. As a result, future year emissions are sensitive to the impact of increasing traffic growth on regional congestion.

Vehicle Technology Adjustments

The MOVES2014b emission model includes the effects of the following post-2017 vehicle programs on future vehicle emission factors:

- **National Program Phase 2 (Model Years 2017-2025)** – The light-duty vehicle fuel economy for model years between 2017 and 2025 are based on the October 15, 2012 Rule "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards" (EPA-HQ-OAR-2010-0799 and No. NHTSA-2010-0131). The new fuel economy improvements apply to model years 2017 to 2025. The standards are projected to result in an average 163 gram/mile of CO_2 in model year 2025. This equates to an average fuel economy of 54.5 mpg.
- **Maryland Clean Car Program** – The Maryland Clean Car Program implements California's low emissions vehicle (LEV) standards to vehicles purchased in Maryland starting with model year 2011. By creating a consistent national fuel economy standard, the 2012-2016 National Program and the Phase 2 2017-2025 National Program, which closely resemble the California program, replaces Maryland's Clean Car Program for those model years. As a result, the GHG reduction credits for the Maryland Clean Car Program, apply only to 2011 model year vehicles and post-2011 electric vehicles that meet the California's zero emission program (ZEV) requirement.
- **National 2014-2018 Medium and Heavy Vehicle Standards** – The medium- and heavy- duty vehicle fuel economy for model years between 2014-2018 are based on the September 15, 2011 Rule "Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles". The rulemaking has adopted standards for three main regulatory categories: combination tractors, heavy-duty pickups and vans, and vocational vehicles. For combination tractors, the final standard will achieve 9 to 23 percent of reduction in carbon dioxide (CO2) emissions and fuel consumption by the 2017 model year compared to the 2010 baseline. For heavy-duty pickup trucks and vans, separate standards have been established for gasoline and diesel trucks, which will achieve up to a 10 percent reduction for gasoline vehicles and a 15 percent reduction for diesel vehicles by the 2018 model year (12 and 17 percent respectively if accounting for air conditioning leakage). Lastly, for vocational vehicles, the final standards would achieve CO2 emission reductions from six to nine percent by the 2018 model year.

Emission Results

The 2017, and 2030 technology scenarios emission results for the Maryland statewide GHG inventories are provided in Table A.4 for 2017 Baseline, and A.5 for the 2030 technology scenario. Within each table, emissions are also provided by fuel type and vehicle type.

Table A.4 2017 Annual On-Road GHG Emissions (mmt)

	VMT (Millions)	CO_2	CH_4	N_2O	CO_2e
TOTAL	**59,892**	**28.41**	**0.00102**	**0.00062**	**28.62**
By Fuel Type					
Gasoline	55,028	22.105	0.000620	0.000609	22.302
Diesel	4,544	6.164	0.000343	0.000010	6.176
CNG	12.3	0.015	0.000049	0.000001	0.016
E-85	307	0.122	0.000006	0.000002	0.122
By MOVES Vehicle Type					
Motorcycle	266	0.098	0.000008	0.000001	0.099
Passenger Car	25,592	8.788	0.000198	0.000211	8.855
Passenger Truck	26,209	11.859	0.000403	0.000349	11.973
Light Commercial Truck	3,731	1.561	0.000054	0.000034	1.572
Intercity Bus	124	0.220	0.000005	0.000000	0.220
Transit Bus	82	0.107	0.000052	0.000001	0.108
School Bus	195	0.183	0.000011	0.000001	0.183
Refuse Truck	35	0.062	0.000002	0.000000	0.062
Single Unit Short-haul Truck	1,367	1.384	0.000067	0.000019	1.391
Single Unit Long-haul Truck	81	0.076	0.000004	0.000000	0.077
Motor Home	19	0.019	0.000001	0.000000	0.020
Combination Short-haul Truck	531	0.934	0.000022	0.000001	0.935
Combination Long-haul Truck	1,659	3.114	0.000191	0.000003	3.120

Table A.5 2030 Technology Scenario Annual On-Road GHG Emissions (mmt)

	VMT (Millions)	CO_2	CH_4	N_2O	CO_2e
TOTAL	**69,392**	**24.23**	**0.00090**	**0.00040**	**24.37**
By Fuel Type					
Gasoline	61,698	16.980	0.000291	0.000373	17.098
Diesel	5,390	6.592	0.000547	0.000012	6.609
CNG	14.7	0.017	0.000041	0.000001	0.018
E-85	2,290	0.643	0.000024	0.000014	0.648
By MOVES Vehicle Type					
Motorcycle	310	0.115	0.000009	0.000001	0.115
Passenger Car	29,559	6.821	0.000130	0.000148	6.868
Passenger Truck	30,464	9.432	0.000212	0.000205	9.498
Light Commercial Truck	4,300	1.270	0.000035	0.000027	1.279
Intercity Bus	143	0.242	0.000007	0.000000	0.242
Transit Bus	93	0.115	0.000045	0.000001	0.116
School Bus	229	0.201	0.000013	0.000001	0.202
Refuse Truck	41	0.070	0.000002	0.000000	0.070
Single Unit Short-haul Truck	1,594	1.501	0.000092	0.000010	1.507
Single Unit Long-haul Truck	89	0.078	0.000005	0.000000	0.078
Motor Home	22	0.022	0.000001	0.000000	0.022
Combination Short-haul Truck	489	0.810	0.000027	0.000001	0.811
Combination Long-haul Truck	2,059	3.556	0.000322	0.000004	3.565

Appendix B: Strategy Definitions and Assumptions

1.0 Policy Scenario 1 (On-the-Books)

As its name implies, this scenario evaluates the emission reductions from funded projects and programs. This includes projects and programs in the Consolidated Transportation Program (CTP), land development assumptions consistent with local plans and Maryland Department of Planning goals, and GHG reducing projects included in fiscally constrained MPO metropolitan transportation plans.

1.1 2018/2019 MPO Plans and Programs yield lower annual VMT growth (0.6%/year)

Strategy Description: Modeled vehicle miles traveled (VMT) and emissions outcomes from implementation of most recent MPO fiscally constrained long-range transportation plans and cooperative land use forecasts.

Key Assumptions: VMT growth for fiscally constrained plans and programs reflect the most recent available assumptions from MPO long-range plans (consistent with adopted LRTPs and recent amendments) and an updated VMT growth trend from 1990-2017 for counties outside MPO areas (consistent with HPMS data). In the 2018 analysis, the business as usual VMT growth trend (based on 1990-2014) was 1.7% annual and the resulting plans and programs growth rate was 1.4% annual. For this analysis, the business as usual VMT growth trend (based on 1990-2017) is 1.2% annual, and the resulting plans and programs growth rate is 0.6% annual.

1.2 On-Road Technology (Transportation System Management and Operations - CHART and other traffic management technologies)

Strategy Description: Continuation of MDOT SHA's CHART program, Smart Traffic Signals within the Traffic Relief Plan, and ongoing implementation of SHAs TSMO Strategic Plan (2018) and TSMO Master Plan will expand the scope and coverage of advanced traffic management and information systems across Maryland roadways. These technologies help manage incidents and reduce congestion through traffic monitoring, incident anagement, travel infromation, communications, and traffic management.

Key Assumptions: MDOT SHAs 2019 Mobility Report documents recent and planned activities to mitigate congestion and improve reliability on Maryland's highway system. This includes TSMO - CHART, signal operations, and smart/adaptive signal systems. Benefits from each of these programs include reduced delay and fuel consumption. Through 2030, these programs are assumed to expand in scope and coverage, consistent with current funding and implementation assumptions, increasing the overall benefit to the system in terms of reduced delay and fuel consumption. In Policy Scenario 1, this translates to increased effectiveness across the CHART coverage area and a 35% expansion of systems on urban arterials and a 15% expansion of systems on rural limited-access facilities.

1.3 Freight and Freight Rail Programs (National Gateway, Howard Street Tunnel, and MTA rail projects)

Strategy Description: Implementation of the CSX National Gateway provides new capacity and eliminates bottlenecks for access to the Port of Baltimore and across MD for rail access westward toward PA and OH and south toward VA and NC, including rail double-stack service through the expanded Howard Street Tunnel.

Key Assumptions: Opening of the Howard Street Tunnel to doublestack rail service by 2030 will support increased rail throughput to the Port of Baltimore, helping to reduce truck VMT and reduce freight rail congestion. Assumptions for truck VMT reductions and freight rail emissions savings are consistent with assumptions in prior MWCOG analysis of the CSX National Gateway program. To the extent that information is available within the Howard Street Tunnel INFRA Grant application, updated estimates could reflect details within the grant benefit-cost analysis.

1.4 Public Transportation (new capacity, improved operations/frequency, bus rapid transit (BRT))

Strategy Description: This strategy includes projects designed to increase public transit capacity, improve operations and frequency, and new BRT corridors not included in MPO modeling in the plans and programs. This includes North Avenue Rising, MD 355/MD586/US29 BRT in Montgomery County, and MARC reliability/park-and-ride/station improvements.

Key Assumptions: MPO plans account for implementation of the Purple Line, MARC capacity/service improvements, and BaltimoreLink and MTA Commuter Bus service expansions through 2030. This strategy addresses benefits from projects not explicitly modeled in the MPO plans, based on preliminary ridership estimates from planning or alternatives analysis/environmental studies.

1.5 Public Transportation (50% Electric Vehicle (EV) transit bus fleet)

Strategy Description: Applies to replacing MTA and WMATA bus fleets in Maryland (approximately 1,500 buses) to a 50% EV fleet by 2030 (consistent with MDOTs Fleet Innovation Plan).

Key Assumptions: Based on current replacement cycles, MTA could achieve a 50% EV transit bus fleet if all replacement and new vehicles starting in 2025 are EV (assuming appx. 400 buses are replaced over the 5-6 year period, mostly from buses that entered the fleet from 2012 to 2018). This strategy also presumes that WMATA moves toward a 50% EV fleet within Maryland by 2030. For LOTS buses, procurement is expected to generally follow existing MTA direction toward clean diesel, with some limited expansion of electric buses as part of recent and ongoing grant awards.

1.6 Intercity Transportation Initiatives (Amtrak Northeast Corridor, Intercity bus)

Strategy Description: Northeast corridor analysis assumes growth in annual ridership by 2030 for Amtrak consistent with addressing growing demand and benefits created through SOGR investments only through 2030.

Key Assumptions: Annual ridership growth on the AMTRAK Northeast Corridor consistent with high growth 2015 - 2019 will continue through 2030, compared to a lower baseline growth since 2010. Continuing this rate of growth assumes that ongoing planned state of good repair investments and limited capacity expansion enables Amtrak to accomodate growth with new and improved service, and enhanced reliability. Ridership is converted to reduced vehicle miles traveled based on an average Maryland trip length for intercity trips.

1.7 Transportation Demand Management (TDM)

Strategy Description: The following programs are included for consideration towards reduction in VMT: Commuter Connections Transportation Emission Reduction Measures (MWCOG), Guaranteed Ride Home, Employer Outreach , Integrated Rideshare, Commuter Operations and Ridesharing Center, Telework Assistance, Mass Marketing, MTA Transportation Emission Reduction Measures, MTA College Pass, MTA Commuter Choice Maryland Pass, Transit Store in Baltimore.

Key Assumptions: VMT reductions are based on current trends as documented in MDOTs Annual Attainment Report, and results of ongoing and emerging programs within MWCOGs Commuter Connections Program and Commuter Choice Maryland. This analysis assumes implementation of TDM programs consistent with pre COVID-19 conditions related to telework and other TDM incentives.

1.8 Pricing Initiatives (Electronic Tolling)

Strategy Description: Ongoing Conversion to All-Electronic Tolling.

Key Assumptions: Consistent with the 2020-2025 CTP, tolling on MDTA facilities is planned for complete coversion to a cashless system by 2030. This includes programmed investments in video toll collection technologies and implementation of cashless tolling on the Francis Scott Key Bridge (I-695) and Hatem Bridge (US 40) by 2025. MDTA is also implementing an extension of the I-95 Express Lanes to the MD24 interchange, with completion planned before 2030. GHG emissions reduction is associated with a reduction in idling at toll plazas, assumed to average 1 minute per transaction.

1.9 Bicycle and Pedestrian Strategies (Provision of non-motorized infrastructure including sidewalks and bike lanes)

Strategy Description: Assumes VMT reductions due to availability of bicycle facility lane miles and improved bicycle level of comfort consistent with existing and planned infrastructure improvements, repaving, and new facilities highlighted in the 2020 - 2025 CTP and current SHA plans.

Key Assumptions: This strategy assumes that improved directional miles of bicycle facilities and bicycle level of comfort will increase through 2030 consistent with the trend reported in the Annual Attainment Report from 2015 through 2019. This is compared to a do-nothing scenario, resulting in increased bicycle and pedestrian activity and reduced VMT.

1.10 Drayage Track Replacements

Strategy Description: This strategy estimates the benefit of replacing 600 total dray trucks resulting from MDE, MDOT and Federal grants through 2030, which is based on the current replacement rate.

Key Assumptions: Consistent with current program status and recent EPA grant award, the Port of Baltimore is still on-track to turnover 600 heavy-duty diesel dray trucks by 2030.

1.11 BWI Airport Parking Shuttle Bus Replacements

Strategy Description: This strategy involves replacement of BWI airport parking shuttles - 50 diesel buses with clean diesel buses and CNG buses.

Key Assumptions: Acquisition information based on what is publicly available from MDOT and news sources including the types of vehicles replacing the existing vehicles.

1.12 MDOT Vehicle Fleet (Fleet Innovation Plan)

Strategy Description: Conversion of MDOT fleet (non-revenue vehicles) to EVs (initial focus on MDOT agency passenger vehicle fleet only, heavy duty vehicles included in Policy Scenario 2).

Key Assumptions: Assume 95% EV conversion of 2,114 passenger vehicles by 2030 averaging 12.5k miles per year.

2.0 Policy Scenario 2 (Emerging and Innovative)

This scenario acknowledges that attaining the 2030 goal will require additional investments to expand or accelerate deployment of previously planned strategies, deployment of new best-practice strategies, and capitalizing on the opportunities created by new transportation technologies. All of the strategies in this scenario require additional funding and, in some cases, private sector commitment. The 22 strategies in this scenario (16 emerging and 6 innovative) represent a combination of approaches to reduce GHG emissions with varying levels of confidence and MDOT responsibility.

Emerging Strategies

2.1 TSMO/Integrated Corridor Management (Limited Access System)

Strategy Description: Integrated corridor management, intelligent transportation systems, or advanced traffic management systems for urban restricted access roadways in the state.

Key Assumptions: The most similar program in the 2020-2025 CTP is CHART, which is funded 60% Federal, 40% State. The same share is assumed for this comparable/extended strategy.

2.2 TSMO/Integrated Corridor Management (Arterial System)

Strategy Description: This strategy estimates the benefits of implementing corridor management, intelligent transportation systems, or advanced traffic management systems are in place on all urban arterials.

Key Assumptions: Only urban arterials are being assumed to be covered as part of this strategy through 2030. The most similar program in the 2020-2025 CTP is CHART, which is funded 60% Federal, 40% State. The same share is assumed for this comparable/extended strategy.

2.3 Variable Speeds/Speed Management

Strategy Description: Corridor management (including ramp metering), intelligent transportation systems, or advanced traffic management systems are in place on all urban restricted access facilities and all urban principal and minor arterials. All urban limited access facilities are assumed to be covered.

Key Assumptions: For ramp metering, a two-minute wait time on average was considered during peak hours at ramp entrance. Ramp fraction was estimated at 8% from MOVES defaults. The most similar program in the 2020-2025 CTP is CHART, which is funded 60% Federal, 40% State. The same share is assumed for this comparable/extended strategy.

2.4 Intermodal Freight Centers Access Improvements

Strategy Description: As noted in the Strategic Goods Movement Plan, reliability improvements and congestion mitigation that positively impact supply chain costs associated with driver and truck delay and fuel consumption is a desired outcome. The strategy to achieve this includes SHA and MDTA continuing to advance appropriate measures to reduce or mitigate the effects of congestion on industry supply chains.

Key Assumptions: The strategy has been applied to intermodal sections in Maryland and the mileage is assumed to be similar to the national share of 1.4% (as data on intermodal facilities mileage in MD was not able to be estimated based on available data). Assumed splits according to Freight and Freight Rail programs in PS 1. As noted in the Strategic Goods Movement Plan, reliability improvements and congestion mitigation that positively impact supply chain costs associated with driver and truck delay and fuel consumption is a desired outcome.

2.5 Commercial Vehicle Technologies (Idle Reduction, Low-Carbon Fleet, Dynamic Routing)

Strategy Description: Considers extended idling only and not short term idling (eg. At a delivery/pick-up point. Data requirements for short term idling are more extensive and might not be substantial compared to the extended idling emissions. It is assumed that APUs will be used to power the trucks during the time spent idling.

Key Assumptions: It is assumed that trucks would have spent time idling in absence of new laws/requirements. A high case and a low case for emission reductions is estimated considering all or just 50% of extended idling is handled by Auxillary Power Units (APUs). Negligible costs to the state for enforcement. Truck drivers purchase APUs.

2.6 Regional Clean Fuel Standard

Strategy Description: Consistent with TCI approach assuming a 15% clean fuel standard (applied to fuel consumption from remaining ICE fleet above and beyond RFS). Ultimately this strategy should be deployed as a regional approach for gasoline and diesel fuel.

Key Assumptions: Administration and program management costs to be totally borne by the state.

2.7 Eco-Driving

Strategy Description: Statewide commitment to a marketing and eduction program and volunatary adoptions by Maryland drivers, including private passenger vehicles and commercial vehicles (light, medium, and heavy-duty trucks).

Key Assumptions: Assumptions based on the extent of government-led programs. Private sector programs not included. For example, fleet operators of trucks, logistical operation enterprises conduct eco-driving for their fleet separately and typically have a higher degree of focus and return on results from the programs. It is assumed that 2% of the statewide population are reached using these general marketing programs. Out of these people, only 50% (1% of total population) have on-board display tools that have on-board display tools that provide feedback from ecodriving. The benefits of eco-driving is two-pronged - one by training and the other due to attention being paid to the on-board display tools. Heavy duty trucks included for this analysis are only assumed to be a part of the general marketing campaign and no specific training provided elsewhere. Modest marketing, education and outreach program costs to be borne by the state.

2.8 Transit capacity/service expansion (fiscally unconstrained, including MTA, WMATA, LOTS, and other intercity providers)

Strategy Description: Potential transit network improvements and expansions noted in BMC and MWCOG long-range plans, in addition to other projects with recent/ongoing planning. This includes the Southern Maryland Rapid Transit Study, Corridor Cities Transitway, additional BRT corridors in Montgomery County, and priority "Early Opportunity" corridors noted in the Central Maryland Regional Transit Plan.

Key Assumptions: The compilation of transit network improvements and expansions in the BMC Maximize2045 plan result in a 0.3% VMT reduction by 2045. This reduction is assumed to be accelerated to 2030, with full implementation of the Mazimize2045 plan (including corridors recommend in the Central Maryland Regional Transit Plan. Other potential transit corridors by 2030 include three additional BRT corridors (MD 650, Randolph Rd., North Bethesda) plus the CCT in Montgomery County and future BRT service in Southern Maryland, consistent with recommendations in the Southern Maryland Rapid Transit Study. The low range assumption assumes that 50% of this system is implemented by 2030, while the high range assumes the entire system is implemented by 2030. Based on transit expansion splits consistent with recent projects and projects in the CTP. This also acknowledges what would be considered a "competitive" funding arrangement for the Federal CIG program (essentially the blanket now for New Starts / Small Starts).

2.9 Expanded Transportation Demand Management (TDM) strategies - Dynamic ridesharing/mobility and non-work demand management

Strategy Description: The TDM programs included in PS1 are broadly expanded consistent with a market-wide implementation of dynamic TDM programs including on-demand ride sharing/shared mobility/microtransit services plus greater market penetration of on-demand deliveries/services through autonomous/drone technologies.

Key Assumptions: There is significant uncertainty in this strategy, given the range of different technologies and services, including many that are led by the private sector. Generally, the assumption is that regular ridesourcing/ridesharing users in Maryland (mobility as a service, micromobility, smart mobility options) range from 10% to 20%, which leads to a reduction in vehicle ownership and overall reduction in travel (ranging from 30% to 60%). These estimates are drawn from academic/industry studies in 2018 and 2019. This includes the potential impact of less non-work trips associated with more at-home deliveries/services. Same as 2018. However, 2018 costs assume that a 100% of the costs are borne by the state, unlike the typical 70%-30% split as assumed in funded PS 1 strategies. The rationale for this is that Federal funds typiucally supporting TDM (e.g. CMAQ) are highly competitive and segmented. A broader TDM program will either require new Federal programs or (more likely) a much higher State commitment.

2.10 Expanded bike/pedestrian system development

Strategy Description: Assumes VMT reductions due to availability of bicycle facility lane miles and improved bicycle level of comfort consistent with a 50% increase in existing and planned infrastructure improvements, repaving, and new facilities highlighted in the 2020 - 2025 CTP and current SHA plans.

Key Assumptions: Total improved directional miles would increase from 367 miles in 2019 (per the Attainment Report) to a low range over 1,300 in 2030 (which is a 25% increase over the current growth trend) to a high range over 1,600 in 2030 (which is a 50% increase over the current growth trend). Splits assumed to be similar to the funded bicycle and pedestrian improvements.

2.11 Expanded Telework

Strategy Description: In light of COVID19 the share of people who are teleworking has seen a multi-fold increase compared to the levels a year ago. It has been a near unanimous opinion in the research literature reviewed for this strategy analysis that the increase in telework trends is going to be a long term phenomenon.There are different views about the share of people now teleworking under the COVID19 constraints who will remain to telework long after the impacts of the pandemic.

Key Assumptions: The share of the regular teleworking workforce (>3 days per week) ranges from 32% to 44% in 2030. These shares are applied to 2030 VMT per capita and an assumption that approximately 30% of total VMT per capita is attributed to commuting. Costs of program management assumed—after considering other states and metro area telework programs, a $10-20 million annual funding was determined to be adequate for a MD-Telework program. If costs to the employers are not assumed, it will lead to underestimation of total costs that are eligible for tax credits, etc. Also, in the case of government employees, the installation and capital costs of equipment, etc., are typically reimbursed.

2.12 MARC Growth and Investment Plan (MGIP) / Cornerstone Plan Completion

Strategy Description: Improvements to MARC service include completion of the fourth track on the Penn Line to facilitiate service exapansion (which requires new Susquehanna and Bush River crossings and replacement of the B&P Tunnel); reduced peak headways, new midday service, and weekend service on the Camden Line (including expansion to three main tracks between Baltimore and Washington); increased service, longer trains, and expanded parking on the Brunswick Line; and, implementation of VRE-MARC Run-Through Service.

Key Assumptions: Estimated 2030 ridership, consistent with full build-out of the MGIP/Cornerstone Plan, totals over 16 million passengers. Compared to a low and an average annual ridership growth rate through 2030, this could yield a statewide VMT reduction between 107 and 165 million miles in 2030. The VRE-MARC Run-Through Servce estimated the potential for over 16,000 trips per day, resulting in a VMT reduction of 30.5 million by 2030. Similar to transit expansion, although typically more access to Federal funds through Federal Railroad Authority fundind/grant programs—justifies a higher Federal split.

2.13 Transit-Oriented Development (TOD) Build-Out (20 incentive zones)

Strategy Description: Estimated TOD build-out across 20 locations totals an additional 36,000 households, each with an average VMT reduction of 33% to 56% based on average VMT savings by transit zone density.

Key Assumptions: Based on Center for Neighborhood Technology (CNTs) nationwide 2010 study, average VMT reductions in transit oriented zones compared to traditional urban/suburban development range from 33% to 56%. Using this range, applied to the potential number of new households at buildout, and average VMT per capita, a range of VMT reductions is determined. CTP Special Funding Source. No Federal Aid. 100% State & Local Funding. Assumes additional funding equivalent to what is in the CTP now to be required for 20 zones build out.

2.14 EV Market Share Ramp-up of an additional 255,000 vehicles

Strategy Description: Additional 255,000 EVs by 2030, compared to the TCI projection to reach 790k ZEVs (with Federal action).

Key Assumptions: Same assumptions are applied as in the reference case for the share of BEV vs. PHEVs and proportion of PHEV travel operating as electric. The cost assumption is based on maxing out the current annual EVSE rebates and EV credits under PS 1 and factored for the additional 255,000 EVs.

2.15 Extended CAFE Standards (Model Years 2026-2030)

Strategy Description: Federal fuel economy standards continue to increase from 2026 through 2030.

Key Assumptions: With support of the auto manufacturers and new Administration for the National Program Standards, if the fuel economy standards would continue to increase by five percent per year through 2030, an additional emissions decrease of 0.80 mmt CO_2e would result from the vehicle technology standards.

2.16 50 percent to 75 percent EV Transit Bus Fleet

Strategy Description: Applies to MTA and WMATA bus fleets in Maryland (approximately 1,500 buses).

Key Assumptions: Based on current replacement cycles, MTA could achieve a 50% EV transit bus fleet if all replacement and new vehicles starting in 2025 are EV (assuming appx. 400 buses are replaced over the 5-6 year period, mostly from buses that entered the fleet from 2012 to 2018). To reach a 75% EV fleet, MTA would need to replace an additional 200 buses, which would include new clean diesel buses entering the fleet in 2019-2021 (or would need to change its current replacement cycle and move toward EVs earlier than 2025). Federal/state splits are consistent with current fundign assumption for bus purchases/replacement in the 2020-2025 CTP. However, higher purchase cost of EV transit buses compared to existing clean diesel procurement could ultimately require larger state share.

Innovative Strategies

2.17 Autonomous/Connected Vehicle Technologies

Strategy Description: Core assumptions regarding market penetration of AVs, change in VMT, and fuel savings have been adopted from an ENO study which lays out three scenarios of AV deployment, of which the low-end penetration of 10% by 2030 is considered in this analysis.

Key Assumptions: Emissions associated with VMT increase resulting from mobility benefits (AVs added to the fleet—this increases emissions and thereby a negative impact, estimated at 20 percent increase); fuel savings due to AVs (savings of AVs only, estimated at 13 percent reduction); congestion reduction benefits on freeways and arterials (assumed LOS E to C on restricted access roadways and unrestricted access roadways). These are due to vehicles following automated vehicles, etc. Level of service criteria for restricted and unrestricted roadway types obtained from HCM and emission rates are applied at the different operating speeds (bins) and assigned to VMT by that roadway type (estimated at 15 percent reduction for limited access facilities and 5 percent reduction for arterials). Ranges for high case have been varied to include a higher market penetration (15%) and thereby an increased freeway congestion reduction benefit (20%). Infrastructure costs to the state considered. 100% to be borne by the state.

2.18 Zero-Emission Truck Corridors

Strategy Description: This strategy considers corridors in MD (port connections, etc.) in line with the I-710 Calstart Corridor.

Key Assumptions: More research required to establish potential deployment scenario within Maryland, primarily at the Port of Baltimore. Options include a zero-emissions dray truck program similar to the proposed program in the Los Angeles region, or deployment in specific corridors (eg. where trucks connect into an overhead electric power system. Current approach assumes that from 300 (low) to 700 (high) dray trucks are electrified in Maryland (approx. 20% to 40% of the total dray truck fleet operating at the Port of Baltimore). California examples primarily are currently using VW Mitigation resources to fund truck replacements up to $200k value. The presumption is that a private share is contributed, but that is unknown. Once VW mitigation trust funding is spent, sources for these programs are uncertain (a fair assumption is a mix of Federal grants, state match or incentives, and private leverage. The cost estimate represents the public share only.

2.19 Freight Villages/Urban Freight Consolidation Centers

Strategy Description: Consolidated freight distribution centers to utilize cleaner last-mile delivery trucks for urban areas (fleet or urban area approach).

Key Assumptions: The benefits are localized to individual intersections/interchanges and ramps, as well as local streets/intermodal connectors providing access to the Port of Baltimore and other intermodal facilities. This is assumed to be implemented on a public-private partnership (PPP) basis. Hence the split was assumed to be 50-50.

2.20 Pay-As-You-Drive (PAYD) Insurance

Strategy Description: PAYD is a usage-based insurance program where charges are based on usage and driver behavior, which is offered by several auto insurance companies in the US. This strategy involves adoption of PAYD insurance, which has been observed in multiple studies to reduce VMT.

Key Assumptions: Range of 10 to 20% of licensed Maryland drivers use a pay-as-you-drive auto insurance premium by 2030. The range of VMT reduction for PAYD insurance is from 8 to 10% based on national research. This reduction is applied to average VMT per capita for the 10 to 20% of Maryland licensed drivers with PAYD insurance premiums. Private insurance providers (administration and marketing) (100%)

2.21 Speed Management on Freeways (increased enforcement)

Strategy Description: Speed Management covering urban and rural restricted access roadways in the state.

Key Assumptions: Assumes coverage of 100% urban restricted access roadways and only 50% of rural restricted access roadways for a high range implementation and 50% urban restricted roadway coverage and 25% rural restricted access coverage for low range implementation. Discounted for peak-period congested travel VMT.

2.22 High-Speed Passenger Rail/SCMAGLEV

Strategy Description: Assumes build-out of the NEC Vision Plan (low range) by 2030 and build-out of NEC Next-Gen Plan (high range) by 2030.

Key Assumptions: Build-out of both of these systems would require a significant influx of Federal and private funding in addition to extensive engineering, environmental, and construction resources to implement. It is highly unlikely given the current Federal funding situation and post-pandemic economic recovery and travel patterns that implementation of such a broad scale expansion of service on the NEC is possible. SCMaglev is assumed to be 100% privately funded. Implementation of the NEC Vision Plan would be primarily Federal, however, there is no funding source existing to support.

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Appendix K

MDA Recommended Practices

2030 GGRA Plan

Greenhouse Gas Reductions From Agriculture: Menu of Recommended Practices

GHG estimates from comet-planner.nrel.colostate.edu/COMET-Planner_Report_Final.pdf		GHG Reduction		
NRCS Conservation Practices		**Mt CO2e/ac/yr**		
Cropland Management	**Description of practice**	**CO_2**	**N_2O**	**Sum**
Conventional Tillage to No Till (CPS 329)		0.42	-0.11	0.31
Conventional Tillage to Reduced Tillage (CPS 345)	Reduced tillage = strip till	0.13	0.07	0.20
N Fertilizer Management (CPS 590)	Improve N fertilizer management to reduce by 15% through 4R or nitrification inhibitors	0.00	0.11	0.11
Replace N Fertilizer w/ Soil Amendments (CPS 590)	Soil amendments include compost, manure	1.75	0.00	1.75
Conservation Crop Rotation (CPS 328)	Decrease fallow or add perennial crop to rotation	0.21	0.01	0.22
Cover Crops (CPS 340)	Add seasonal cover crop to cropland	0.32	0.05	0.37
Insert forage planting into rotation (CPS 512)	Add annual or perennial forage to rotation	0.21	0.01	0.22
Mulching (CPS 585)	Add high carbon mulch to cropland	0.32	NA	0.32
Land use changes- add herbaceous plants				
Conservation Cover (CPS 327)	Convert to permanent unfertilized grass, legume, pollinator or other mix, ungrazed	0.98	0.28	1.26
Forage and biomass planting (CPS 512)	Convert to grass, forage or biomass plant	0.21	0.01	0.22
Riparian herbaceous cover (CPS 390)	Convert area near water to permanent unfertilized grass	0.98	0.28	1.26
Contour buffer strips (CPS 332),	Covert strips to permanent unfertilized grass, legume, pollinator or other mix	0.98	0.28	1.26
Field border (CPS 386)	Convert strips to permanent unfertilized grass/legume to reduce runoff	0.98	0.28	1.26
Filter Strip (CPS 393)	Convert strips to permanent unfertilized grass/legume	0.98	0.28	1.26
Grassed Waterway (CPS 412)	Convert strips to permanent unfertilized grass/legume to filter water	0.98	0.28	1.26
Vegetative barrier (CPS 601/342)	Plant stiff vegetative cover on hillsides or by streams to reduce erosion; can be used in critical areas	0.98	0.28	1.26
Land use changes- add woody plants				
Convert unproductive cropland or grassland to farm woodlot (CPS 612)	Plant trees and shrubs in marginal cropland to restore diversity, improve water quality	1.98	0.28	2.26
Tree & shrub establishment (CPS 612)	Plant trees and shrubs	1.98	0.28	2.26
Riparian Forest Buffer Establishment (CPS 391)	Replace strip of cropland near water with woody plants	2.19	0.28	2.47
Alley Cropping (CPS 311)	Replace 20% of annual cropland with woody plants	1.71	0.03	1.74
Multistory Cropping (CPS 379)	Replace 20% of cropland with trees & shrubs of different heights, could be permaculture	1.71	0.03	1.74
Hedgerows (CPS 422)	Replace strip of cropland with one row woody plants, could combine with Conservation Cover for pollinators	1.42	0.28	1.70
Grazing				
Silvopasture (CPS 381)	Add trees and shrubs tograzed pastures (> 20 plants/acre	1.34	0.00	1.34
Prescribed grazing/rotational grazing (CPS 528)	Short-term intense grazing in small paddocks	0.26	0.00	0.26

Note: Some implementation guidelines not listed in the NRCS Conservation Practice Standards (CPS) may be required to ensure adequate carbon sequestration and alignment with the GHG reduction estimates from COMET-Planner.

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Appendix L

Public Comments on the 2019 GGRA Draft Plan

2030 GGRA Plan

2019-2020 GGRA Draft Plan Outreach - Summary of Comments (as of 4/17/2020)

MDE hosted 8 public meetings (5 in-person and 3 webinars)

- December 3, 2019 - Eastern Shore – Chesapeake College
- December 17, 2019 - Central Maryland – MDE Main Office
- January 10, 2020 Western Maryland – Frostburg State University
- January 14, 2020- Southern Maryland – Charles County Government Building
- January 29, 2020 – Webinar
- January 31, 2020 - Central Maryland – MDE Main Office
- February 12, 2020 – Webinar
- March 4, 2020 - Webinar

Comments were received verbally at public meetings, electronically via email, and by letter. All comments will be considered in the development of the final GGRA Plan. The comments will be compiled and included in the final plan as an appendix, consistent with the previous GGRA Plan writing process.

General Comments

- Lateness of draft Plan
- Plan doesn't consider the latest science (Oct 6, 2018 IPCC report)
- Market forces will not be sufficient to meet more aggressive goals
- Plan should provide guidance for the public on adapting to climate
- MD should set a 40-60% reduction goal by 2030, net-zero by 2045
- Plan should follow established science in specific areas
- Communities should be required to build only high-density housing
- 40% of state resources dedicated to emissions reduction should be spent in frontline and disadvantaged communities
- Plan should establish labor protections
- Plan relies on undeveloped and unproven technologies
- MD is wealthy and should bear the GHG reduction load
- GGRA should include the moral impact of inaction
- all state agencies should consider climate impacts in their decisions

GGRA plan doesn't include:

- How affordable clean energy will be made available to disadvantaged communities
- How MD will increase RE and EVs
- How transportation spending will reduce GHGs
- How to mitigate GHGS through food production/consumption
- Green Purchasing
- Cost of inaction in economic analysis
- Public Health (asthma rates in MD)
- Risk assessment analysis
- Impacts on criteria air pollutants
- Electricity grid efficiency

Process

- Final Plan should be on-time
- MDE should consult public in development via interim draft
- need to advertise GGRA outreach meetings via social media

Sector-specific: Buildings

- Require new public buildings (funded at least 25% with state funds) to meet net zero emissions buildings standards
- Require at least one of the next five schools in each county to meet net zero for state funded buildings
- Require new commercial buildings with at least 20,000 square feet of roof space to install rooftop solar
- No new gas in government buildings
- Plan should include EE standards for existing buildings when they undergo renovation or retrofit
- complete fossil fuel elimination in buildings by 2050
- net zero building standards for new buildings by 2025
- No new natural gas connections to new buildings
- enhance EmPower
- reduce GHGs not kWh
- electrify w/ EmPower investments
- the Public Service Commission adopt a new program for EmPOWER Maryland that specifically incentivizes the switching from fossil fuels (gas, propane, heating oil, etc.) to electric heating systems and appliances
- "green" building construction in both the public and private sectors

Sector-specific: Energy

- Increase energy efficiency from 2% to 2.8% annually
- No new gas-fired power plants in Maryland
- 100% Clean Electricity
- Moratorium on additional new fracked gas infrastructure
- Prohibit trash incinerators
- electric motors redesigned to help reduce pollution
- Accelerate wood energy in Maryland
- All six (6) existing coal plants should be shut down now
- MD to create a "Coal Community Transition Fund"
- PSC to factor climate change into all its electric sector regulation
- "aggregating" power for residents through contracts
- GGRA doesn't include a mechanism to increase RE in CARES
- Mattawoman Power Plant permit should be revoked
- no fracked gas consumption in MD
- include upstream leakage of NG in GHG inventory
- CARES should only rely on RE
- RGGI needs to be expanded
- no Nuclear resources in CARES
- 20 yr GWP for GHGs in goals and inventory
- MDE should review NG sector fugitive leak rate
- MD should prohibit NG expansion
- No more WTE, Biomass/Poultry litter in CARES
- MD should make Ocean City OSW part of GGRA
- Plan needs to require long term contract for Solar
- include the programs to clean up coal's power plant ash storage seepage
- retrofit existing buildings, e.g.,40% conversion of oil and propane and 20% natural gas to electricity by 2030; 80% oil and propane and 60% natural gas by 2040; and 100% in 2050.

Sector-specific: Transportation

- Electrify the state light vehicle fleet by 2030
- fully electrify bus transport in Maryland by 2035
- expand funding for WMATA and MTA.
- fund Red Line, the Corridor Cities Transitway, and MARC expansion initiatives

- Stop highway expansion
- how are GHGs reduced while expanding highways
- Increase public transit funding
- Only purchase electric buses starting in 2022
- Support expansion of charging stations, especially in multi-unit housing
- MD should keep working on TCI
- TCI not ambitious (40% by 2032)
- transit investment are insignificant
- EV goal is too ambitious w/out mechanism to implement
- need better EV incentives
- MD should pressure auto industry

Sector-specific: Waste

- more robust zero waste policies and practices
- assess all waste treatment facilities for resilience and reliability of operation

Environmental Justice

- MD needs a plan for coal plant shut-downs
- Just transition: how to fund and implement
- landlords holding back EE in low income

Nature-based Solutions

- Plant 5 million trees by 2030
- net forest and tree canopy gains in Maryland by 2025
- strengthened Forest Conservation Act.
- Promote composting
- Prevent large organic waste generators from sending waste to landfill or incinerators if there is a compost or digester facilities within 30 miles
- Provide incentives to transition to sustainable agriculture practices
- Update MDE air emission regulations for the use of woody biomass
- Establish thermal energy credits as an incentive the development of woody biomass.
- provide sustained support for the Maryland Wood Grant Program
- better support of commercial woody biomass projects by state government

From: **David Smedick** <david.smedick@sierraclub.org>
Date: Tue, Apr 21, 2020 at 5:05 PM
Subject: Sierra Club Comments on Draft GGRA Plan
To: Ben Grumbles -MDE- <ben.grumbles@maryland.gov>
Cc: Chris Hoagland -MDE- <chris.hoagland@maryland.gov>, <gslater@mdot.maryland.gov>, <climate.change@maryland.gov>, Josh Tulkin <josh.tulkin@mdsierra.org>

Secretary Grumbles,

Attached to this email please find Sierra Club's comments (and supporting resources) on the MDE'a Draft Greenhouse Gas Reduction Act Plan. I have CC'd Secretary Slater for MDOT, Chris Hoagland, the Climate Change Program's general email address.

We appreciate the opportunity to submit these comments and resources and look forward to working with you and everyone at MDE, MDOT, and the Hogan administration on finalizing the state's GGRA Plan.

If you or your staff have any questions please do not hesitate to contact me.

Sincerely,
David

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SIERRA CLUB

David Smedick
Senior Campaign Representative
Beyond Coal and Dirty Fuels Campaigns
Maryland, Delaware, & District of Columbia
Sierra Club

Phone: (443) 789-4536
david.smedick@sierraclub.org

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Chris Hoagland
Program Manager
Climate Change Program
Maryland Department of the Environment
(410) 537-3291
chris.hoagland@maryland.gov

Click here to complete a three question customer experience survey.

November 9, 2019

Sierra Club
7338 Baltimore Ave, Suite 102
College Park, MD 20740

Maryland Commission on Climate Change
1800 Washington Blvd
Baltimore, MD 21230

RE: Comments Regarding Maryland Commission on Climate Change Annual Report Recommendations

Dear Commissioners,

We are deeply concerned that the Commission on Climate Change (the Commission) and the Mitigation Working Group (MWG) within the Commission are failing to meet their charge of providing recommendations to the Governor and General Assembly on strategies and programs to reduce climate-disrupting pollution.

For consecutive years, the recommendations from the MWG fail to propose any specific new or innovative programs to tangibly reduce climate pollution. Instead, the MWG is again proposing to recommend merely analysis, study, and coordination, in many cases on programs that already exist. The state, nation, and planet are facing an existential climate emergency, yet Maryland's primary stakeholder body charged with considering climate mitigation efforts is not recommending action to reduce pollution. This is unacceptable and damaging to our efforts to fight climate change.

We urgently request that the Commission adopt the following tangible recommendations. Many of these recommendations have been included in previous Commission Annual Reports or discussed in the MWG and in the public for the past two or more years.

Electricity Sector

- **Responsible phase-off of coal power plants in Maryland**[1] — We recommend that by the end of 2020 the General Assembly and the Governor work with public stakeholders to develop and finalize a responsible and specific plan for transitioning from Maryland's six large-scale coal electricity generators over the ensuing decade, while maintaining reliable power, and for the establishment of programs that protect and support

[1] This recommendation was included in the 2018 Annual Report of the Commission, within the Minority Note, but was not adopted by the Governor or the General Assembly. (pages 64-65, https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/MCCC_2018_final.pdf)

communities and workers traditionally reliant on these fossil fuel facilities before those coal plants are closed.

  - The plan should follow the best practices for just transition as detailed in Appendix I of the Maryland Department of the Environment's (MDE) Draft 2019 Greenhouse Gas Reduction Plan, including, but not limited to:
    - Providing a timeline for the phase-out of activities and facilities
    - Receiving input from workers and impacted communities early in the planning stages
    - Responding to the concerns, feedback, and questions from those impacted stakeholders

- **No new gas-fired power plants in Maryland** — We recommend that the Governor or General Assembly adopt a moratorium on the construction or permitting of any gas-fired power plants in the state that are not already online and fully operational.
- **100% Clean Electricity** — We recommend the Governor, MDE, and the Maryland Energy Administration (MEA)—in consultation with the General Assembly, relevant stakeholders, and the public—develop a plan to reach 100% clean electricity no later than 2040 that does not include electricity generated in Maryland from fossil fuels like coal, gas, and oil, nor additional ratepayer or taxpayer subsidies for nuclear power.

Transportation

- **Electric Buses** — We recommend MDE and MDOT set a goal to fully electrify bus transport in Maryland by 2035, including setting aggressive targets for the rapid deployment of EV school buses, as well as provisions for low-interest financing.
- **Funding Public Transit and Sustainable Land Use** — We recommend that the state expand funding for WMATA and MTA. Maryland should also provide funding for critical projects such as the Baltimore Red Line, the Corridor Cities Transitway, and MARC expansion initiatives. We recommend the state also fund and support sustainable land use initiatives such as adding a bicycle and pedestrian crossing on the rebuilt Harry W. Nice Memorial/Senator Thomas "Mac" Middleton Bridge.
- **Stop Highway Expansion** — We strongly recommend that Maryland not expand or build new major highways. Maryland should not expand I-495 (the Capital Beltway), I-270, or the Baltimore Washington Parkway, or add a third span across the Potomac. These projects do not solve congestion issues and induce demand for more cars on the road, exacerbating air, water, climate, and noise pollution. Instead, Maryland must invest in real solutions that avoid and reduce congestion including funding transit oriented development projects, expanding affordable housing, and funding public transit as listed above.

Buildings

- **No new gas in Government buildings** — We recommend that the Governor issue an Executive Order or the General Assembly enact legislation to end gas hookups for state-owned new construction projects and instead rely on air source heat pump systems and induction cooking alternatives, where appropriate.

- **Incentivize Switching from Fossil Fuel Heating and Appliances to Electric** — We recommend the Public Service Commission adopt a new program for EmPOWER Maryland that specifically incentivizes the switching from fossil fuels (gas, propane, heating oil, etc.) to electric heating systems and appliances. The program should seek to annually incentivize the retrofit of 40,000 homes in order to meet a goal of a decarbonized residential building sector by 2050.

__Other__

- **Moratorium on additional new fracked gas infrastructure** — We recommend the Governor direct agencies to place a moratorium on approval of permits and applications of new fracked gas infrastructure such as new pipelines and compressor stations.
- **Forest Protection and Gains** — We recommend that the General Assembly and the Governor require net forest and tree canopy gains in Maryland by 2025 through the enactment of various forest management and tree planting programs and initiatives; including a strengthened Forest Conservation Act.[2]

This list of recommendations is not all-encompassing of what we believe needs to be done in the state to mitigate climate disruption. Maryland needs to adopt more robust zero waste policies and practices by phasing off of polluting trash incinerators and expanding composting, expand healthy soils and wetlands practices to draw-down and sequester carbon through natural processes, and provide more funding for the equitable deployment of more light-duty electric vehicles.

A body that is charged to recommend measures to mitigate climate disruption, but does not provide any recommendations for the state to reduce pollution, is a body that is broken. The Commission must fill in the missing pieces left by the MWG's failure to do its job by adopting specific recommendations to reduce climate pollution in its 2019 Annual Report.

Thank you for your time and consideration. Please do consider these recommendations and do not hesitate to reach out to the Sierra Club for additional information.

Sincerely,

David Smedick
Senior Campaign Representative
Sierra Club
david.smedick@sierraclub.org
443-789-4536

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[2] This recommendation was included in the 2018 Annual Report of the Commission, within the Minority Note, but was not adopted by the Governor or the General Assembly. (pages 66, https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/MCCC_2018_final.pdf)

IQ - Refer to ARA

MARYLAND HOUSE REPUBLICAN CAUCUS
6 Bladen Street, Room 212 · Annapolis, Maryland 21401 · *Phone* 410-841-3401 · *Fax* 410-841-3451

Minority Leader
Delegate Nicholaus R. Kipke, District 31

Minority Whip
Delegate Kathy Szeliga, District 7

RECEIVED
DEC 16 2019
OFFICE OF THE SECRETARY
MD DEPT OF THE ENVIRONMENT

December 12, 2019

The Honorable Lawrence J. Hogan, Jr.
Governor of Maryland
State House
Annapolis, MD 21401

Dear Governor Hogan:

I write with concern regarding Maryland's participation in the Transportation and Climate Initiative (TCI). A cleaner environment is a need that we can all agree on. However, the ways and means of getting there vary widely. We must be sure that the policy choices we make create not only a healthy environment, but maintain a healthy economy.

As you are aware, the TCI proposals are under development. One of the more concerning aspects being considered by TCI planners is a Cap & Trade program similar to the one enacted in California. The measure would impose carbon taxes on businesses and consumers in this state. Currently, the Carbon Tax in California is 12 cents/gallon. We already know the regressive nature of fuel taxes, they have the most impact on those who can least afford it. As of October, gas prices in California were averaging $4.13 per gallon, $1.50 above the national average. Even with these exorbitant prices, California is one of six states whose carbon emissions have increased since 2013.

With the potential impact to the everyday lives of Marylanders, notice and input from the public and from stakeholders is key. To date, there have been very few opportunities for the public and stakeholders to weigh in on these significant policy matters.

Before Maryland moves forward with TCI, I urge you to hold multiple public outreach sessions across the state to educate, engage, and get feedback from our citizens – those who will be the most impacted by these policy decisions. There is no doubt that we all have a stake in a cleaner environment, and it is that very reason why everyone should have a voice.

Thank you in advance for your consideration of this matter. Please feel free to contact me should you like to discuss this issue in greater detail.

Sincerely,

Nic Kipke

Nic Kipke
Minority Leader

cc: The Honorable Ben Grumbles, Secretary, Maryland Department of the Environment

Dear Governor Hogan,

I have recently read over the Maryland Draft Plan for Reducing Greenhouse Gas Emissions. The plan has several positive qualities such as being the increases in Average Job Impact, GSP Impact, Personal Income Impact, Avoided Mortality, and Avoided Climate Damages. This will save about 52.96 billion dollars by 2030 and 11,649 job-years, by 2050 will save about 65.09 billion dollars and 6,703 job-years. Not only is the GGRA helping the environment, but it is also helping the economy, public health, and employment rate, this could be monumental. Another positive quality is the commitment to try and get 100% clean electricity by 2040, this is super significant because the GGRA will do this at the lowest cost possible, CARES is trying their absolute best to make this happen by 2040. They are taking steps to ease into the idea in converting to a complete clean electricity system in Maryland. Another positive quality is the duty of reducing Greenhouse Gases, they have the state goal of reducing Greenhouse Gases by 40% by 2030 and 80% by 2050, which is a tremendous amount. The work being put towards the reductions are amazing, and I'm sure if the GGRA keeps up the hard work we will have no problem reducing Greenhouse Gas emissions. Although, the plan has some areas to improve, such as how will new jobs open up for coal miners, qualification for the new "green" job could be higher than what coal miners have. Shutting down the coal mines will leave many people unemployed. Another question would be what is the cost of this new clean electricity, many may not be able to afford this because clean electricity has to come at a high cost. Also expanding transportation ways is contradicting to the reduction of fossil fuel pollution. Expanding transportation more people will drive and release more carbon dioxide into the atmosphere.

Therefore, Governor Hogan, I hope that you will maintain the aspects of the new plan that are strong, but also encourage you to improve upon the weaknesses before the plan is put into action.

Sincerely,

[redacted]

Dear Governor Hogan,

I have recently read over the Maryland Draft Plan for Reducing Greenhouse Gas Emissions. The plan has several positive qualities such as, the overall plan to reduce emissions by 40% by 2030. Also, providing 100% clean electricity at the lowest cost is very beneficial to the residents of Maryland, and that ensuring a net increase in jobs and economic benefit are positive factors within this document.

However, the plan also has some areas to improve. I have concerns with converting to 100% green energy, I live in Western Maryland where coal runs everything. Everywhere you go, you will probably talk to two or more coal miners and not even know it. All around are families that are relying on coal to heat their homes, and to be able to shelter them and their family, and put food on their tables. Converting to 100% clean energy could cost people more money than needed and send the less wealthy ones into bankruptcy. It could also cost people their jobs, the coal miners for example. Also where I live, hunting and fishing are very common. Taking away privately owned land for forest management could take away the citizen's hunting and fishing grounds making people very unhappy.

Therefore, Governor Hogan, I hope that you will maintain the aspects of the new plan that are strong, but also encourage you to improve upon the weaknesses before the plan is put into action.

Sincerely,

[redacted]

Dear Governor Hogan,

I have recently read over the Maryland Draft Plan for reducing Greenhouse Gas Emissions. The plan has several positive qualities, including the goal of reducing carbon emissions by 40% by the year 2030. Another positive quality is the goal of the 100% clean electricity by 2040. Lastly, I thought the idea of the expansion of public transport has potential.

The plan also has some areas to improve especially when it comes to how we will be paying for all the changes. Another area that can be improved is including ways that normal citizens can help out. Finally, I think that there should be more focus on renewable energy sources instead of "cleaner" energy sources.

Therefore, Governor Hogan, I hope that you will maintain the aspects of the new plan that are strong, but also encourage you to improve upon the weaknesses before the plan is put into action.

Sincerely,

[redacted]

Dear Governor Hogan,

I have recently read over the Maryland Draft Plan for reducing Greenhouse Gas Emissions. The plan has several positive qualities such as a set of measures to reduce and sequester GHGs, including investments in energy solutions, widespread adoption of electrical vehicles (EVs), and improved management of forests and farms to sequester more carbon in trees and soils. I also think that clean energy will open up more job opportunities for our area.

The plan also has some areas to improve such as the public transit expansion. In our area we don't have many options for public transit and it may be difficult to expand further. I think that reducing 44% of the state's GHG emissions is a good goal to have, but we need to spread more awareness to achieve it. Adaption to better solutions are needed, but people need to want to make a change themselves which could be sparked by initiatives to want to change lifestyles.

Therefore, Governor Hogan, I hope that you will maintain the aspects of the new plan that are strong, but I also encourage you to improve upon the weaknesses before the plan is put into action. Overall, I think that this is an excellent step in the right direction to becoming a more sustainable state.

Sincerely,

[redacted]

Dear Governor Hogan,

I have recently read over the Maryland Draft Plan for Reducing Greenhouse Gas Emissions. I feel as if this is a very good plan that can overall be successful. The plan has several positive qualities. The first one being the Enhanced Forest Management which is supposed to increase the rate of carbon sequestration in forest biomass and increase the amount of carbon stored in harvested wood products. This is supposed to result in increased availability of renewable biomass for energy production. Another thing is to continue on the path of decreasing GHG emissions. If we have already decreased past our goal for 2025 in 2017, then there's no reason that we are incapable of going even lower than our goal to make the air cleaner. The last thing is spending on capital is lower which leaves consumers with more money to spend on other goods and services. The plan also has some areas to improve in. First off there should be more things in this article that the people of Maryland can do to help out. Another is that this act should not have a risk that will cause certain resident's electric bills to go up just because you are trying to reduce GHG. Also if we reduce GHG emissions there is a chance of it greatly affecting human health. Not only that but also affecting the frequency and intensity of a variety of storms. One more thing to add would be if there could be more focus on 100% renewable energy and not just clean energy. I'm very glad that your ideas focus on energy conservation. Therefore, Governor Hogan, I hope that you will maintain the aspects of the new plan that are strong, but also encourage you to improve upon the weaknesses before the plan is put into action.

Sincerely,
[redacted]

CHESAPEAKE CLIMATE ACTION NETWORK
ccan

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December 03, 2019

To: The Maryland Department of the Environment

My name is Anthony Field and I am the Maryland Campaign Coordinator with the Chesapeake Climate Action Network. Thank you for the opportunity to comment on the Administration's draft Greenhouse Gas Reduction Plan ("draft Plan").

At CCAN, I focus on helping to ensure that fracked gas does not replace coal as an energy source and crowd out renewables. Emerging science shows that when the full lifecycle of gas is taken into account, it is likely just as bad for the climate as coal. Unfortunately, as demonstrated by this Plan and other policy commitments, this Administration continues to embrace fracked gas as a bridge fuel.

Released almost a year after it was due, the draft Greenhouse Gas Reduction Plan relies heavily on Governor Larry Hogan's Clean and Renewable Energy Standard ("CARES") plan, which claims to create a path to 100% clean electricity despite continued reliance on fossil fuels. CARES is essentially a set of bullet points that proposes to achieve "100% zero- and low-carbon" electricity by 2040.

Of particular concern is CARES's reliance on gas. The plan qualifies gas plants that employ carbon capture and storage as "available and emerging zero- and low-carbon sources" that will help to achieve 100 percent clean electricity, but a reliance on these technologies could continue our dependence on fossil fuels and impede the transition to renewable energy sources. Further, this technology is not currently an approved fuel source within Maryland's existing renewable energy program.

Additionally, the draft Plan's evaluation of methane is not based on the best available science. For example, the latest report from the Intergovernmental Panel on Climate Change finds that methane is 86 times more potent a greenhouse gas over a 20-year period than carbon dioxide, yet the draft Plan uses an outdated global warming potential of 21--underestimating methane's impact on the climate by a factor of four.

I was last on the Eastern Shore to testify at a public hearing held by the Maryland Energy Administration, another Maryland agency, to express my concerns about its plan to "kick-start" a gas expansion across Maryland. Two gas pipelines are currently proposed for the Eastern Shore with another, nearly 100-mile-long pipeline being contemplated and Maryland is poised to invest $30 million in state funding into this expanded fossil fuel infrastructure. I joined 27 concerned Eastern Shore residents at that meeting to ask this Administration to stop its efforts to lock Maryland into further reliance on this harmful fossil fuel. Unfortunately, this draft Plan further demonstrates this Administration's blind spot when it comes to gas. Instead, Maryland should be focusing on proven clean energy technologies that continue to decrease in cost that can and must be deployed at increasing rates across the country.

The United Nations' Intergovernmental Panel on Climate Change has made it overwhelmingly clear that we have 10 short years to reduce our climate-disrupting emissions to avoid the worst impacts of a rapidly warming planet. The use of fracked-gas and fossil fuel infrastructure has no place in a real greenhouse gas reduction plan.

These are not bridge fuels to a better climate, they are bridges to disaster.

Thank you again for the opportunity to comment.

Anthony Field

Maryland Campaign Coordinator

Chesapeake Climate Action Network anthony@chesapeakeclimate.org

From: **Jonathan S. Kays** jkays@umd.edu
Subject: Comments on Draft GHG Reduction Plan
Date: April 2, 2020 at 12:28 PM
To: climate.change@maryland.gov, Christopher.Beck@maryland.gov, Suzanne Dorsey -MDE- suzanne.dorsey1@maryland.gov
Cc: Bill Hubbard whubbard@umd.edu

JK

Attached are comments for consideration regarding the Draft MD Greenhouse Gas Reduction Plan. Please feel free to contact me. Given the present situation I can be reached on my cellphone at 301-318-8044.

Jonathan

--
Jonathan S. Kays, Forestry Extension Specialist
University of Maryland Extension
Western MD Research & Education Center
18330 Keedysville Road, Keedysville, MD 21756
Phone: 301-432-2767 x323
Email: jkays@umd.edu
Website: www.extension.umd.edu/woodland

GHGR plan letter-...0.docx

What Can The US Lea...1.docx

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TEL 301-432-2767 x 323
jkays@umd.edu

Christopher Beck, Climate Change Program Division Chief
Maryland Department of the Environment
Christopher.Beck@maryland.gov

Mr. Beck,
I am a forestry extension specialist and faculty with the University of Maryland College of Agriculture and Natural Resources. I have been providing organizational leadership for the Maryland Wood Energy Coalition since 2010, and my role has been to provide research-based educational information for policymakers, citizens, and others. The Coalition is composed of agencies, industry, nonprofits and others who seek to advance the adoption of clean-burning wood energy technology in Maryland. I have organized a number of educational efforts such as:

- Accelerating Wood Energy in Maryland – 2012 https://www.youtube.com/playlist?list=PL0RQ962SbK2gKrlUcl6wbywK8J6OpmMiO
- Advancing Sustainable Wood Energy In Maryland – 2013
- Biomass Boot Camp – 2015 https://extension.umd.edu/woodland/your-woodland/workshop-resources-library#Biomass2015
- A Prospectus For Advancing Biomass Thermal Energy In Maryland Developed By the Maryland Wood Energy Coalition – February 2012 https://extension.umd.edu/sites/extension.umd.edu/files/_docs/programs/woodland-steward/20120212MarylandWoodEnergyProspectus.pdf

The Coalition has four main objectives:

1) Update MDE air emission regulations for the use of woody biomass which was accomplished
2) Establish thermal energy credits as an incentive the development of woody biomass. The Thermal REC bill has not passed.
3) Provide sustained support for the Maryland Wood Grant Program. MEA continues to support this very popular program.
4) Public agencies & facilities to lead the way. There is a great need for better support of commercial woody biomass projects by state government to demonstrate the technology.

Based on my knowledge of the use of woody biomass I have provided some specific points to address in the draft and then some suggestions for inclusion.

1) Pg 73 has references to biomass - see text below from plan:

EPA Biogenic Carbon Accounting Framework not finalized

- *Considerable debate amongst academics/policy makers how to treat biomass emissions*
- *Agreed that timescale of emissions source/sink is critical*

- *MDE has chosen to include biogenic emissions at the point of consumption*

The text says biomass is not considered carbon neutral but considers all emissions at the point of consumption as an input with no reduction due to regrowth. That is counter to EPA policy and how it is treated by other states and the European Union Climate Action. I do not believe there is "considerable debate" on this issue. Researchers that argue biomass energy is not carbon neutral recognize the carbon is re-sequestered but do not have assurance it will be taken back over time, and question what damage the initial released carbon may cause before that regrowth. There are nuances to be addressed perhaps if land is not reforested or mitigated elsewhere, but harvesting and then regrowth of forests on the same land or mitigated land to produce biomass is an accepted part of a reasonable long-term strategy for carbon cycling.

The present MDE modeling eliminates counting the reduction in greenhouse gases provided by using biomass that would otherwise be produced by fossil fuels. Fossil fuels add to the pool of carbon, they do not recycle as per the definition of renewable and is not a viable long-term solution, biomass is. The present modeling is really saying that woody biomass is not a quantifiable renewable energy source. MDE has made an erroneous assumption here that needs to be addressed to bring carbon neutrality within more accepted thinking. A recent paper "*Forests: Carbon sequestration, biomass energy, or both?*" provides an excellent overview of this issue and concludes that the expanded use of wood for bioenergy will result in net carbon benefits, but an efficient policy is also needed to regulate forest carbon sequestration.

- *Alice Favero, Adam Daigneault, and Brent Sohngen. (2020). Forests: Carbon sequestration, biomass energy, or both? Science Advances, 25 Mar 2020: Vol. 6, no. 13, eaay6792. DOI: 10.1126/sciadv.aay6792*

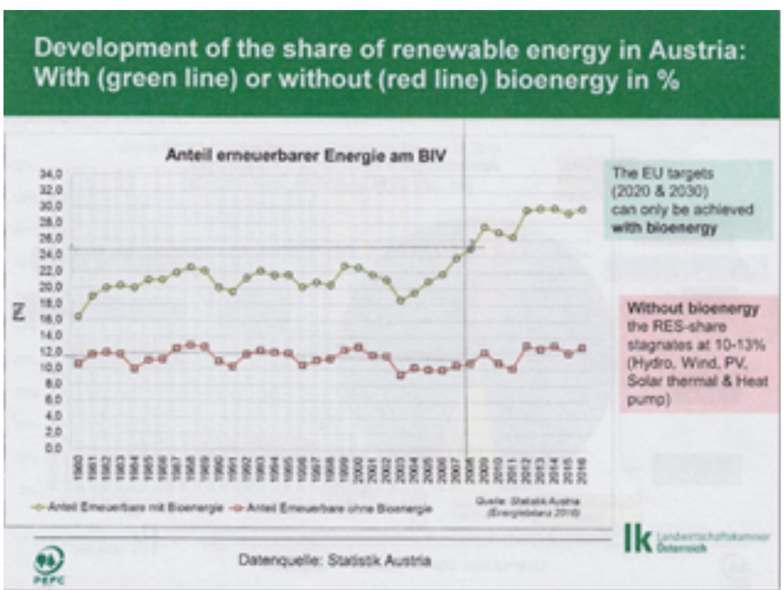

Figure 1

It is highly questionable if the aggressive goals for greenhouse gas reduction in Maryland will be met without woody biomass. The European Union Climate Action Plan includes thermal energy from district heating systems as a contribution to reducing GHG's. I visited Austria and Germany for 10 days in February 2019 and I have seen how they incentivize biomass use. The graph below shows the major contribution biomass has made to reaching Austria's GHG reduction goal. This is progressive thinking and should be adopted in Maryland. This requires providing a method to account for the thermal production using biomass. The development of a thermal REC program in Maryland would incentivize biomass and geothermal contributions. I have attached an article that I wrote on, *"What Can The US Can Learn from Europe Advances in Biothermal Energy*?" It provides a useful perspective on the issue.

2) Page 122. Biomass for Energy Production

This section does not provide an accurate assessment of the biomass situation and fails to provide recommendations that would encourage commercial biomass applications.

- DNR is working with partners. Much of what has been accomplished since 2010 on woody biomass has come from the MD Wood Energy Coalition, which worked with MDE to update regulations so that the use of wood as a fuel is no longer prohibited for commercial boilers. This was an implementation milestone. The University of Maryland Extension has helped to organize many conferences and resources to educate policymakers, nonprofits, agencies, citizens and others about wood energy applications. This includes a website with resources and information: https://extension.umd.edu/woodland/wood-energy-opportunities.
- Coalition members were instrumental in communicating with policymakers to establish the Maryland Energy Administration Residential Wood Grant Program to expand the use of pellet and wood stoves for residential citizens. This program has been very successful.
- Due the lack of passage of a Thermal REC bill, there is the lack of incentives for development of the industry. This was done for solar and wind and would do much to advance the use of woody biomass in Maryland.
- The MEA Wood Boiler grant program referred to under Implementation Milestones did not have a successful project. However, it must be noted there was only about one month given around the Christmas holiday to find project applicants and even with the short timeframe, there were three good application. Unfortunately, none were negotiated. Any grant program must allow a reasonable timeframe to get out the word and find potential project.
- Government needs to lead the way with renewable energy technologies that are not well understood. This was done with the solar and wind industries but is not being done for woody biomass. The best use of woody biomass is for producing thermal energy (heat), not electricity. However, all the legislation and renewable portfolio standard (RPS) address electricity, not thermal. This is where policy and government can have influence.
- Some enhancements that would help include:
  - Establish a Fuel for Schools program that has been very successful in PA, VT, NH and other states. Schools are low hanging fruit as are state prisons and hospital facilities that require large amounts of heat and hot water. Combined heat and power units could also produce electricity at these facilities. This is off-the-shelf technology that is widely available.
  - Provide funding to analyze state facility records and identify best candidates for woody biomass systems. Facilities that due for a boiler replacement, are off the natural gas grid, and require large amounts of steam and hot water are good candidates.
  - Address environmental justice for rural and low income populations. Forests now produce more than 2.6 times that which is harvested or dies. Forests can be sustainably managed to produce forest products including woody biomass that is now underutilized. Many rural areas contain an abundance of woody biomass that is presently underutilized due to closure of mills.

- The use of biomass creates jobs and economic development that is now lost. Studies in Maine have found that for every dollar spent on oil for heating, 80 cents leaves the community, while for every dollar spend on woody biomass for heating, 80 cents stays in the community. This is because wood can economically be transported about 50 miles, so it creates local jobs and economic development. Not using biomass fails to access potential economic development.
- A few biomass enterprises in Maryland have not materialized because of the stringent air toxics regulation that applies to drying of wood. If wood is burned for heat the new regulations apply, but if the heat is used to dry wood then a whole new air toxic regulation applies. Extra cost for modeling of various pollutants is required whether or not a permit is approved, which seems to depend on how far the stack is from the border. This applies whether it is an urban or rural area. Many states do not apply this toxic regulation to wood drying. It is an indirect barrier to biomass development. What businessperson would build a facility, then have MDE require the modeling, and if it meets the air toxic regulation, then approve the installation? This happened to an eastern shore enterprise with the resultant loss of jobs and economic development to another state. This is a barrier to enterprise development and while it does not directly affect greenhouse gas reduction, it reduces the development of businesses and jobs that would use woody biomass. The air toxic regulation for drying wood should be reexamined.
- An informative webinar on this topic was held with Matt Hafner of MDE. https://www.youtube.com/watch?v=oOJiQjzLj4Q&feature=youtu.be

These are few items to consider based on my work with the MD Wood Energy Coalition. As per the webpage, I am sending the comments to: climate.change@maryland.gov .

Sincerely,

Jonathan Kays
Forestry Extension Specialist

Attachment: • *What Can The US Learn from Europe Advances in Biothermal Energy?*

What Can The US Learn from Europe Advances in Biothermal Energy?

April 26, 2019

In 2008 I traveled with a group of forestry and engineering professionals to Austria to learn about the application of biothermal wood energy taking place on a national scale. The number of wood biomass plants was impressive. It is now 2019 and I had the opportunity to visit Austria again and see the advances in technology and application that has taken place in Austria, and much of Europe. In 2015 Austria had 2,200 biomass heating plants and 140 biomass combined heat and power (CHP) plants, all in a country no bigger than the state of North Carolina (Figure 1). The use of wood to produce thermal heat and some electricity (use CHP) in Austria has the full support of government through generous subsidies to residential and commercial applications, and through progressive policies and regulations that use carbon taxes and other policy tools. The question is how would this approach work in the US, what parts are applicable, and what can we learn from the Austria experience?

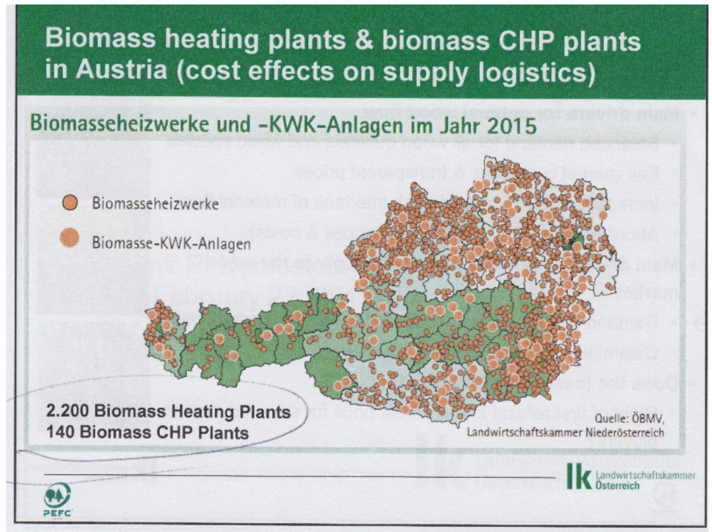

Figure 1

In the last few decades the Austrians have supported all technologies the will achieve renewable energy, sustainability, energy security and fossil carbon energy reduction objectives. In brief, they have taken seriously climate change goals imposed by the European Union (EU) and they want to reduce the dependence on Russian gas supplies, which is a huge security issue. European Union Renewable Energy Target 2020 sets binding targets for member states to reduce greenhouse gas emission (GHG) by 20% by 2020 compared to 1990 levels. The EU 2030 targets seek a 40% cut in GHG emissions by 2030. They realized that the only way to significantly increase renewable energy and meet the EU targets was with bioenergy, more specifically, the use of wood fuel, which is carbon neutral by EU definition and by the US Environmental Protection Agency (EPA).

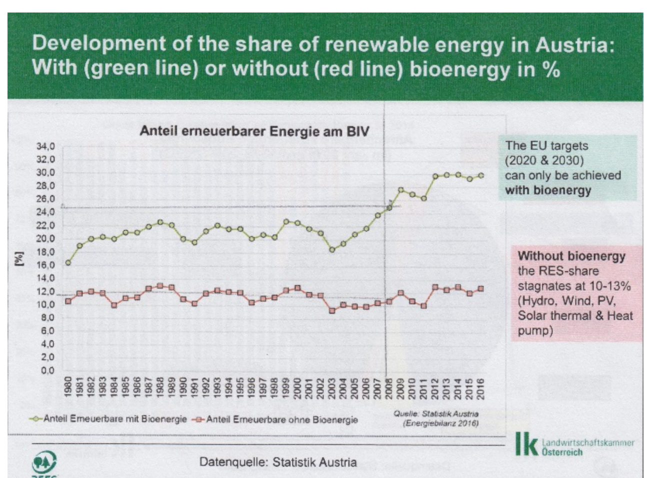

Figure 2

Figure 2 shows that without the use of bioenergy the renewable energy share stagnates at 10-13% relying only on hydro, wind, PV, solar & heat pumps. The only path to reach EU targets for 2020 & 2030 is with bioenergy.

State governments in US have set similar goals known as Renewable Portfolio Standards (RPS) but they are largely limited to producing 20 or 30% of electricity from renewable sources, they never acknowledge the use of thermal energy, its contribution to the energy stream, nor the use of wood biomass an efficient and clean technology to produce thermal energy and CHP.

Europeans countries generally understand the thermal energy value of wood and have incentivized it while the US has not. They have well-developed supply chains and woodland owners regularly thin their woods and leave logs along the roadside to be picked up and transported to district energy facilities or other locations, from whom they are paid. Harvest areas are immediately planted with new seedlings and the young forest nurtured to grow vigorous to produce a new forest (Figure 3). The level of forest management is impressive because there are markets for low and high-quality wood products, much of this in the thermal energy production market.

Figure 3

Unfortunately, the US has an unrealistic look at energy production, which is about one-third for electricity, one-third for transportation, and one-third for thermal energy to heat and cool our homes. Renewable energy production is focused primarily on electricity, with only one state including thermal energy. Environmentalist in the US are supportive of solar and wind, but unwilling to accept the carbon neutral status of renewable wood biomass and encourage its use. Fortunately, many US citizen know better and wood and pellet stoves and furnaces are very popular, the challenge being to replace older high emission units with more current clean burning technology.

The lesson that Europe can provide the US is, for renewable energy to increase, solar and hydro must be supplemented by wood biomass to attain the renewable portfolio standards (RPS) that are presently in place and the increases being recommended. The Austrians and Europeans in general, have recognized the carbon-neutral status of woody biomass and developed supply chains, incentives and markets needed to aid its development. The US needs to follow suit.

There are some other major differences between Austria and the US, especially regarding workplace safety. During visits to many manufacturing facilities, workers did not wear hardhats, ear or eye protection, or have any of the safety requirements required by OSHA in the United States. Workers smoked at work stations, there were no beepers on equipment, and wiring and equipment installed in district heating systems lacked the level of protection found in the US. OSHA regulations protect US workers and they are essential. The point is that lower work safety requirements in Austria translate into lower costs for installation and maintenance of biomass and other energy systems compared to the US.

Austrian policies to incentivize wood biomass result in significant carbon-based taxes on fossil fuels and electricity to cover the higher cost of thermal and electrical energy produced by biomass and conservation improvements. Austrians pay about $0.24/kwh for electricity while in the US electricity is a half to a third of that depending upon where you live. Gasoline is more than twice as much in the US. The use of carbon taxes on gas and electricity is not politically likely in the US but allowing wood biomass systems to compete equally with other renewables such as solar and wind for public projects makes sense. Btu's of thermal output is typically converted to kilowatt hours of electricity using the conversion of 3,412 Btu's per kilowatt hour. Wood is not the answer for many energy applications but if builders, architects, and governments have the choice, it can then rise or fall on its own merits.

A major stumbling block is the unfamiliarity of architects and engineers with commercial and residential wood biomass systems. This is where government agencies, trade organizations, and other educational institutions can have an impact. Enhancing demand and supply chains can be encouraged with public facilities putting biomass on an equal level with other renewable energy systems. This was the case with the fledgling solar industry years ago and it can be repeated for the wood biomass industry. Creating a thermal Renewable Energy Credit for wood and heat pumps would be a positive step by capture existing energy production in RPS targets and providing an incentive for more development.

As a forester, expansion of wood markets for renewable energy production would provide woodland owners more opportunities to derive income from forest properties to accomplish their objectives and encourage sustainable management. Forests of high-quality trees can only developed if there are markets for low-grade material and solutions to thinning forests to prevent wildfires requires economic models with viable markets to utilize the wood. The US is not Europe but incorporating aspects of Austrian wood energy economy would benefit renewable biomass energy efforts in the US.

Jonathan Kays
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From: maryjeffsilva@verizon.net
Subject: GGRA Comment: GGRA Plan With CARES Is Not Legitimate
Date: April 22, 2020 at 3:48 AM
To: Christopher.beck@maryland.gov

Dear Mr. Beck and Members of The Maryland Commission on Climate Change:

The 2019 GGRA Plan Draft from the Maryland Commission on Climate Change (MCCC) is deficient because it fails to comply with COMAR §2-1206, and the Greenhouse Gas Emissions Reduction Act – Reauthorization (GGRA of 2016). As stated in ES.2 of the Draft of 2019 GGRA Plan release to the public on 10/15/2019, "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." We are past that Dec. 31, 2019 date for a final plan.

In ES.3 of the Draft of 2019 GGRA Plan it says, "the state's GHG emissions are already below the 2020 Plan goal." While that is fortunate, we still have to identify the state and local government infrastructure that will be taken from us when damaged by the effects of Climate Change and have the money to pay for adaptation programs that are yet to be determined. Continuing on through ES.3, Governor Hogan's Clean and Renewable Energy Standard (CARES) proposal components are described.

The following will be a deconstruction, *in italics*, of the phrases used in the CARES proposal.
ES.3 asserts the state will have 100% clean electricity by 2040. *Who would not want 100% clean electricity immediately? So, we are starting in agreement.*
ES.3 asserts CARES would adopt a Market Based and Technology-Neutral approach to achieving 100% clean electricity at the lowest cost. *Maryland already has a Market Based choice of different generators of electricity that supply to the customer through his electricity distribution company. Electricity is not technology-neutral. It needs exacting technological conditions to perform as we have used it in the past. Now, the challenge is to repeat that past reliability harnessing diffuse, variable forces that have no pollution, converting what was collected into some form of stored energy and then converting the stored energy into usable electricity with a 99.9% reliability.*

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. *Notice CARES focus is on vague future zero and low-carbon sources. What CARES is doing is promoting energy production and ignores conserving and storing energy.*
The broad set of eligible technologies would include:

- Additional Maryland solar beyond the requirements of the RPS solar carve out
  An assertion performed in writing only. Maryland's ability to fulfill the new RPS carve out depends on allocating tax money for rebates and tax credits. The carbon tax revenue distribution plan in Policy Scenario 3 would obtain the solar gain beyond the RPS carve out.

- New efficient Combined Heat and Power (CHP), cogeneration systems in Maryland
  Will insurers allow Maryland to relax its fire prevention codes to facilitate wide spread use of uncommon devices used to fulfill this claim?

- Hydropower in Maryland
  This is possible, but it conventionally requires permanent disturbance of large tracts of land where there is adequate elevation change. Tidal current flow technology to harness the tide conditions of the Chesapeake Bay could be researched and developed if the Governor pays for it.

- Nuclear Power in Maryland
  First, nuclear power requires many mining, manufacturing, construction, and disposal operations that permanently damage the environment. Has any nuclear reactor been disassembled and disposed? Has any spent nuclear fuel been moved from a single commercial electricity production plant? Does anyone prefer to use a product of a process that requires a hostile, around the clock level of armed security? If nuclear power is so clean, does everybody knowingly want to be in its presence? Is nuclear power a market-based energy provider when the government pays its accident liability insurance?
  Since no was the answer to all these questions about nuclear power, the conclusion is nuclear power is disqualified from being clean and market based. Furthermore, during the Feb. 21, 2020 Mitigation Working Group meeting a representative of Exelon Corp. using teleconference mentioned the company's confidence the money dedicated to maintenance of the Calvert Cliffs nuclear power station would last only through 2021.
  <u>The Draft of 2019 GGRA relies on Calvert Cliffs to be relicensed to continue operating past 2034, but the plant's owner is confident about it being economical only through 2021</u>.
  Finally, the C2ES and CATF presentation that emphasized the advantages of nuclear power never once used the word 'safe'.

- Natural gas power with carbon capture and storage (CCS) technology in Maryland
  With CCS, carbon pricing would first need to be established to induce market-based forces towards research, development and manufacturing machinery capable of economically performing CCS. However, CARES was intended to negate market-based carbon pricing yet Governor Hogan still claims CARES is market-based. Then there still is the sequester problem of a substance that is only valuable if it is inaccessible for thousands of years.

• Homegrown Energy and Jobs
o 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.

All of the above makes Maryland pay the established organizations that control of existing polluting power production facilities to greenwash the public while the public is endangered by the consequences of their past business practices. Resilience and sustainability will require distributed onsite energy collection, municipal energy storage and thorough energy conservation design and implementation. CARES insures homeowners will be sending their money out of their communities. Marylanders want careers, and that implies work is more sustainable than a job. Renewable energy is sustainable energy that is collected, stored and used in the local community. The money spent for conservation and the collection of onsite energy stays in the community instead of constantly buying out of state sources of energy, such as natural gas.

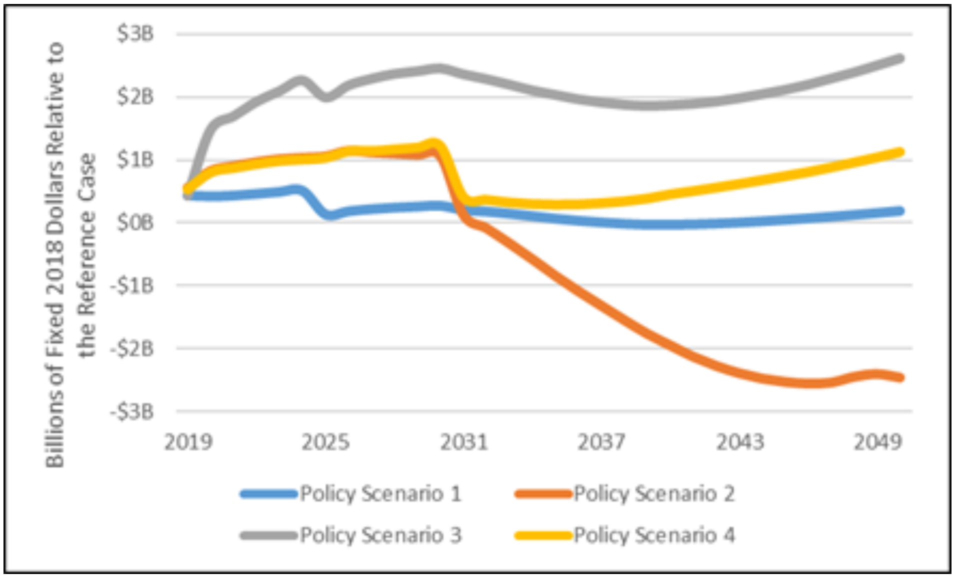
This is a good introduction to the pricing of carbon and envisioned in Policy Scenario 3 (PS3) model that explored the environmental and economic results of Maryland placing a tax on carbon based fuels. Policy Scenario 3 contains carbon pricing as a strategy to reduce carbon emissions instead of using regulations. The carbon price for this scenario was modeled as starting at $20 per metric ton in 2020, rising to the social cost of carbon in 2030 and beyond.

Revenue from the carbon pricing scheme (PS3) is allocated based on the Regional Cost Collection Initiative (RCCI) bill, or House Bill 939, introduced in the Maryland General Assembly in 2018, with modifications:
• $10 million each year is allocated towards administration of the program;
• 50 percent of total revenue, less $10 million, is rebated to consumers in lower income brackets;
• 30 percent of total revenue each year is allocated to additional carbon mitigation measures;
• 10 percent of total revenue is allocated to adaptation and resilience policies, which help vulnerable communities to prepare for and react to climate change; and
• 10 percent of total revenue is allocated to just transition efforts, which provide job retraining efforts and assistance for workers and communities impacted by the transition away from fossil fuels.

A disadvantage of PS3 is it is estimated to increase the cost of a gallon of gasoline by over 50 cents in 2030. At the time PS3 was calculated gasoline cost 78 cents more per gallon in 2018 than it does now. According to AAA, the average price of gasoline in Maryland is now $1.94/gallon and in 2018 the average price of gasoline was $2.72. Considering that yesterday, 4/20/2020, West Texas intermediate (WTI), a benchmark in oil pricing, closed with the price for a barrel of oil at minus $13.10 or -$13.10! Obviously, the drag on the economy that a carbon tax is expected to create does not exist at this time and quite possibly will not if renewable energy quickly replaces fossil fuels. If fossil fuels had their artificial subsidies removed then they could be made obsolete. A tax on carbon at this time would not be felt by the public. The revenue collected could be pumped back into Maryland's economy providing mitigation work and training to significantly reduce the need for fossil fuels.
Establishing a carbon tax would start the Transfer Effect. The carbon fee reduces profits of industries that have relatively low employment in-state (utilities and

profits of industries that have relatively low employment in state (utilities and petroleum manufacturing). Revenue reinvestment, in the form of consumer rebates, construction and government spending, tends to stay within Maryland.

Below is a graph that illustrates the transfer effect as in the form of personal income.



This comment about the 2019 Draft of the GGRA Plan started by saying it fails to comply with COMAR §2-1206. COMAR Environment Article §2-1206 (8) requires that the plan produce a net economic benefit to the State's economy, and a net increase in jobs in the State. Comparing the job creation in 2030 between Scenario 3 and Policy Scenario 4 (PS4) we see 698 more jobs in PS4, but there are more jobs in 2050 with PS3 by 802 jobs. Also, there is much more personal income when pricing carbon as in PS3 than with out pricing carbon as in PS4 for both 2030 and 2050.

COMAR §2-1206 (5) and (6) require MDE to ensure that the plan doesn't threaten the reliability and affordability of electrical service and statewide fuel supplies, and to consider whether it will increase electricity costs to consumers. The household energy burden is a significant issue for low- and moderate-income Marylanders.

> PS3 meets this directly with 50 percent of total revenue, less $10 million, is rebated to consumers in lower income brackets. CARES does not mention a policy or intent to fulfill §2-1206 (5) and (6) directly. Then there is the reliability part of §2-1206 (5) and (6), which is addressed by the renewable energy's on-site collection characteristics. If the power source of one area is lost the rest of the network may still function, if the network is designed for it, because renewable energy production in Maryland involves hydroelectricity, solar power, wind, and biomass. Immediate replacement of fossil fuel power plants with renewable energy will diminish the severity of an atmospheric storms destabilized by manmade Climate Change.

COMAR §2-1206 (8) requires MDE to ensure that the plan does not disproportionately impact rural or low-income, low- to moderate-income, or minority communities, or any other particular class of electricity rate-payer.

> PS3 meets this directly with 50 percent of total revenue, less $10 million, is

PS3 meets this directly with 50 percent of total revenue, less $10 million, is rebated to consumers in lower income brackets. CARES does not mention a policy or intent to directly fulfill §2-1206 (8). In addition, owners of fossil fueled power stations had to scrub the exhaust from their power plants. Where was enforcement of COMAR §2-1206 (8) when collected toxic exhaust materials were dumped in ash storage sites frequently adjacent to black property owners. Those fossil fuel power plant owners stole those black Maryland citizens their wealth and shorten their lives.

COMAR §2-1206 (8) also requires the plan to encourage new employment opportunities in the State related to energy conservation, alternative energy supply, and GHG emissions reduction technologies.

PS3 has 30 percent of total revenue each year is allocated to additional carbon mitigation measures beyond those of CARES. CARES does not directly fund energy conservation, alternative energy supply, and GHG emissions reduction technologies. Therefore, CARES is not able to encourage new employment opportunities. Also, PS3 has 10 percent of its carbon tax total revenue is allocated to just transition efforts, which provide job retraining efforts and assistance for workers and communities impacted by the transition away from fossil fuels. CARES does not pay for just transition programs.

Last, CARES does not directly budget money to adaptation and resilience policies, which help vulnerable communities to prepare for and react to climate change. Contrast that to PS3 that allocates 10 percent of total carbon fee revenue to adaptation and resilience policies.

Thank you for your time and attention.

Jeff Silva
Jftsilva13@gmail.com
12517 Fostoria Way
Darnestown, MD 20878

From: [redacted]
Subject: GGRA Draft Plan comments
Date: April 21, 2020 at 4:39 PM
To: christopher.beck@maryland.gov

CD

Hi Christopher,

Many thanks for the opportunity to comment. I've been working in the climate change field (Paris Agreement and coastal wetlands) for the past 7 years so feel obliged to provide the following feedback:

1) The 40% by 2030 GHGe reduction target is not ambitious enough. The plan makes clear that the goal will be surpassed with policies/activities to be undertaken (44%). We have to up the ante on ambition. Why not make the goal 45%-50% by 2030? Or "at least 44% by 2030"?

2) A mid-century carbon neutrality target is needed. 100% carbon neutrality by 2050. This kind of ambition is necessary to embolden regulatory and legal action to MEET the targets. We need to be reaching, not settling.

3) There needs to be an emphasis on protecting living shorelines as an adaptation strategy. Our salt marsh is one of the most precious in the world. Controlling nitrate pollution alone will not save it. Development pressures are vast and compounded in a changing climate. The plan should include a conservation or restoration of salt marsh target given their climate mitigation and adaptation values.

Many thanks,

[redacted]
Silver Spring, MD

From: [redacted]
Subject: GGRA Comment: Plan Does Not Demand Abatement Reserves for Coal Ash Dumps
Date: April 21, 2020 at 12:27 PM
To: Christopher Beck christopher.beck@maryland.gov

JS

Dear Members of The Maryland Commission on Climate Change:

The 2019 GGRA Plan Draft from the Maryland Commission on Climate Change (MCCC) is deficient because it has no requirement for power plant owners to post a bond or fill an escrow account to pay for the abatement of hazardous materials when their properties are decommissioned and/or abandoned. All fossil fueled power plants in Maryland dump collected exhaust ash containing toxic materials in storage ponds.

According to an article “One of The Most Polluting Coal Ash Dumps in The U.S. Is in Maryland” on March 4, 2019 by WAMU’s Jacob Fenston it states, a “landfill in Prince George’s County has been in operation since the early 1970s, storing decades’-worth of ash from three coal-fired power plants. It now holds nearly 8 million tons of the stuff.” “Among the pollutants in the groundwater at Brandywine, lithium is 222 times higher than the safe level, as determined by the Environmental Protection Agency. According to the EPA, lithium can cause neurological damage, birth defects, and kidney damage. Molybdenum is 111 times the safe level. Cobalt is 47 times the safe level, and Arsenic is five times the safe level.” And that is not an exceptional case. “According to a new report by the Environmental Integrity Project and Earthjustice, 91 percent of coal ash sites nationwide have unsafe levels of at least one pollutant from coal ash in the groundwater. The landfill in Prince George’s is in the top 10 — ranked as the seventh-most-contaminated out of 265 sites across the country.”

Prince George’s County is a minority majority jurisdiction. The real estate industry, from which Governor Hogan has prospered, has practiced both government sanctioned and tacit segregation of black minority Marylanders when they purchased property. The conservative edict of property ownership as experienced by black people was that attainable properties were limited by all facets of the real estate industry and as a result, they did not have the wide choices of locations to purchase as compared to white people of the same income level. The black people did the best that they could and so they bought where they could, which was less desirable because it was close to industrial forms of transportation such as railroad tracks or worn down or both. Simultaneously, the electric power companies located their fossil-fuel power facilities adequately far enough away from influential neighborhoods to avoid drawing attention and close to railroad lines for fuel and equipment. Then when owners of power stations had to scrub the exhaust from their power plants the collected toxic materials were and still is dumped in ash storage sites frequently adjacent to black property owners who did everything the wealthy and/or conservative majority population told them to do. These power plant owners stole those black Maryland citizens their wealth and shorten their lives.

The Draft of the Maryland Commission on Climate Change’s 2019 GGRA Plan intends to retire all existing coal fired power plants in 2023. Without Maryland demanding those power plant owners to fill an escrow account to pay for the abatement of hazardous materials prior to demolition and the cleaning of the land under and surrounding their facilities then MCCC will be complicit with the harm done to black Maryland citizens. The way an industry treats its neighbors is how it will treat everyone. For example, Murray Energy filed for bankruptcy to abandon its pension obligation to its retired employees. Now the households within the states where Murray operated are burdened with the former employees of a company whose chairman still had $300,000 to give to Trump's inauguration.   According to votesmart.org, as of 2018 Governor Hogan received over $365,000 of contributions from energy and natural resource companies.

Please include within the Draft of the 2019 GGRA Plan the requirement that power companies start paying into an escrow fund that pays for the inspection and the abatement of hazardous material at their power generating facilities. If MCCC recommends halting the use of power plant owners' assets then you have the obligation to be smart by protecting Marylander's from a tactic used by others in fossil-fuel industries.

Thank you for your time and attention.

[redacted]

From: [redacted]
Subject: Re: Cimate and Recent Event
Date: April 8, 2020 at 2:20 PM
To: christopher.beck@maryland.gov

D

Thank you for your reply. Regarding the electric motor I have in mind. The idea needs a group with skills for custom designs and a lot of imagination. If the idea does not prove to be a success;I hope the groundwork could be in place for a future breakthrough. The patent office is not available to me or anyone else at this time. If you could advise who could help develop my idea let me know, After I can vet the idea and patent it the idea could be tested.

All the best.
David

-----Original Message-----
From: Christopher Beck -MDE- <christopher.beck@maryland.gov>
To: dposner585 <dposner585@aol.com>
Sent: Mon, Mar 30, 2020 4:32 pm
Subject: Re: Cimate and Recent Event

Thank you for your comment David. Also, any comments you would like to offer about electric motors is welcome.

Chris

CHANGING Maryland FOR THE BETTER

Christopher Beck
Division Chief
Climate Change Program
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, Maryland 21230
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410-537-3594 (O)
Website | Facebook | Twitter

Click here to complete a three question customer experience survey.

On Mon, Mar 30, 2020 at 10:14 AM [redacted] wrote:

> Dear Mr. Beck:
>
> I am writing to say we are living in a once in a lifetime situation to obtain data and other information about the greenhouse gas emissions.
>
> As we focus on them many challenges of the day I wonder can any good emerge from our current situation?
>
> Please tell all like minded concerned People about the hidden cost of carbon emissions on the public. Collect data needed to go forward in a more sustainable world.
>
> When I open the windows and doors now I believe the air is much better now than.
>
> I do have some ideas for electric motors redesigned to help reduce pollution. My ideas are untested and unproven. I am not a person with a lot of expertise in design or engineering but I do have some

ideas which I hope have merit.

Thank you for your consideration.
Sincerely
[redacted]

Click here to complete a three question customer experience survey.

From: [redacted]
Subject: Comments on the MD Draft GGRA
Date: March 26, 2020 at 3:15 PM
To: [redacted]
Cc: [redacted]

Dear Mr. Beck,
Jonathan Kays of UMD Extension requested that interested parties provide comments to you on the Maryland Draft Greenhouse Gas Reduction Act.

The attached comments are the result of the review of the draft MD GGRA by members of the US Forest Service Wood Energy Technical Assistance Team. Our Team provides assistance to agencies, communities, facility owners, and facility managers across the US that are interested in the use of wood energy. We provide assistance in the use of wood energy for both thermal and combined heat and power (CHP) applications. We have provided this assistance for more than 12 years and have worked on the review and development of more than 200 project ranging in size from small community buildings to projects that served over 1,000,000 ft^2 of conditioned space or utilized in excess of 150,000 tons of wood residues annually.

In addition to our comments on the Draft GGRA, we have attached an example of the importance of the use of wood for energy to combat creation of additional greenhouse gas impacts. This example is based on our experience at trying to utilize the material managed at Baltimore's Camp Small wood yard. This facility is one of the sites that the City of Baltimore stores and processes urban wood residues removed during the management of the city's street trees and other city owned or managed properties. We believe that this analysis provides additional support to the importance of being able to use wood for energy in Maryland.

I have also attached an analysis of a project that was proposed to utilize a portion of the material coming to Camp Small. Unfortunately, the Poly-Western High School project was not implemented. However it would have provided a great opportunity to reduce the amount of material stored annually at Camp Small and reduce fossil fuel use at the school.

Best regards,
[redacted]

Lew R. McCreery
Forest Products Technologist
Wood Energy Technical Assistance Team Leader
Forest Health and Economics

Forest Service
Eastern Region State and Private Forestry

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Caring for the land and serving people

MD Draft GGRA comments.docx

20200324 Camp...um.pdf

20170210 Poly-Wester...AL.pdf

Date: 03/26/2020

TO:

Christopher Beck
Climate Change Program Division Chief
Maryland Department of the Environment

Subject: US Forest Service Wood Energy Technical Assistance Team Comments on the Maryland Draft Greenhouse Gas Reduction Act (GGRA)

1) There are conflicting and confusing statements with respect to the treatment of biomass in the GGRA draft. This has a **major negative impact on the forest products manufacturing industry**. This industry is not mentioned as seeing an impact from this rule in Section 7 Protecting Manufacturing. In primary forest products manufacturing, between 50-60% of the wood material that comes into a mill in log form ends up as a manufacturing residue that must be removed from the facility. These residues, unless beneficially reused, will ultimately become methane or carbon dioxide released to the atmosphere without positive benefits. Additionally, if this material does not have a market with any value, it becomes a waste that must be landfilled, and a major cost for this manufacturing industry. This is a cost that the industry cannot absorb and stay viable.

   One of the most sustainable and beneficial uses of this low value material is for energy that offsets the use of a non-renewable fossil fuel. This avoids these wood residues from becoming emitted methane, while offsetting emissions from fossil fuel, thus, directly and immediately reducing GHG impacts. Even more importantly from a carbon perspective, it is absolutely critical to understand that **a thriving forest products manufacturing industry is required to allow for sustainable forest management**, which is a pillar of the GGRA as currently written. Undermining this industry limits the ability to sustainably manage forests, and drives land use changes that move land away from being forested.

   a. **Chapter 7 should be amended to include major protection of Forest Products Manufacturing given the current discussion on biomass in the GGRA and the lack of policies supporting a market for wood manufacturing residues. Note that if the GGRA is changed to include policies that generate markets for manufacturing residues for clean and efficient use for energy, these industries will not need protection.**
   b. Overall methane from landfills is a reasonably significant concern, as identified in several locations in the GGRA. The fate of wood residues from industry do not seem to be considered or mentioned, and a new influx of wood manufacturing residues to landfills is not discussed in the GGRA.

2) The GGRA relies heavily on expanding existing sustainable forest management in the State to avoid land use changes on existing forestland, and to provide a very valuable carbon sink. This sustainable management, by definition, will generate low value residues that need to be removed from the forests. It is imperative that there is a market for these residues. Otherwise, their fate is to generate methane and carbon dioxide, or possibly worse if the residues are addressed with open burning. The mix of GHG emissions from these residues depends on their ultimate fate. **The benefits of sustainable forest management should not be claimed in the GGRA if the GGRA is ambiguous or negative on the use of wood residues from sustainable**

forest management for clean and efficient use of these residues for thermal and combined heat and power energy pathways.

a. GGRA counts around 11% of the annual emissions as taken back up by forests in MD, and forests are by far the largest carbon sink claimed. The claim is around what is sustainably managed, and there are targets for bringing more acres under sustainable management over time to maintain or increase the size of this carbon sink.

3) There is a good discussion of the importance of encouraging the use of wood for thermal / combined heat and power in support of sustainable forest management. Section 4.3.10.4 Biomass for Energy Production identifies ongoing steps to help create these sustainable markets being taken by DNR (see below). However, in terms overall recommendations to address GHG emissions, there is no mention of policy recommendations that will specifically address this in any way.

   a. The following are the summarizing statement of actions needed as defined by DNR: “Actions that still need to be implemented include:

      i. 1. Developing a policy supporting thermal energy

      ii. 2. Recognizing wood as a renewable energy source, on par with solar, geothermal and wind”

4) The GGRA does not significantly address potential land use changes associated with any of the policies around renewable energy adoption, particularly solar and wind projects. These can have a major impact on Maryland’s forestland if not carefully considered, as can the lack of policies recognizing the need for sustainable management and what to do with the residues that come from this sustainable management.

5) There is very little mentioned with regard to addressing renewable thermal energy in the GGRA. Key steps are identified as using more efficient gas appliances, electrification of buildings (and switching electric to renewables), and encouraging bio methane to reach 25% of gas delivery by 2050. This seems to be a large hole in the GGRA with respect to real policies that will drive change. Low value wood residues are a particularly good match for protecting industrial energy users that could be majorly impacted from a thermal energy cost perspective if there is a carbon tax or other changes to address carbon emissions that drive up their energy costs.

6) In a related item, Maryland policy language seems to limit the use of woody biomass (both manufacturing and forest management residues) for obtaining thermal REC’s. Currently, wood residues (other than old growth timber) are “qualifying biomass” that fall under Tier I resources for electric REC production. However, wood residues do not appear to be allowed for thermal REC production unless they are used in systems where the majority of the energy comes from animal manures. Allowing wood residues to be the major fuel for both thermal and/or combined heat and power is a more efficient use of this fuel rather than electricity only. Additionally, most wood-fired thermal and CHP projects are at a scale that makes mixing wood and animal manure not financially viable. Thus, the technical merits of requiring mixtures with animal manure do not seem to make sense.

From: [redacted]
Subject: Comments: 12 Feb 20 GGRA Public Presentation
Date: February 12, 2020 at 1:44 PM
To: Christopher.beck@maryland.gov

JS

Dear Mr. Beck:
Thank you for your service to the public. Below are my comments for improving the GGRA plan.

Item 1
Searched of GGRA draft for the word ash using the Ctrl-F method and ash had 4 returns. None mentioned coal fly ash storage ponds generated by the filtering of coal power stations to reduce the particulate.

That is a serious defect.
Appendix I titled Just Transitions has the same defect.

The Governor must include the programs to clean up coal's power plant ash storage seepage that has contaminated the adjacent ground water from those power plants' supplemental facilities. The power plant owners must be made to pay for their pollution or Just Transitions is "just a travesty".

Item 2
Searched of GGRA draft for the words "waste treatment" using the Ctrl-F method and the phrase waste treatment had 1 return on page 156 as a source of methane and other GHG.

These facilities are crucial to the infrastructure that makes urban and suburban areas home to the majority of Maryland's population but they are not directly mentioned in the GGRA draft plan. Many of these sewage waste treatment facilities are placed in low elevation locations to take advantage of gravity to perform its collection function. In the event of high quantity rain events and prolong periods of precipitation these treatment plants must operate during flood conditions and possible power outages.

I doubt without a direct mention of this requirement within the GGRA draft, the protection of Maryland's urban and suburban population centers will be left to a thin layer of capability that municipal governments have available to meet an increased level of adversity. Maryland should individually assess all waste treatment facilities for resilience and reliability of operation during periods of high participation that are anticipated by our Climate Crisis as part of the final GGRA. After that assessment, the evaluation of sewage treatment plants in major population centers for renovations to capture and use GHG could be performed.

Thank you for your time and attention.

[redacted]
12517 Fantasia Way Damascus, MD 20878

Dear Governor Hogan,

I have recently read over the Maryland Draft Plan for reducing Greenhouse Gas Emissions. The plan has several positive qualities, and will have a positive impact on Maryland's economy. The Draft Plan provides strong evidence to support each point, and is very influential and encouraging to make change. This plan protects manufacturing jobs and creates significant “Green Jobs” in Maryland. The Draft Plan uses a high-end dynamic modeling tool used by various federal and state agencies, which makes all of the models very reliable. It also mentions that fuel savings will be greater than the amount that they spend on capital cost. The plan also has some areas to improve. The Draft Plan offers natural gas as the main conversion to “clean energy”, even though it still has a high, negative impact on the environment. The plan does not explain what the actual people of Maryland can do. It contains many ways that the government and businesses can help, but not simple ways that we can. Although this plan explains many ways to convert to cleaner energy and the reduction of emissions, the plan does not mention or even offer the use of renewable energy sources. The Maryland Greenhouse Gas Reduction Act Draft Plan provides many strong points, but leaves the citizens in Maryland with many questions. What “green jobs” is the government providing? Will this require funding, and come from higher taxes? The Draft Plan is a great start for a cleaner, more sustainable and more efficient future, but does need a few improvements. Therefore, Governor Hogan, I hope that you will maintain the aspects of the new plan that are strong, but also encourage you to improve upon the weaknesses before the plan is put into action.

Sincerely,

[redacted]

Dear Governor Hogan,

I have recently read over the Maryland Draft Plan for Reducing Greenhouse Gas Emissions. I feel as if this is a very good plan that can overall be successful. The plan has several positive qualities. The first one being the Enhanced Forest Management which is supposed to increase the rate of carbon sequestration in forest biomass and increase the amount of carbon stored in harvested wood products. This is supposed to result in increased availability of renewable biomass for energy production. Another thing is to continue on the path of decreasing GHG emissions. If we have already decreased past our goal for 2025 in 2017, then there's no reason that we are incapable of going even lower than our goal to make the air cleaner. The last thing is spending on capital is lower which leaves consumers with more money to spend on other goods and services. The plan also has some areas to improve in. First off there should be more things in this article that the people of Maryland can do to help out. I live in Western Maryland where many people are coal miners and many families rely on coal to heat their homes. Therefore I’m a little concerned with the 100% green concept relating to what will happen to these people. Another is that this act should not have a risk that will cause certain resident’s electric bills to go up just because you are trying to reduce GHG. Also if we reduce GHG emissions there is a chance of it greatly affecting human health. Not only that but also affecting the frequency and intensity of a variety of storms. One more thing to add would be if there could be more focus on 100% renewable energy and not just clean energy. I’m very glad that your ideas focus on energy conservation. Therefore, Governor Hogan, I hope that you will maintain the aspects of the new plan that are strong, but also encourage you to improve upon the weaknesses before the plan is put into action.

Sincerely,

[redacted]

From: [redacted]
Subject: 2019 GGRA draft plan comments
Date: February 7, 2020 at 9:03 AM
To: christopher.beck@maryland.gov

AC

Dear Governor Hogan,

I have recently read over the Maryland Draft Plan for reducing Greenhouse Gas Emissions. I think it is a great thing that our state's government is taking proactive measures to reduce Greenhouse Emissions, and I think this is a step in the right direction to be a green state.

The plan has several positive qualities. One of the positive qualities that will benefit the state tremendously is that it will create jobs. Not only will it give those already living in Maryland jobs and bring the unemployment rate down, but it will cause others from other states to relocate in search for jobs. The reduction of the use of these gas emissions will help to protect the public health of Maryland citizens and improve air quality and the Chesapeake Bay water quality, which will also improve our economy because it depends on the fisheries in the Chesapeake Bay. The plan also wants to transition to cleaner and more efficient public transportation, which will reduce pollution and gas emissions.

The plan also has some areas to improve. These possible improvements are to identify where the money to make these changes happen. Also, this plan is identifying what the state is going to do to make changes and improvements, but is not identifying what we as Maryland citizens can do to make improvements. Another improvement that could be added to the plan is that 100% clean energy is not the same as 100% renewable energy. Renewable energy is solar and wind energy, and the plan states that it wants to stray away from using coal and oil to become 100% clean, while natural gas is still a nonrenewable fossil fuel. The last improvement that I identified was that there are no standards of renewable energy, such as exactly how much coal we want to be using by 2030, and the amounts of wind, solar, and natural gas we are hoping to be using by 2030.

Therefore, Governor Hogan, I hope that you will maintain the aspects of the new plan that are strong, but also encourage you to improve upon the weaknesses before the plan is put into action.

Sincerely,

[redacted]

From: [redacted]
Subject: GGRA draft plan comments
Date: February 5, 2020 at 11:11 AM
To: Christopher Beck christopher.beck@maryland.gov, Chris Hoagland MDE chris.hoagland@maryland.gov

DM

To: Christopher Beck and Chris Hoagland
From [redacted]

re: GGRA draft plan

Thank you so much, and to Governor Hogan and the General Assembly, for embarking on this plan. The future of our state, nation, and world is at stake, and our actions (and inactions) will have consequences.

I will review the plan in depth, and I signed up for the February webinars.

In the meantime, let me share the following comments:

The emphasis on conservation is important, but I didn't see anything specific about encouraging "green" building construction in both the public and private sectors. Buildings consume about 50% of total energy generated, and smart designs techniques can reduce that use considerably. The LEED system bears this out. If you haven't done so already, you might want to contact the US Green Building Council and the state's Green Building Council.

For energy generation, please add specifics about solar, wind, and other renewables. What can be done to encourage use by the public and private sectors?

As noted, trees are important to sequester carbon. The draft emphasizes forests, which is fine, but is silent about trees in urban and suburban areas. This should be added.

Last, there's an excellent 55-minute documentary movie about environment, design, and the role of business, which I urge you to watch. It's "The Next Industrial Revolution", available through the usual sources and https://vimeo.com/20372160.

Regards,
[redacted]
[redacted]
[redacted]8

From: [redacted]
Subject: Our comment on draft plan
Date: February 1, 2020 at 9:47 AM
To: christopher.beck@maryland.gov

G

Dear Mr. Beck:
Please consider this message as our comment on the draft plan under the Greenhouse Gas Reduction Act. I participated in yesterday's public meeting at MDE headquarters. Thank you and the MDE team for the lucid presentation of the plan. I appreciated the presence of Secretary Ben Grumbles to hear some of our questions and comments.

We have three concerns we would like MDE to include in the final plan:

1. All coal-fired power plants in Maryland should be shut down by 2025. We need aggressive action to get rid of this source of greenhouse gases. MDE has already done the analysis. We heard the results at MDE public meetings on the subject several years ago. But nothing was done. Please include shutdown of these plants in the final plan.

2. Rewrite the transportation section of the draft to cut down on highway expansions. We reject the rationale that adding more lanes on the interstate highways could in any way reduce greenhouse gas emissions. We've seen the effect of opening Maryland Route 100 on our neighborhood traffic. At first Route 100 drew commuter traffic off South Rolling Road, which passes one block from our house. But after a few years the commuter traffic on South Rolling is back at the same level. It's clear to us that if you build more highways, traffic will expand to fill them, and we'll have more greenhouse gas emissions from the cars.

3. Rewrite the public transportation section to call for more public transportation, especially rail routes that can take people where they need to go. In our vacations in France we have seen new urban streetcar systems open in city after city over the past 30 years. They take people to work, to school, and to recreation sites such as parks and stadiums. The final plan should reinstate the Red Line here in Baltimore and also provide for effective systems of urban rail, suburban rail comparable to the RER in the Paris region, and intercity rail connecting Baltimore-Annapolis-Washington-Frederick-Hagerstown-York PA. Existing lines such as the MARC Penn Line, Camden Line, and Brunswick Line should have more service and go farther to serve riders farther out. All these elements will replace gasoline-fueled private cars.

4. Strengthen the carbon sequestration provisions by providing more incentives for agriculture and for forest management. The state forests are part of the picture and should be managed for more old-growth stands instead of small trees that are cut before they store much carbon. Incentives should be provided to landowners to grow trees to an older age. Incentives should be provided to housing developers to keep part of their property in forest cover.

Thank you for considering our comments.

Sincerely,
[redacted]

From: [redacted]
Subject: Re: Ambitious [redacted] Reduction Necessary
Date: January 21, 2020 at 7:29 PM
To: Christopher Beck -MDE- christopher.beck@maryland.gov

SN

Chris -

Thank you for that information. I appreciate it. I look forward to reviewing a summary of the discussion.

Regards,
[redacted]

> -----Original Message-----
> From: Christopher Beck -MDE-
> Sent: Jan 21, 2020 1:29 PM
> [redacted]
> Cc: Chris Hoagland -MDE-
> Subject: Re: Ambitious Goal for Greenhouse Gas Reduction Necessary
>
> Thank you for your email Susan. I'll include your comments in the record. Many of the issues you mentioned in your email were discussed today at the Mitigation Work Group of the Maryland Commission on Climate Change (MCCC). MDE and partner agencies, along with the MCCC have committed to review programs in the transportation sector like TCI. Please check the MCCC website in the coming days for a summary of the discussion.
>
> https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Pages/MWG.aspx
>
> CHANGING Maryland FOR THE BETTER
>
> **Christopher Beck**
> Division Chief
> Climate Change Program
> Maryland Department of the Environment
> 1800 Washington Boulevard
> Baltimore, Maryland 21230
> christopher.beck@maryland.gov
> 410-537-4415 (O)
> Website | Facebook | Twitter
>
> Click here to complete a three question customer experience survey.
>
> On Mon, Jan 20, 2020 at 2:01 PM Susan Nerlinger <snerlinger@earthlink.net> wrote:
>
> > Memo to: The Maryland Commission on Climate Change – Mitigation Working Group,
> > Mr. Ben Grumbles, Chairperson
> >
> > From: [redacted]
> >
> > Date: Monday, January 20, 2020
> >
> > Re: Ambitious Goal for Greenhouse Gas Reduction Necessary
> >
> > Via email to Christopher.beck@maryland.gov; climate.change@maryland.gov

To the Commission –

I am writing as a concerned citizen of Maryland and member of the Maryland Sierra Club to urge the Commission to adopt an ambitious goal for greenhouse gas emission reduction for the decade from 2022 to 2032. The global climate change crisis is in full swing. The U.S. is already behind the curve in reducing greenhouse gas emissions.

Recent events clearly show the need for decisive action. Recently widespread fires in Australia were so powerful they could not be extinguished. Receiving less media attention but no less disturbing, some 15 inches of rain fell in one day in Jakarta, Indonesia. In 2019, the hottest temperature ever recorded in the UK was exceeded on July 25 in Cambridge, where the thermometer hit 38.7C (101F).

So the time for assertive action is now, because the damaging effects of climate change are here already. The Intergovernmental Panel on Climate Change recommends a reduction of climate pollution of 45% by 2030. What needs to be done to limit greenhouse gas emissions? We will have to greatly expand public transportation and develop walking and biking infrastructure. We will need to electrify the school and public transit bus fleets and promote passenger electric vehicles (EVs). Personally I live in a multi-family residence and our community does not have EV charging stations. They would have to be installed in our parking lots at great expense, something for which our Homeowners' Association does not have funds. The state of Maryland will need to get involved in making EV ownership available to the millions of citizens who live in multi-family communities if we are going to expand EV ownership sufficiently to make a real difference.

The Sierra club recommends a 45% reduction in emissions. I am informed that the Commission is considering reductions of as little as 20 to 25%. That is insufficient, but even opting for the larger reduction of 25% would make huge positive difference. Projected revenues would be $500 million annually if a reduction of 25% were adopted. This is the equivalent of the entire budget of the Maryland Transportation Authority and would begin to generate the funds that will be needed to finance the degree of change in our transportation infrastructure that needs to happen.

Furthermore, in addition to limiting pollution from gas and diesel fuels, it will also be necessary to address emissions from biofuels, aviation fuels, marine fuels and methane and propane used as transportation fuels. The state should regulate CO_2 emissions upstream, focusing on "prime suppliers" of transportation fuels as defined by the US Energy Information Administration.

Finally investments should provide people with equitable and reliable access to housing, jobs, education and other amenities through improvement of the transportation infrastructure.

I hope the commission will have the courage to commit to the bold action that the times demand.

Sincerely yours,

[redacted]