Maryland Department of the Environment

Appendix G

Economic Impacts

2019 GGRA Draft Plan

Chapter 7: Economic Impacts

Commissioned by
Maryland Department of the Environment

Regional Economic Studies Institute
Daraius Irani, Ph.D., Chief Economist
Michael Siers, Director of Research
Catherine Menking, Economist
Nicholas Wetzler, Economist
Jacob Leh, Research Associate

April 25, 2019

Towson, Maryland 21252 | 410-704-3326 | www.towson.edu/resi

Table of Contents

Table of Figures

Acronyms and Abbreviations

AVERT	Avoided Emissions and Generation Tool
CES	Clean 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
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

7.1 Executive Summary

The Regional Economic Studies Institute (RESI) of Towson University was tasked by the Maryland Department of the Environment (MDE) to provide a coherent set of analyses to inform the development of its proposed plan to reduce statewide greenhouse gas emissions by 40 percent from 2006 levels by 2030, to satisfy MDE's obligations under the Greenhouse Gas Emission Reduction Act (GGRA) Reauthorization. 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, while the current chapter contains the results of the economic modeling, which the Project Team completed using REMI PI+ (REMI).[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 the specific demographic features of Maryland as a whole and five regions of the state:

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

To model economic impacts, the team synthesized data from a number of sources, including Pathways output and estimates of program costs from state agencies. Additionally, the team conducted public health modeling to estimate the economic impact associated with improved air quality under each policy scenario.

7.1.1 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 mandate and qualifies as meeting the economic goals of the GGRA, the team used the following set of indicators:

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

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

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

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

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

7.1.2 Overview of Policy Scenarios One, Two, and Three

In evaluating policies to reduce carbon emissions in Maryland and achieve the goals set forward in the GGRA plan, the Project Team evaluated a total of four policy scenarios. This section provides an overview of the first three scenarios. The results of these three policy bundles were then examined, and feedback was solicited from policy makers to arrive at the final policy scenario, highlighted here in Section 7.1.4 and discussed fully in Section 7.6.

7.1.2.1 Policy Scenario One

Policy Scenario One represents a continuation of current policies. Under Policy Scenario One, energy efficiency is extended as EmPOWER investment continues through 2050, rather than ending in 2023. This corresponds with increased sales of efficient appliances and reductions in electricity usage through behavioral conservation. In addition to increased energy efficiency, Policy Scenario One contains extensions of the Zero Emissions Vehicle MOU, leading to increased sales of electric vehicles through 2050. This policy scenario results in 300,000 additional zero emissions vehicles (ZEVs) in 2050, relative to the reference scenario. Additionally, transportation policies proposed by the Maryland Department of Transportation (MDOT) will reduce vehicle miles traveled (VMT) for both heavy- and light-duty vehicles.

Policy Scenario One also contains an increase in the renewable portfolio standards (RPS) from 25 percent by 2020 to 50 percent by 2030. This increase is modeled after proposed state legislation.[2]

7.1.2.2 Policy Scenario Two

Policy Scenario Two represents an extension of Policy Scenario One designed to achieve deeper reductions in carbon emissions. Instead of generally continuing existing policies, Policy Scenario Two also contains a number of new programs. For example, Policy Scenario Two replaces the RPS with a 75 percent clean energy standard (CES) goal by 2040. The CES encompasses other sources of generation beyond renewable energy, including combined heat and power (CHP) and nuclear power.

[2] The increase in Maryland's RPS is consistent with HB1435 and SB0732 proposed in the 2018 legislative session.

Additionally, Policy Scenario Two models rapid adoption of zero emission vehicles. Zero emission vehicles are assumed to be 50 percent of new sales by 2030 and 100 percent of light-duty vehicle sales by 2050. In addition to these sales of light-duty vehicles, the team assumed that 95 percent of heavy-duty vehicle sales in the state would be electric vehicles or diesel hybrids by 2050. Regarding energy efficiency, the team modeled 100 percent of electric and natural gas appliance sales in Maryland as high-efficiency by 2030.

7.1.2.3 Policy Scenario Three

While the other policy scenarios were developed by MDE, Policy Scenario Three was developed by the Mitigation Working Group of the Maryland Commission on Climate Change. Similar to Policy Scenario Two, Policy Scenario Three uses Policy Scenario One as a foundation. In addition to the measures discussed in Section 7.1.2.1, Policy Scenario Three contains carbon pricing as a strategy to reduce carbon emissions instead of regulations. The carbon price for this scenario was modeled as starting at $20 per metric ton in 2020, rising to the social cost of carbon in 2030 and beyond.

Revenue from the carbon pricing scheme is allocated based on the Regional Cost Collection Initiative (RCCI) bill, or House Bill 939, introduced in the Maryland General Assembly in 2018, with modifications:

- $10 million each year is allocated towards administration of the program;
- 50 percent of total revenue, less $10 million, is rebated to consumers in lower income brackets;
- 30 percent of total revenue each year is allocated to additional carbon mitigation measures beyond those modeled in Policy Scenario One;
- 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.[3]

7.1.3 Results of Policy Scenarios One Through Three

Overall, as summarized in Figure 1, the first three policy scenarios all achieve the 2030 economic goal. Additionally, Policy Scenario Two and Policy Scenario Three meet both the 2020 and 2030 emissions goals.

[3] H.B. 939, Session of 2018 (Mar. 2018), p.1, http://mgaleg.maryland.gov/2018RS/fnotes/bil_0009/hb0939.pdf.

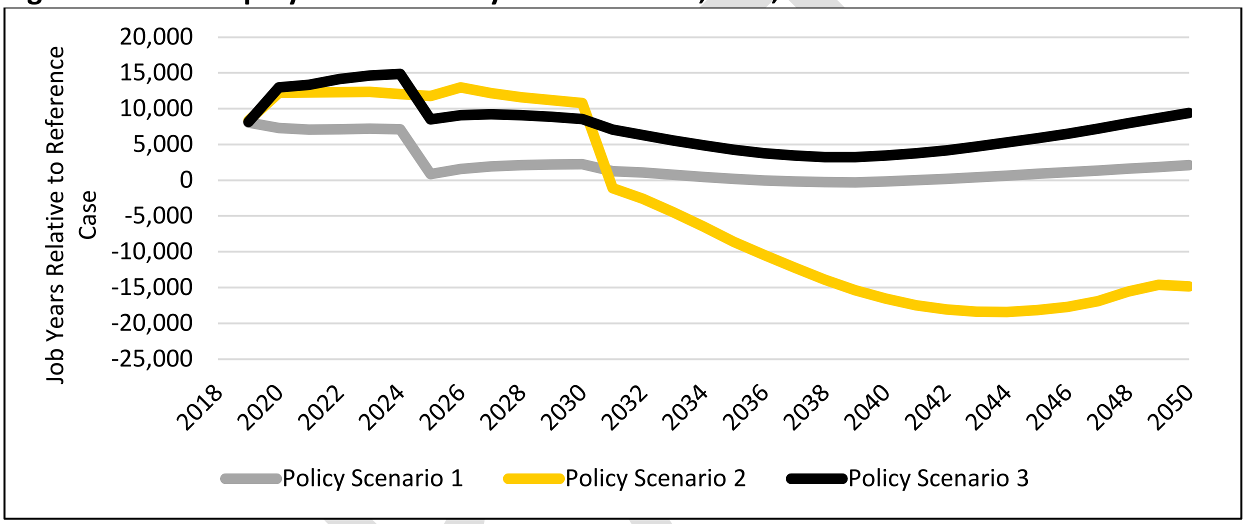
Figure 1: Summary of Policy Scenarios

Policy Scenario	Achieve 2020 Emissions Goal?	Achieve 2030 Emissions Goal?	Achieve 2030 Economic Goal?
Policy Scenario One	Yes	No	Yes
Policy Scenario Two	Yes	Yes	Yes
Policy Scenario Three	Yes	Yes	Yes

Source: RESI

In terms of employment, as illustrated in Figure 2, all three policy scenarios exhibit average positive job growth through 2030.

Figure 2: Total Employment for Policy Scenarios One, Two, and Three



Sources: REMI PI+, E3, MDE, MDOT, RESI

Policy Scenario Two produces the most jobs between 2019 and 2030, averaging 11,665 jobs, while Policy Scenario One produces the least at 4,564 jobs. By 2050, these numbers are significantly lower across all policy scenarios, with Policy Scenario Two losing an average of 3,811 jobs between 2019 and 2050, but Policy Scenarios One and Three still maintaining positive job growth.

To summarize, these results are due to a number of aspects contained in each bundle of policies:

- **Transportation infrastructure spending**
  Policy Scenario Two, in particular, shows large near-term employment increases due to the I-495 and I-270 lane expansion projects. Both Policy Scenarios One and Three begin the same, but the divergence in 2020 is due to the presence of the carbon fee as a funding source for infrastructure projects.
- **Carbon fee and dividend**
  The carbon fee plays a pivotal role in boosting employment numbers for Policy Scenario Three in the long run. The revenue from this fee is able to mitigate some of the negative

effects of Policy Scenario One by providing rebates to consumers for increased energy prices, as well as the provision of funding for additional job-creating mitigation measures. The rationale behind this job-creating policy is that the fee acts as a filter—redirecting funds that would have previously flowed out of the state towards job creation activities within the state.

- **In-state wind and solar generation**
  Because Maryland is traditionally a net importer of energy, increasing the percentage of self-supplied energy enables money that would have been spent out of the state, to stay within the state.

Although the employment impacts displayed in Figure 2 appear large, they in fact represent a very small proportion of Maryland's total economy. Employment impacts, both positive and negative, do not vary more than one percentage point beyond the levels forecast in the reference case. Even under Policy Scenario Two, which contains aggressive policies aimed at reducing carbon emissions in the state, employment is expected to decline by less than 0.5 percent at its most extreme point. Given the scale of the spending occurring under each policy as described later in Section 7.5.1, employment impacts are relatively muted.

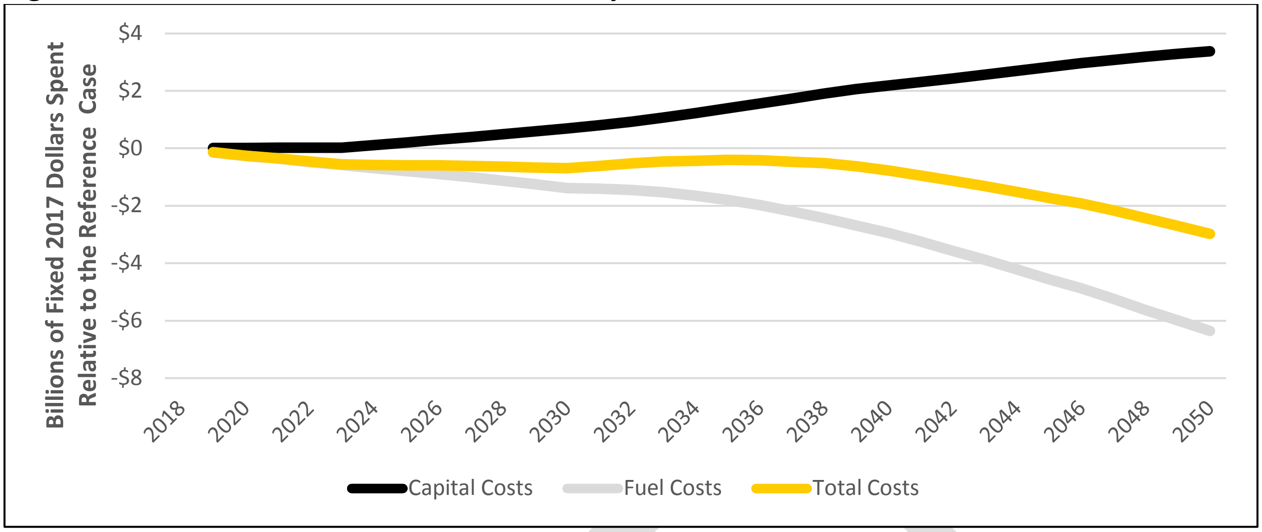
7.1.4 Policy Scenario Four

After the emissions and economic impacts associated with Policy Scenarios One through Three were estimated and analyzed, Policy Scenario Four 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. Policy Scenario Four uses Policy Scenario One as its foundation. Policy Scenario One represents a collection of policies that are either a continuation or extension of current programs. In addition to these measures, Policy Scenario Four consists of new programs explored in Policy Scenario Two. For example, as in Policy Scenario Two, Policy Scenario Four includes a 75 percent Clean and Renewable Energy Standards (CARES) goal by 2040 instead of the RPS modeled in Policy Scenario One.[4] Other policies modeled similarly to Policy Scenario Two include bus electrification, transportation programs, and forest management and healthy soils initiatives.

Similar to Policy Scenario One, Policy Scenario Two, and Policy Scenario Three, Policy Scenario Four meets the economic goals outlined in Section 7.3.7. Notably, Policy Scenario Four achieves these goals with low levels of spending. As illustrated in Figure 3, in every year in Policy Scenario Four, consumers and businesses spend less on capital costs and fuel costs relative to the reference case.

[4] However, the CARES program modeled in Policy Scenario Four contains different carveouts than the CARES program modeled in Policy Scenario Two. In Policy Scenario Two, carveouts include 12.5 percent for in-state solar, 12.5 percent for offshore wind, and 25 percent for tier one renewables. In Policy Scenario Four, the carveouts include 15 percent for in-state solar, 10 percent for offshore wind, and 20 percent for tier one renewables.

Figure 3: Total Costs from PATHWAYS in Policy Scenario Four Relative to the Reference Case



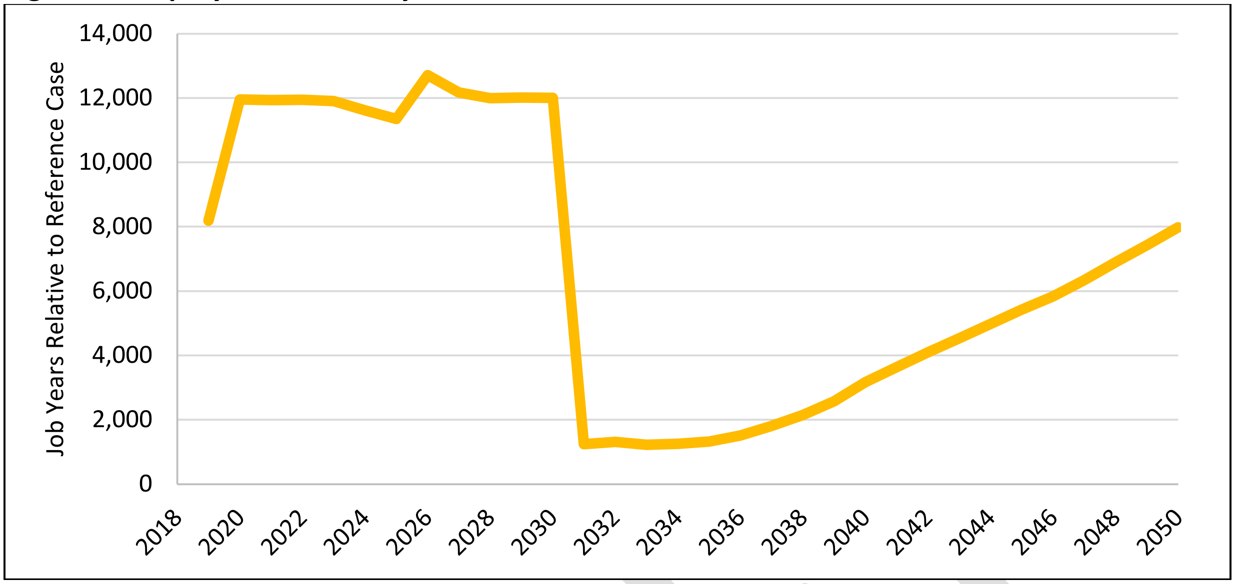
Sources: E3, MDE, RESI

As seen in Figure 3, although consumers and businesses are spending more on capital costs (e.g., new energy-efficient appliances or new electric vehicles) in Policy Scenario Four than in the reference case, fuel savings exceed this amount every year. This is in contrast to the other policy scenarios and is attributable to two general trends:

- Spending on transportation infrastructure projects is high in Policy Scenario Four. These projects are generally due to policies aimed at reducing fuel usage through behavioral changes (e.g., increased mass transit usage or increased use of bike lanes) as well as more direct capital outlays (e.g., truck stop electrification or bus electrification). The level of spending on these projects is equal to the level in Policy Scenario Two, which is the highest level modeled.
- Capital costs are generally low. Through 2025, capital costs in Policy Scenario Four are equal to those in Policy Scenario One, the scenario with the lowest spending on capital costs. Although capital expenditures after 2025 are higher in Policy Scenario Four than in Policy Scenario One, they never approach those in Policy Scenario Two or Policy Scenario Three.

The impacts of infrastructure spending and capital costs can both be seen when examining the economic impacts of Policy Scenario Four. As seen in Figure 4, Policy Scenario Four supports an average of 11,649 jobs each year through 2030 relative to the reference case.

Figure 4: Employment in Policy Scenario Four Relative to the Reference Case

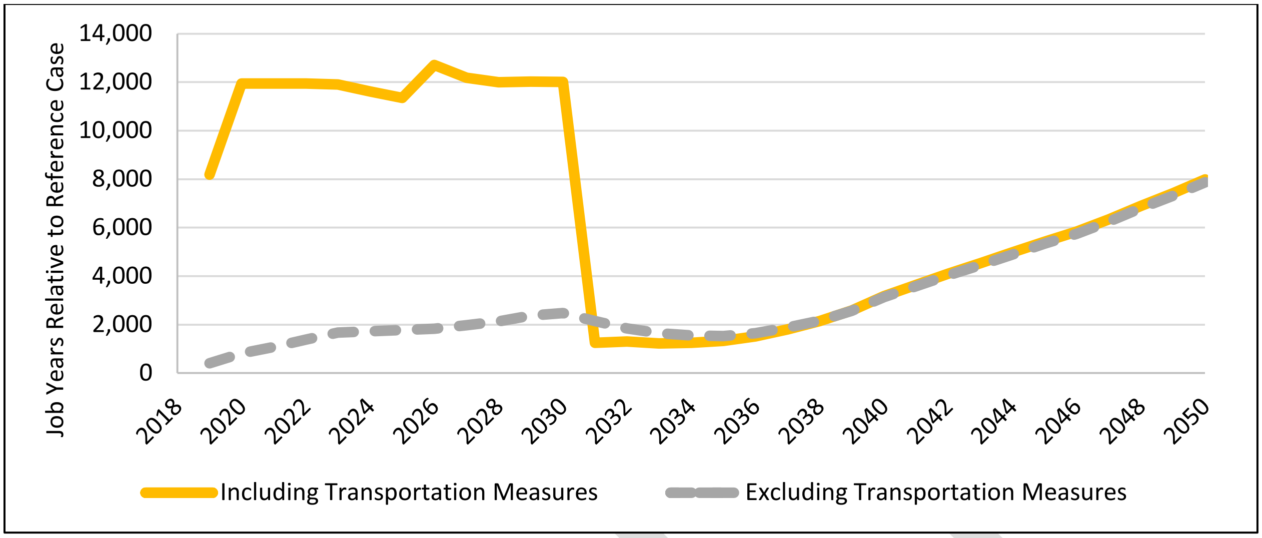


Sources: E3, MDE, REMI PI+, RESI

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. The steady increase in employment after 2030 is due in part to the relatively low capital costs seen in Policy Scenario Four. Because spending on capital is lower, consumers have more money to spend on other goods and services, and businesses are more profitable. These positive impacts, coupled with reductions in spending on fuel, result in a slow albeit steady increase in jobs supported relative to the reference case.

To visualize the impact of spending on transportation infrastructure on the economic impact results for Policy Scenario Four, Figure 5 below shows employment differences in Policy Scenario Four with and without this spending.

Figure 5: Employment in Policy Scenario Four With and Without Transportation Spending Relative to the Reference Case



Sources: E3, MDE, REMI PI+, RESI

The impact of transportation spending in Policy Scenario Four is similar to the impacts in the other three policy scenarios. On average through 2030, transportation infrastructure measures support 10,013 more jobs compared to the scenario without this spending. This is illustrated above as the difference between the two lines. Regardless of the status of the transportation spending, however, employment impacts are steadily positive for Policy Scenario Four.

In sum, as shown in Figure 6, all four policy scenarios achieve the 2030 economic goals and three policy scenarios meet both the 2020 and 2030 emissions targets as well.

Figure 6: Summary of Policy Scenarios

Policy Scenario	Achieve 2020 Emissions Goal?	Achieve 2030 Emissions Goal?	Achieve 2030 Economic Goal?
Policy Scenario One	Yes	No	Yes
Policy Scenario Two	Yes	Yes	Yes
Policy Scenario Three	Yes	Yes	Yes
Policy Scenario Four	Yes	Yes	Yes

Source: RESI

Sensitivity analyses were performed for Policy Scenario 4 under a number of difference scenarios, including:

1. A decrease in future renewable energy credit (REC) prices.
2. A rollback of the federal level Corporate Average Fuel Economy (CAFE) program. Removing the CAFE standards for fuel efficiency means an increase in emissions from vehicles and less pressure for consumers to purchase zero emissions vehicles.
3. Reduced consumer adoption of energy efficient appliances and zero emission vehicles. Under this sensitivity, consumer purchases of efficient appliances and zero emission

vehicles are 50 percent lower than originally modeled, leading to increased emissions, reduced capital costs, and reduced fuel savings.

4. A sensitivity analysis combining the rollback of the CAFE standards with the reduced consumer adoption sensitivity.

The results indicate that the economic outcomes of Policy Scenario 4 are robust to large changes in policies, consumer behavior deviations, and an uncertain economic environment. Under all the sensitivity analyses, the economic goals are still met.[WND1]

7.2 Introduction

The Regional Economic Studies Institute (RESI) of Towson University was tasked by the Maryland Department of the Environment (MDE) to provide a coherent set of analyses to inform the development of its proposed plan to reduce statewide greenhouse gas emissions by 40 percent from 2006 levels by 2030, to satisfy MDE's obligations under the Greenhouse Gas Emission Reduction Act (GGRA) Reauthorization. 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, while the current chapter contains the results of the economic modeling.

7.3 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 PI+.[5]

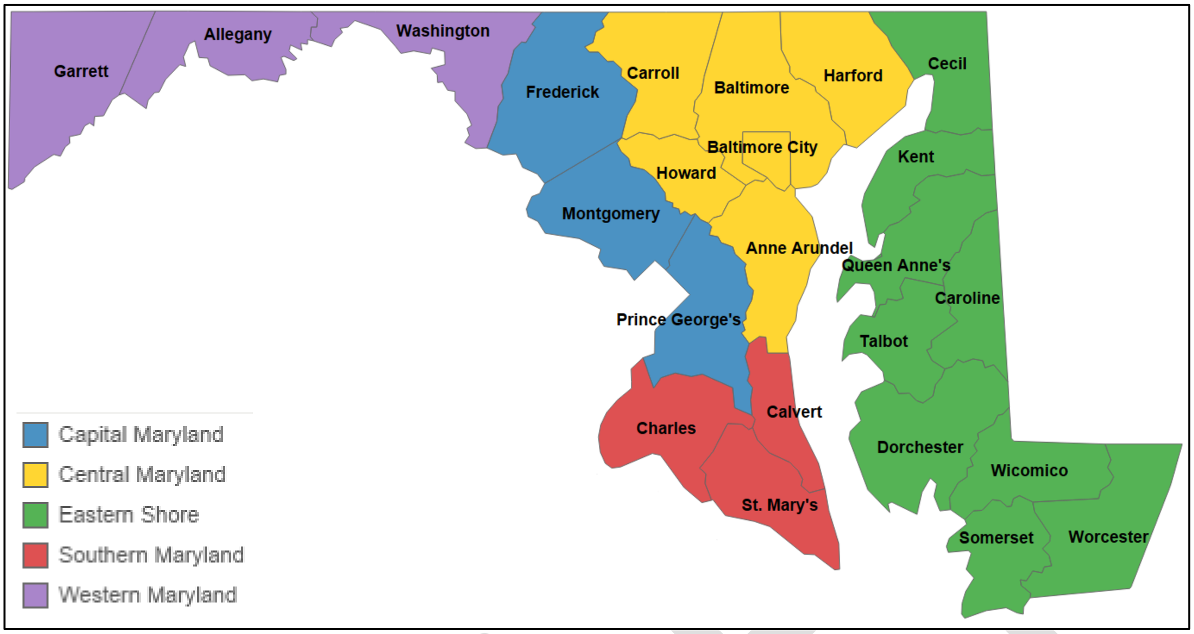
The REMI model is a high-end dynamic modeling tool used by various federal and state government agencies in economic policy analysis. The REMI model is calibrated to the specific demographic features of Maryland as a whole and five regions of the state:

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

A map of these regions is found in Figure 7.

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

Figure 7: Maryland Counties and Corresponding Region within REMI PI+



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 (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, which 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 PI+ has a time component which makes it especially useful in evaluating the long-term impact of policies in the future.

7.3.1 Translating Pathways Output to REMI PI+ 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:

- Residential,
- Commercial,

- Industrial, and
- 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 PI+. 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, there are also negative impacts to the economy of consumers purchasing additional washing machines. 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 is generally entered into REMI twice: 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 project, 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.[6]

[6] 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.

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 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.

7.3.2 Modeling Policy Costs Not Captured Within Pathways

Although the economic impact modeling used Pathways output in order to be as consistent as possible with the emissions modeling, not all policies are able to be explicitly modeled within Pathways. Economic data from Pathways are incomplete because the model is limited to generating cost estimates for items that have a physical stock (e.g., automobiles, appliances, HVAC systems) or that are related to fuels (e.g., electricity, natural gas, diesel). Many policies include 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 are still calculated, even though no costs are captured within Pathways. If no cost data were entered separately into REMI, emissions reductions would be achieved for free. Therefore, it is 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 are generally modeled as an increase in the demand for construction, while updates to the bus fleet are modeled as an increase in demand for motor vehicle manufacturing. By increasing the baseline demand values with REMI, REMI assumes some production will be satisfied by out-of-state sources.

Generally, funding for future MDOT projects will come from three general 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 does 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.[7]

7.3.3 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 control model will impact how policies are evaluated in the model. Similarly, policy scenarios within Pathways are evaluated relative to a reference scenario, as described in more detail in Chapter 6. For consistency across models, the REMI standard regional control was adjusted to more closely match 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 team created a new regional control model within REMI that accounts for all policies included in the reference case. To do so, the team followed the methodology outlined in Section 7.3.1, 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.

[7] 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.

7.3.4 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, regardless of if the power is generated by a renewable source, such as wind, or by 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:

- Wind electric power generation,
- Solar electric power generation, and
- 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 crosswalked IMPLAN industry classifications to REMI. 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 8. 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 8: 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 PI+, RESI

7.3.5 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, which will lead to a number of health benefits for Maryland residents. These factors 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.[8,9]

[8] 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.

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).[10,11] Baseline emission estimates are included for both 2017 and 2025, allowing users to change emissions in either year.[12] 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.[13]

Except for emissions from electric utilities, all of the COBRA inputs were derived from PATHWAYS using the change in final fuel demand (measured in millions of British Thermal Units, or MMBTU) for every sector between the reference scenario and the policy scenario being modeled. The formula for estimating changes in emissions varied by sector.

For example, gasoline and diesel use, particularly in vehicles, makes up the largest portion of emission changes in the policy scenarios, outside of electric utilities. To determine emissions for gasoline and diesel fuels, the change in MMBTUs provided by Pathways was converted into gallons of fuel using conversions rates provided by the U.S. Energy Information Administration.[14] 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.[15]

---

[9] "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.

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

[11] 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.

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

[13] 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.

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

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

Emissions for natural gas sectors were calculated using emissions factors for greenhouse gases published by the EPA.[16] 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 by the use of biogas are calculated using emissions factors made available by the California Air Resources Board.[17] As with natural gas, emissions for $PM_{2.5}$, NO_x, SO_2, and VOCs are calculated directly using the factors provided.

Emission changes due to shifts 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.[18] Additionally, AVERT is used to estimate emissions reductions resulting from increased generation of wind and solar energy. These emissions shifts are then input into COBRA.

COBRA output consists of a number of different 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.[19]

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

[16] U.S. Environment Protection Agency, "Natural Gas Combustion," 6, accessed January 20, 2019, https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s04.pdf.
[17] 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.
[18] "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.
[19] 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 in order 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 20.[20] 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.[21] 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, and reallocated 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.[22]

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.[23] 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.[24]

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. Since these impacts do not involve hospital admission or missed work days, they are reflected in the REMI model using a change in the amenity value for each region. The values entered into the model are taken directly from COBRA's valuation of each of the four health impacts.

[20] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," F-6.
[21] "HCUPnet, Healthcare Cost and Utilization Project," Agency for Healthcare Research and Quality, accessed August 15, 2018, https://hcupnet.ahrq.gov/.
[22] Revenue was reallocated in the REMI model to insurance carriers, federal, state, and local government, and consumer spending.
[23] For RESI's model, a single restricted activity day is treated as 0.5 missed work days.
[24] Active working days exclude weekends and non-working holidays.

7.3.6 Estimating the Impact of Carbon Pricing

Policy Scenario Three, discussed in more detail in Section 7.4.3, used carbon pricing as a strategy to reduce carbon emissions. A carbon price is a market-based approach to reduce greenhouse gas emissions by, generally, imposing a fee on each unit of carbon dioxide (or other emissions) produced. In this way, the polluting firm must internalize the negative externality that results from the firm's behavior.[25] The revenue collected from this fee is then used to compensate consumers for increased energy costs and/or fund additional reductions in greenhouse gas emissions.

In Policy Scenario Three, the price of carbon begins at $20 per metric ton in 2020 and rises to the social cost of carbon in 2030. The social cost of carbon is a price determined by the EPA, to fully account for the negative externalities associated with carbon emissions. The price for one metric ton of carbon emissions each year between 2020 and 2050 is displayed in Figure 9.

Figure 9: Carbon Price Escalation

Year	Carbon Price ($2017)	Year	Carbon Price ($2017)
2020	$19.61	2036	$68.35
2021	$23.75	2037	$69.57
2022	$27.89	2038	$70.79
2023	$32.04	2039	$72.01
2024	$36.18	2040	$73.24
2025	$40.32	2041	$74.33
2026	$44.46	2042	$75.43
2027	$48.61	2043	$76.53
2028	$52.75	2044	$77.63
2029	$56.89	2045	$78.73
2030	$61.03	2046	$79.83
2031	$62.25	2047	$80.93
2032	$63.47	2048	$82.03
2033	$64.69	2049	$83.13
2034	$65.91	2050	$84.23
2035	$67.13		

Source: RESI

Policy Scenario Three represents an extension of Policy Scenario One with the addition of a carbon pricing scheme. However, to estimate revenues generated by carbon pricing, the Project Team could not simply multiply the carbon price by the emission levels for each year in Policy Scenario One. Carbon pricing makes carbon-intensive fuels more expensive, thus altering consumer and business behavior. For example, if the price of gasoline increases, consumers may choose to drive less or carpool to use less gas. If the price increase is not seen as a

[25] Kevin A. Hasset, Aparna Mathur, and Gilbert Metcalf, "The Incidence of a U.S. Carbon Tax: A Lifetime and Regional Analysis," 2009. *The Energy Journal, International Association for Energy Economics* 30 no. 2 (2009): 155-178.

temporary shock, consumers may make longer-term decisions, such as buying an electric vehicle. To measure the amount consumption of carbon-intensive fuels changes in response to price shocks, the team used a model based on Washington State's Carbon Tax Assessment Model (CTAM).[26]

CTAM is considered an industry standard in estimating the impact of various carbon pricing programs, and has been used in conjunction with REMI on several similar analyses.[27] However, the base CTAM model does have limitations. For one, the base CTAM model assumes the carbon price will increase by a constant amount each year, up to a maximum cap. However, for Policy Scenario Three, the carbon price has two rates of change:

- One rate of change between 2020 and 2030, where the carbon price starts at $20 and climbs to the social cost of carbon in 2030; and
- One rate of change between 2030 and 2050, where the carbon price rises in line with the social cost of carbon.

Another limitation of the base CTAM model in this analysis is that the emissions and consumption categories used do not directly match with the categories within Pathways. A third limitation is that the CTAM model does not distinguish between short-term consumption responses and long-term investment responses to price shocks. For example, in the prior example regarding the cost of gasoline, the consumer reducing unnecessary trips is a consumption response and does not have an associated cost to capture. If the same consumer perceives the price change as long-term and purchases a new electric vehicle in response, this is a cost that should be fully captured in economic models. Both responses will lead to reductions in emissions, but investment responses are accompanied by additional investments. This differentiation is not possible within the base CTAM model.

Therefore, the Project Team adapted the methodology behind the CTAM model to fit the needs of this analysis. First, the applicable price adjustment for each fuel source was calculated by taking the carbon emission rate for each fuel source and multiplying it by the carbon price for each year. Then, total elasticity values (the effect of both consumption and investment responses to increased price) were gathered from CTAM and applied to relevant Pathways categories. The short-run consumption effect was estimated by analyzing literature, including published sources from the EPA. The investment response is estimated as the difference between the consumption effect and the total elasticity. Within the model, investment

[26] "Carbon Policy and Strategies—Washington State Department of Commerce," Washington State Department of Commerce, accessed September 19, 2018, https://www.commerce.wa.gov/growing-the-economy/energy/washington-state-energy-office/carbon-tax/.
[27] Scott Nystrom, Katie O'Hare, and Ken Ditzel, "The Economic, Fiscal, and Emissions Impacts of a Revenue-Neutral Carbon Tax," (July 2018): 1, accessed January 14, 2019, https://www.fticonsulting.com/~/media/Files/us-files/insights/reports/impacts-revenue-neutral-carbon-tax.pdf.

elasticities are phased in over ten to twenty years in order to more accurately depict how consumers and businesses make long-term decisions.[28]

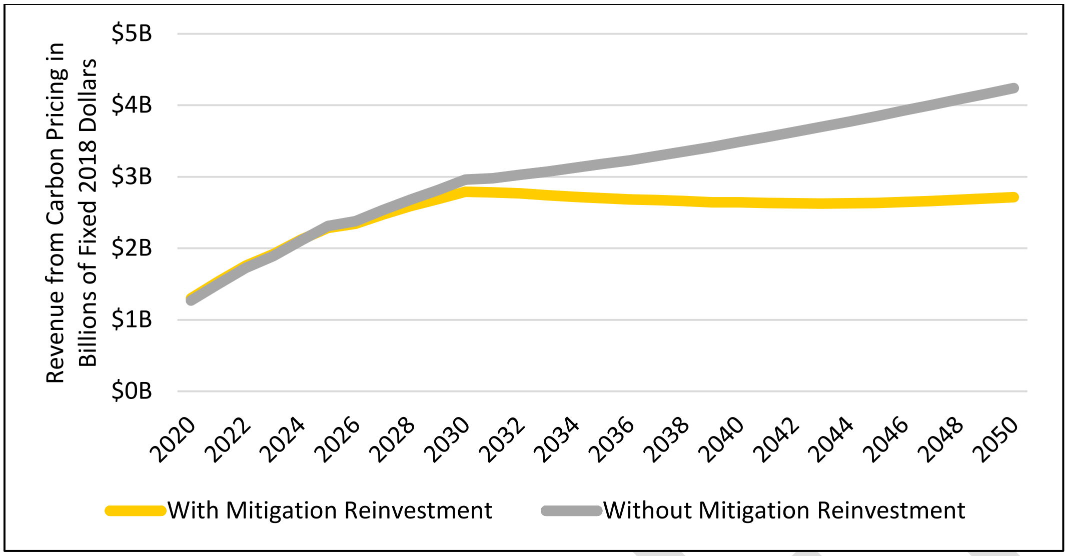
The consumption response for a given fuel each year is calculated as the product of the baseline consumption of that fuel, the consumption elasticity, and the percentage the price of that fuel changes as a result of the carbon pricing. The investment response is calculated in a similar manner, except using the relevant investment elasticities instead of consumption elasticities. After calculating the consumption and investment response, the adjusted consumption for each Pathways sector is calculated as the baseline consumption less the consumption and investment responses.

To generate the revenue associated with a carbon pricing scheme, the adjusted consumption levels for each fuel are multiplied by the carbon price for the given year and by the emission value associated with that fuel.

Once collected, revenue in Policy Scenario Three are distributed through the economy in several different ways as determined by the Mitigation Working Group of the Maryland Commission on Climate Change and described in Section 7.4.3. Thirty percent of all funds will be spent on mitigation activities. Mitigation activities will reduce the amount of carbon, therefore reducing the revenue raised in future years. The team used an iterative approach to modeling revenues from a carbon pricing scheme. Reductions in emissions as a result of mitigation measures were calculated, and then revenue was re-estimated. The revenues generated each year with and without mitigation reinvestment are displayed below in Figure 10.

[28] The timeframe for phasing in the investment elasticity for each fuel and sector combination is derived from the base CTAM model.

Figure 10: Revenue from Carbon Pricing With and Without Reinvestment in Mitigation Measures



Sources: E3, MDE, RESI

In addition to investing in mitigation efforts, the team modeled 50 percent of generated revenue as redistributed to lower-income households. However, a limitation of REMI is that household spending cannot be increased for consumers in given income brackets. Therefore, the Project Team modeled the increase in household spending as an increase in spending on consumption categories that are necessities within REMI (e.g., food, transportation, rent/mortgage) to model how consumers in lower-income brackets would spend rebates.

One limitation of integrating carbon pricing into REMI is that the default REMI model does not assume policies will impact farms unless explicitly modeled. However, carbon pricing applied in a single state could generally lead to negative impacts for farms in the absence of exemptions, given the industry's reliance on energy as an input. The team used estimates of reduced farm output under potential carbon pricing schemes as a guide for estimates within REMI.[29] These estimates were adjusted based on the makeup of Maryland's farming industry.

7.3.7 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 team used the following set of indicators:

- Average positive job growth through 2030;

[29] Ronald Sands and Paul Westcott, "Impacts of Higher Energy Prices on Agriculture and Rural Economies," Economic Research Service, Economic Research Report Number 123 (August 2011): 21, accessed November 19, 2018, https://www.ers.usda.gov/webdocs/publications/44894/6814_err123_1_.pdf?v=41432.

- 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.[30]

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

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

Reducing carbon emissions and ensuring net benefits to Maryland's economy are not mutually exclusive goals. The following sections will outline the various policy bundles that the Project Team considered, as well as the results of the analysis. Emissions results are presented in Chapter 6 of this report.

7.4 Overview of Policy Scenarios One, Two, and Three

In evaluating policies to reduce carbon emissions in Maryland and achieve the goals set forward in the GGRA plan, the Project Team evaluated a total of four policy scenarios. This section provides an overview of the first three scenarios. The results of these three policy bundles were then examined, and feedback was solicited from policy makers to arrive at the final policy scenario, presented in Section 7.6. For more detail on individual assumptions and policies in all policy scenarios, please see Appendix A.

7.4.1 Policy Scenario One

Policy Scenario One represents a continuation of current policies. Under Policy Scenario One, energy efficiency is extended as EmPOWER investment continues through 2050, rather than ending in 2023. This corresponds with increased sales of efficient appliances and reductions in electricity usage through behavioral conservation. In addition to increased energy efficiency, Policy Scenario One contains extensions of the Zero Emissions Vehicle memorandum of understanding (MOU), leading to increased sales of electric vehicles through 2050. This policy scenario results in 300,000 additional zero emissions vehicles in 2050, relative to the reference scenario. Additionally, transportation policies proposed by MDOT will reduce vehicle miles traveled (VMT) for both heavy duty and light duty vehicles.

Policy Scenario One also contains an increase in the renewable portfolio standards (RPS) from 25 percent by 2020 to 50 percent by 2030. This increase is modeled after proposed State legislation.[31]

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

7.4.2 Policy Scenario Two

Policy Scenario Two represents an extension of Policy Scenario One designed to achieve deeper reductions in carbon emissions. Instead of generally continuing existing policies, Policy Scenario Two also contains a number of new programs. For example, Policy Scenario Two replaces the RPS with a 75 percent clean energy standard (CES) goal by 2040. A CES encompasses other sources of generation beyond renewable energy, including combined heat and power (CHP) and nuclear power.

Additionally, Policy Scenario Two models rapid adoption of zero emission vehicles. Zero emission vehicles are assumed to be 50 percent of new sales by 2030 and 100 percent of light duty sales by 2050. In addition to these sales of light duty vehicles, the team assumed that 95 percent of heavy-duty vehicle sales in the state would be electric vehicles or diesel hybrids by 2050. Regarding energy efficiency, the team modeled 100 percent of electric and natural gas appliance sales in Maryland would be high efficiency by 2030.

7.4.3 Policy Scenario Three

While the other policy scenarios were developed by MDE, Policy Scenario Three was developed by the Mitigation Working Group (MWG) of the Maryland Commission on Climate Change (MCCC). Similar to Policy Scenario Two, Policy Scenario Three uses Policy Scenario One as a foundation. In addition to the measures discussed in Section 7.4.1, Policy Scenario Three contains carbon pricing as a strategy to reduce carbon emissions instead of regulations. The carbon price for this scenario was modeled as starting at $20 per metric ton in 2020 rising to the social cost of carbon in 2030 and beyond.

Revenue from the carbon pricing scheme is allocated based on the Regional Cost Collection Initiative (RCCI) bill, or House Bill 939, introduced in the Maryland General Assembly in 2018, with modifications: [32]

- $10 million each year is allocated towards administration of the program;
- 50 percent of total revenue, less $10 million, is rebated to consumers in lower income brackets;
- 30 percent of total revenue each year is allocated to additional carbon mitigation measures beyond those modeled in Policy Scenario One;
- 10 percent of total revenue is allocated to adaptation and resilience policies, which help vulnerable communities 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.[33]

---

[31] The increase in Maryland's RPS is consistent with HB1435 and SB0732 proposed in the 2018 legislative session.
[32] H.B. 939, Session of 2018 (Mar. 2018), p.1, http://mgaleg.maryland.gov/2018RS/fnotes/bil_0009/hb0939.pdf.
[33] Regional Carbon Cost Collection Initiative, H.B. 939, Maryland General Assembly 2018 Session, 1, (2018), http://mgaleg.maryland.gov/2018RS/fnotes/bil_0009/hb0939.pdf.

7.5 Results of Policy Scenarios One, Two, and Three

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, employment growth may be hampered. The following section contains the economic results of Policy Scenario One, Policy Scenario Two, and Policy Scenario Three. As summarized in Figure 11, all three policy scenarios achieved the economic goals described in Section 7.3.7. However, impacts on employment, personal income, and gross state product (GSP) varied.[34]

Figure 11: Summary of Policy Scenarios

Policy Scenario	Achieve 2020 Emissions Goal?	Achieve 2030 Emissions Goal?	Achieve 2030 Economic Goal?
Policy Scenario One	Yes	No	Yes
Policy Scenario Two	Yes	Yes	Yes
Policy Scenario Three	Yes	Yes	Yes

Source: RESI

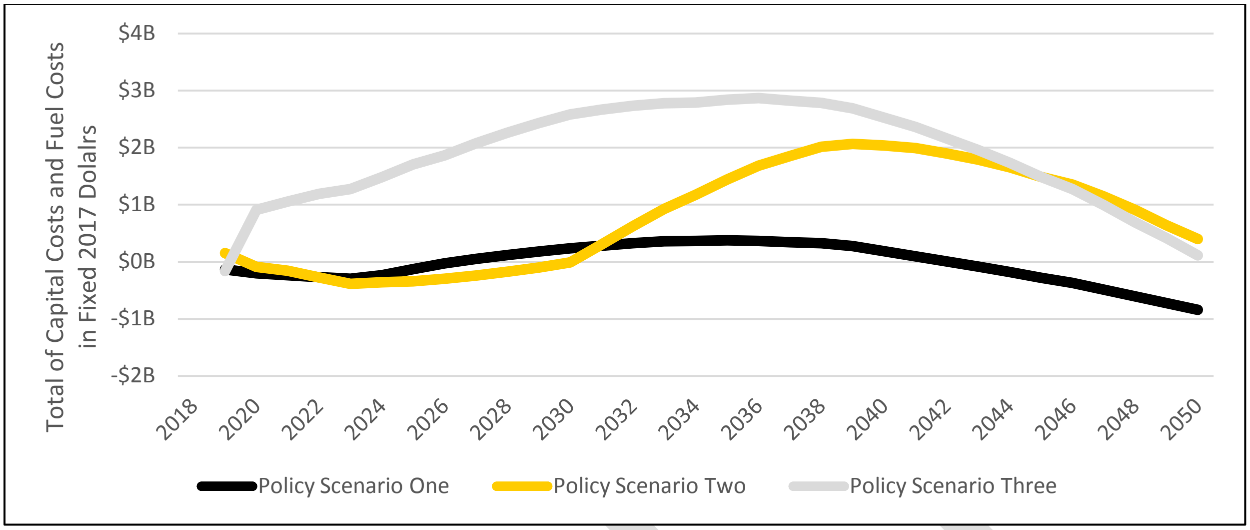
7.5.1 Spending in Policy Scenarios One, Two, and Three

Within each 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 price. However, if fuel savings are not enough to compensate for the initial capital expenditure (above and beyond what would have been spent on a gasoline-powered car), 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 each policy scenario will be lower than in the reference case. As seen in Figure 12, the total spending in each policy scenario is very different.

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

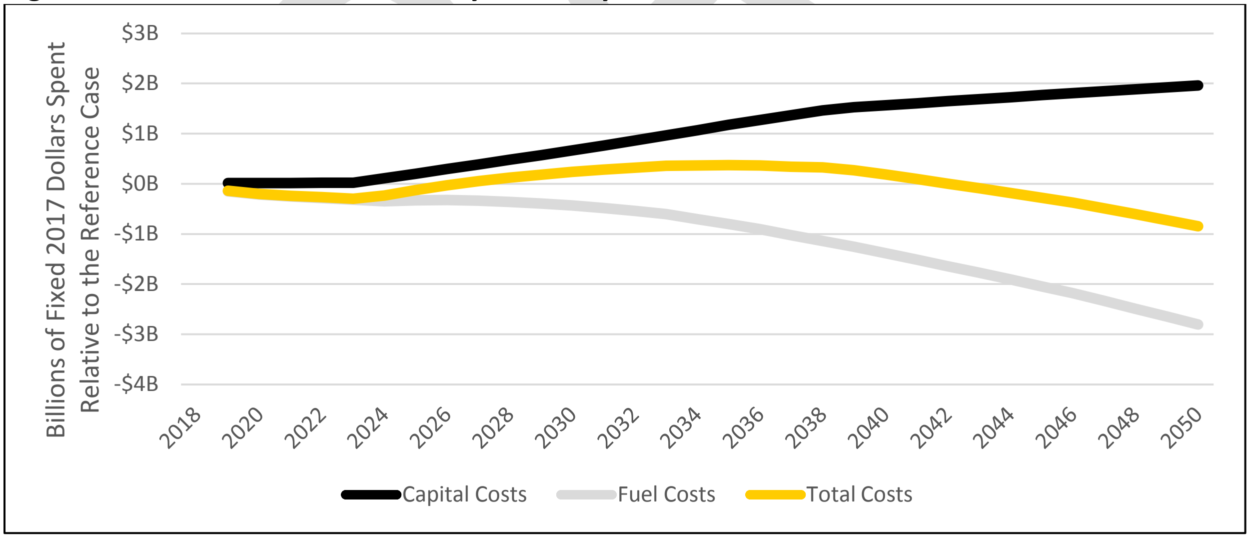
Figure 12: Total Costs from Pathways for Policy Scenario One, Policy Scenario Two, and Policy Scenario Three Relative to the Reference Case



Sources: E3, MDE, RESI

Figure 13, below, illustrates the total amount spent on fuel costs and capital costs (e.g., new energy-efficient appliances or new electric vehicles) in Policy Scenario One, relative to the reference case.

Figure 13: Total Costs from Pathways in Policy Scenario One Relative to the Reference Case

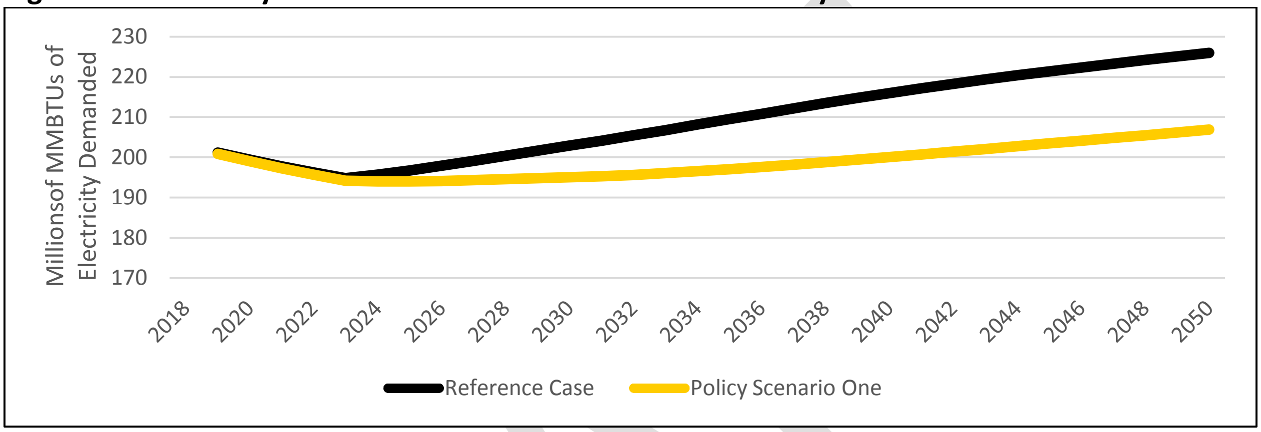


Sources: E3, MDE, RESI

As seen in Figure 13, fuel costs in Policy Scenario One are lower than in the reference case, indicating that consumers and businesses are spending less money on electricity, natural gas, and other fuel sources. This is generally due to reductions in consumption outweighing rising prices. In the short-term, the fuel savings are large enough that the total costs in Policy Scenario One are lower than in the reference case. This is largely because near-term infrastructure projects lead to reductions in vehicle miles traveled and reductions in consumption. However, as consumers and businesses purchase more energy-efficient appliances and systems, total costs rise and remain higher than in the reference case through 2045. At this point, fuel savings from new technologies are large enough that total costs are less than in the reference case.

Figure 14 illustrates how electricity demand specifically in Policy Scenario One differs from electricity demand in the reference case.

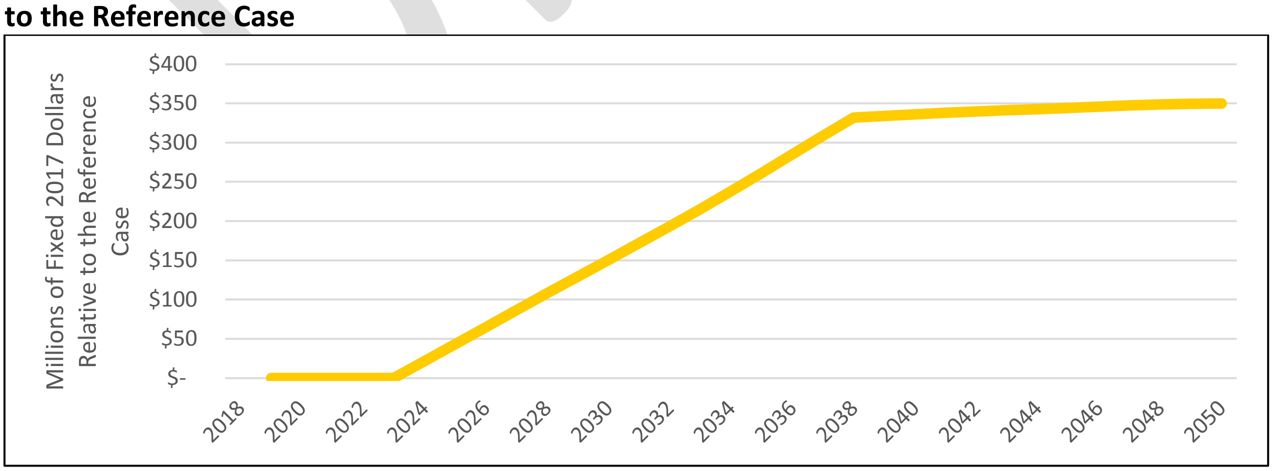
Figure 14: Electricity Demand in the Reference Case and Policy Scenario One



Sources: E3, MDE, RESI

As illustrated in Figure 14, total electricity demand declines in the reference case until 2023. At this point, the current iteration of EmPOWER expires, causing consumers and businesses to purchase less energy-efficient technologies. However, Policy Scenario One contains an extension of EmPOWER, which leads to a continuation of reduced demand for electricity after 2023. The impact of EmPOWER can be seen looking at purchasing patterns of more energy-efficient residential air conditioning units, shown in Figure 15.

Figure 15: Capital Costs for Residential Air Conditioning Units in Policy Scenario One Relative to the Reference Case

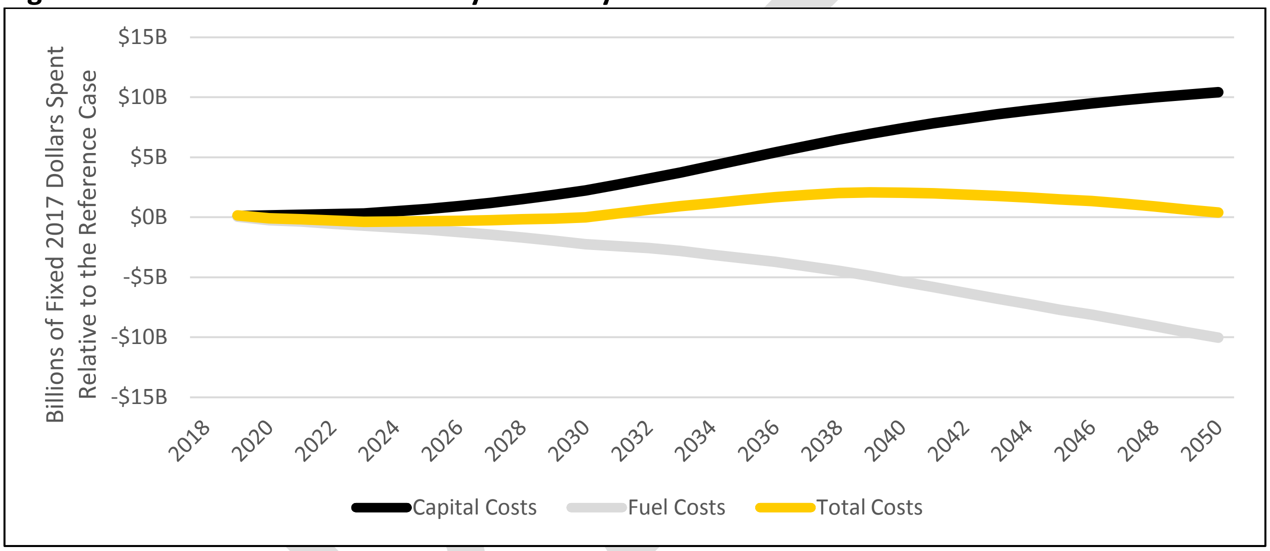


Sources: E3, MDE, RESI

As shown in Figure 15, residential spending on energy-efficient air conditioning units under Policy Scenario One is not different than in the reference case through 2023. However, starting in 2024, when the new EmPOWER extension is enacted, consumers steadily spend more on new appliances through 2038. Between 2038 and 2050, new sales of efficient appliances remains relatively constant.

Policy Scenario Two exhibits a similar overall pattern of spending on fuel costs and capital costs as in Policy Scenario One, illustrated in Figure 16.

Figure 16: Total Costs from Pathways in Policy Scenario Two Relative to the Reference Case

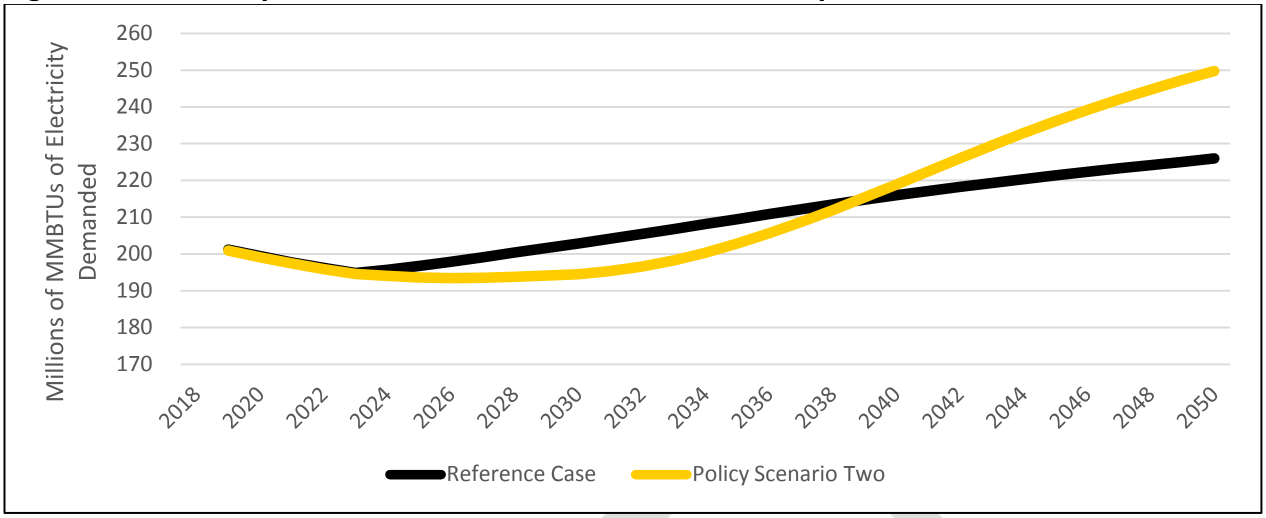


Sources: E3, MDE, RESI

Similar to Policy Scenario One, fuel savings in the near-term period help keep total costs to consumers and businesses lower than in the reference case. However, as aggressive policies encouraging sales of zero emission vehicles and energy-efficient appliances come into effect, thus increasing capital costs, total costs in Policy Scenario Two increase relative to the reference case, peaking in 2039. After 2039, total costs decrease and approach zero. However, unlike in Policy Scenario One, fuel savings in later years are not enough to create savings in the economy.

One interesting pattern in Policy Scenario Two concerns the demand for electricity, as shown in Figure 17.

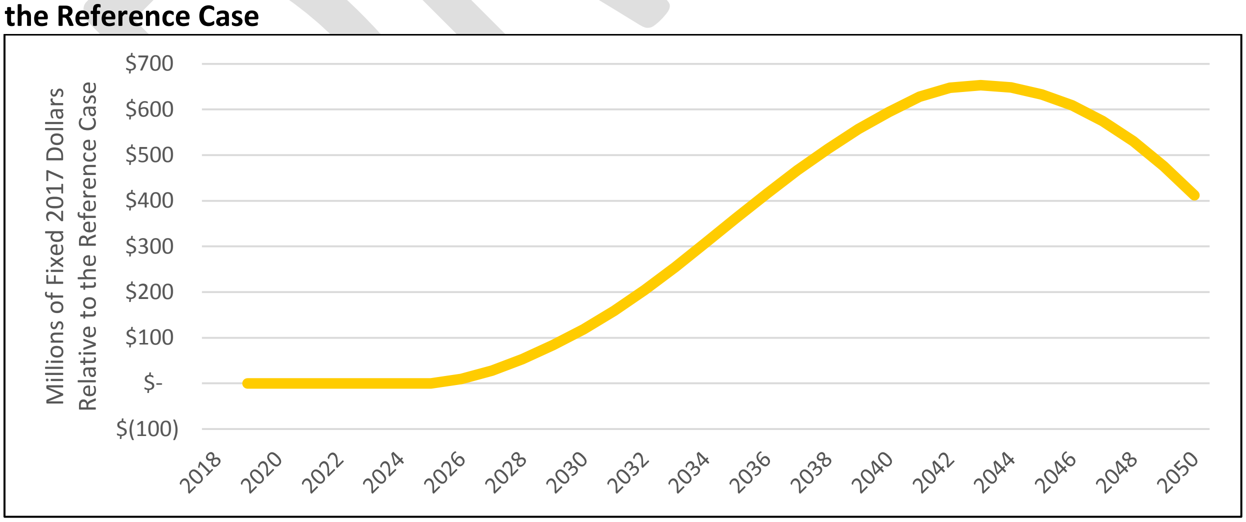
Figure 17: Electricity Demand in the Reference Case and Policy Scenario Two



Sources: E3, MDE, RESI

Similar to Policy Scenario One, demand for electricity in Policy Scenario Two is lower than in the reference case in the near term. Although Policy Scenario Two does contain measures that reduce consumer demand for electricity before the current 2023 EmPOWER end-date, the difference is not substantial until the EmPOWER extension goes into effect. The main difference between Policy Scenario Two and Policy Scenario One is that demand for electricity is higher in Policy Scenario Two than in the reference case in the later years of the study period. This increase in demand is due to an aggressive transfer of light-duty and heavy-duty vehicles to run on electricity rather than traditional gasoline or diesel. Capital costs associated with light-duty vehicles under Policy Scenario Two are presented below.

Figure 18: Capital Costs Spent on Light Duty Automobiles in Policy Scenario Two Relative to the Reference Case

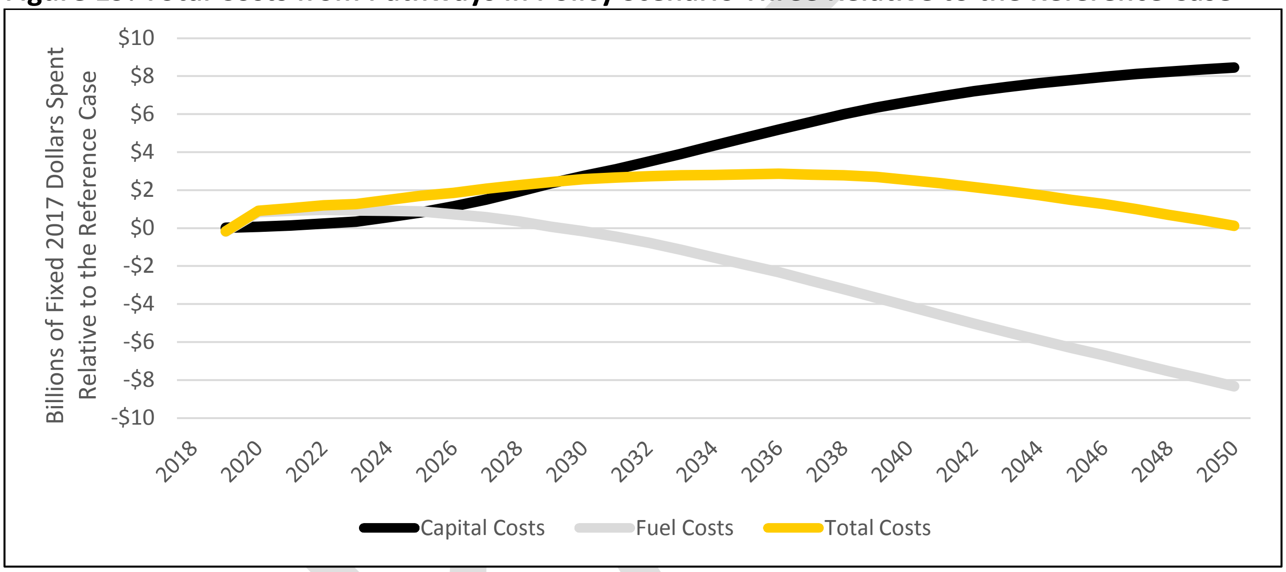


Sources: E3, MDE, RESI

As seen in Figure 18, purchases of new electric vehicles are substantial, with large increases starting in 2026 relative to the reference case. These changes reflect programs that incentive the use of electric vehicles. Spending on new purchases of efficient vehicles peaks in 2043 at roughly $650 million in purchases before declining to approximately $400 million in purchases by 2050.

Overall, the cost patterns in Policy Scenario Two are very similar to that of Policy Scenario Three, as illustrated in Figure 19.

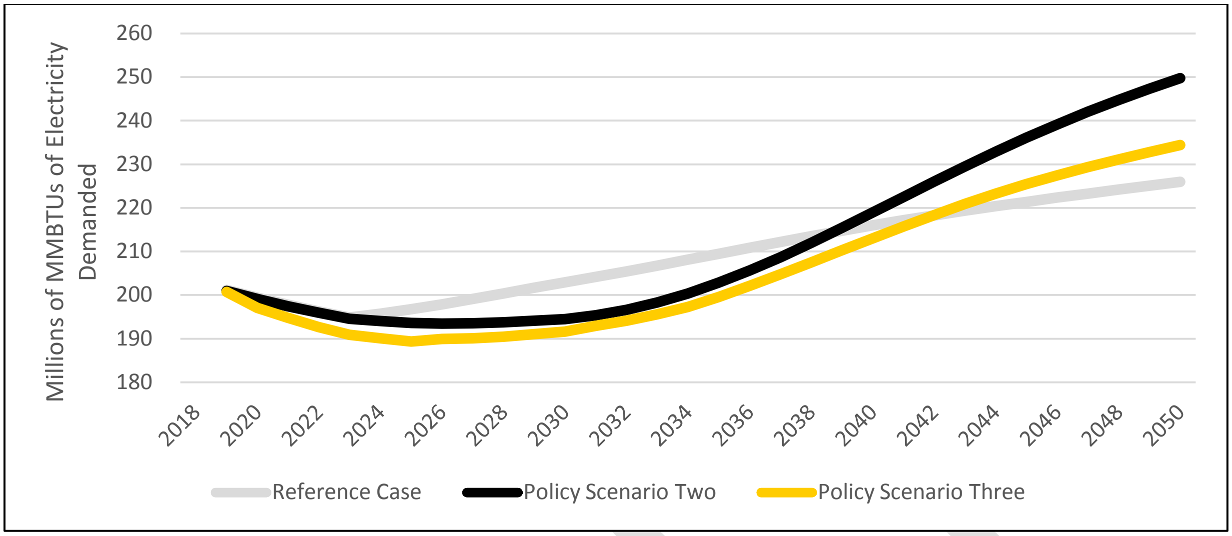
Figure 19: Total Costs from Pathways in Policy Scenario Three Relative to the Reference Case



Sources: E3, MDE, RESI

As seen in Figure 19, total costs in Policy Scenario Three never fall below levels of the reference case between 2020 and 2050. In the short term, spending on fuel is actually higher in Policy Scenario Three than in the reference case. This is due to the modeled carbon price increasing the cost of carbon-intensive fuels, an effect which outweighs reduced consumption by consumers and businesses. In the long term, a pattern similar to Policy Scenario Two emerges, where heightened levels of spending on capital costs outweigh the fuel savings from those purchases. The similarities between Policy Scenario Two and Policy Scenario Three with respect to electricity demand are represented in Figure 20.

Figure 20: Electricity Demand in the Reference Case, Policy Scenario Two, and Policy Scenario Three



Sources: E3, MDE, RESI

Policy Scenario Two and Policy Scenario Three both contain strategies to aggressively reduce carbon emissions in Maryland. However, the two scenarios contain very different policies, as Policy Scenario Two contains a more traditional mix of programs while Policy Scenario Three relies on carbon pricing. As shown in Figure 20, although these two policies pursue carbon reductions through different tactics, they lead to very similar patterns in energy consumption. Noticeable differences in electricity consumption between policy scenarios only emerge around 2038, with Policy Scenario Three not exhibiting the same increase in demand for electricity as seen in Policy Scenario Two, mostly in transportation.

7.5.2 Employment

To meet the economic goals as described in Section 7.3.7, policy scenarios must achieve positive job growth, on average, through 2030. This section presents detailed employment results for each policy scenario. 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 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 7.3, and 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.[35] NAICS categorizes industries into two- to 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 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 groups to more detailed occupations.[36] For employment results shown within this section, occupations were categorized into major SOC groups.

Job zones were developed by O*NET as a way to categorize jobs based on their similarities in regard to education, related experience, and on-the-job training requirements.[37] 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.

[35] "North American Industry Classification System," U.S. Census Bureau, accessed February 14, 2019, https://www.census.gov/eos/www/naics/.
[36] "Standard Occupational Classification," U.S. Bureau of Labor Statistics, accessed February 14, 2019, https://www.bls.gov/soc/home.htm.
[37] "O*NET OnLine Help: Job Zones," O*NET OnLine, accessed February 13, 2019, https://www.onetonline.org/help/online/zones.

- 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.[38]

The jobs supported by Policy Scenario One 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.[39]

Improved health outcomes affect employment through a number of 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.

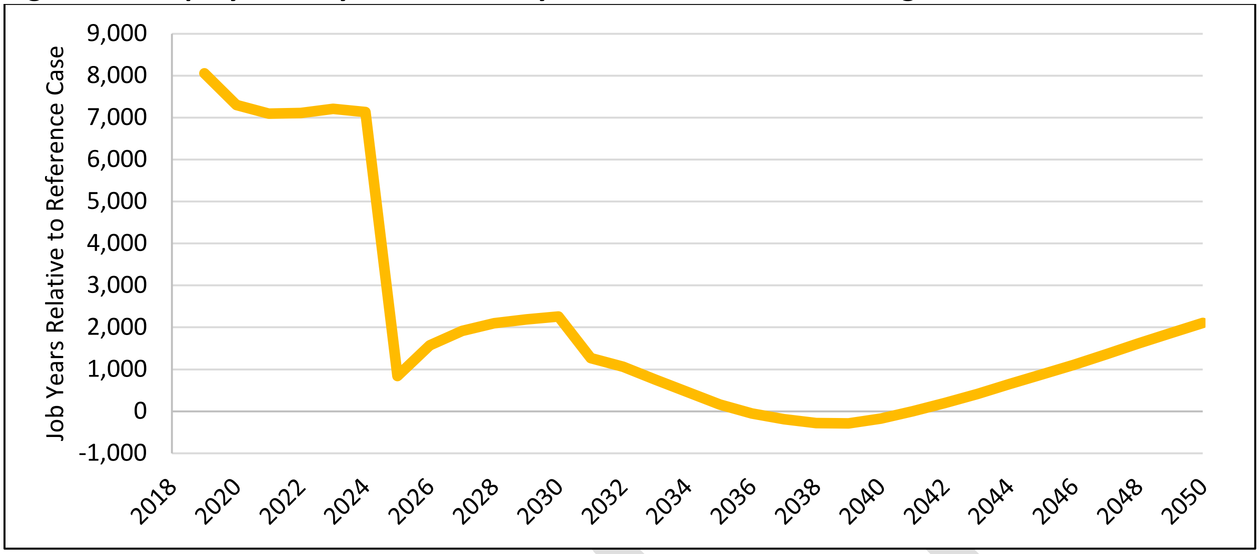
7.5.2.1 Employment in Policy Scenario One

Policy Scenario One, representing a continuation of existing and planned programs, achieves the economic goal of positive job growth through 2030. As seen in Figure 21, Policy Scenario One supports an average of 4,564 jobs each year through 2030 relative to the reference case.

[38] "O*NET OnLine Help: Job Zones," O*NET OnLine.

[39] 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.

Figure 21: Employment by Year for Policy Scenario One, 2019 Through 2050



Sources: REMI PI+, E3, MDE, MDOT, RESI

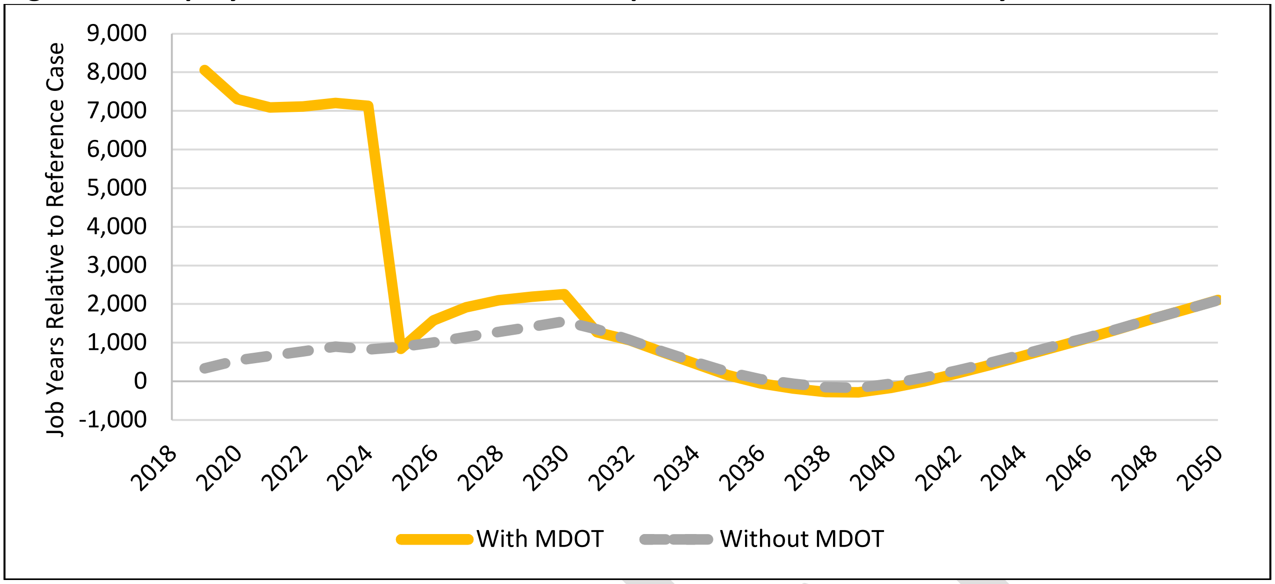
In the short term, employment gains are relatively high, due to spending on a variety of infrastructure projects, including new funding for Metropolitan Planning Organization (MPO) plans and programs. Many of these infrastructure projects are set to be completed by 2025, corresponding with the decrease in job growth seen at this time.

After 2030, job growth relative to the reference case slows and approaches zero. During this time, capital expenditures significantly outweigh reductions in energy consumption, as discussed in Section 7.5.1. 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 21 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.

Although transportation spending in the near term constitutes a large percentage of the employment impacts, Figure 22 shows that job growth is dominantly positive relevant to the reference case, even after removing transportation spending from the model. Transportation spending in Policy Scenario One consists of two main phases as seen in the graph below.

Figure 22: Employment with and without Transportation Measures in Policy Scenario One



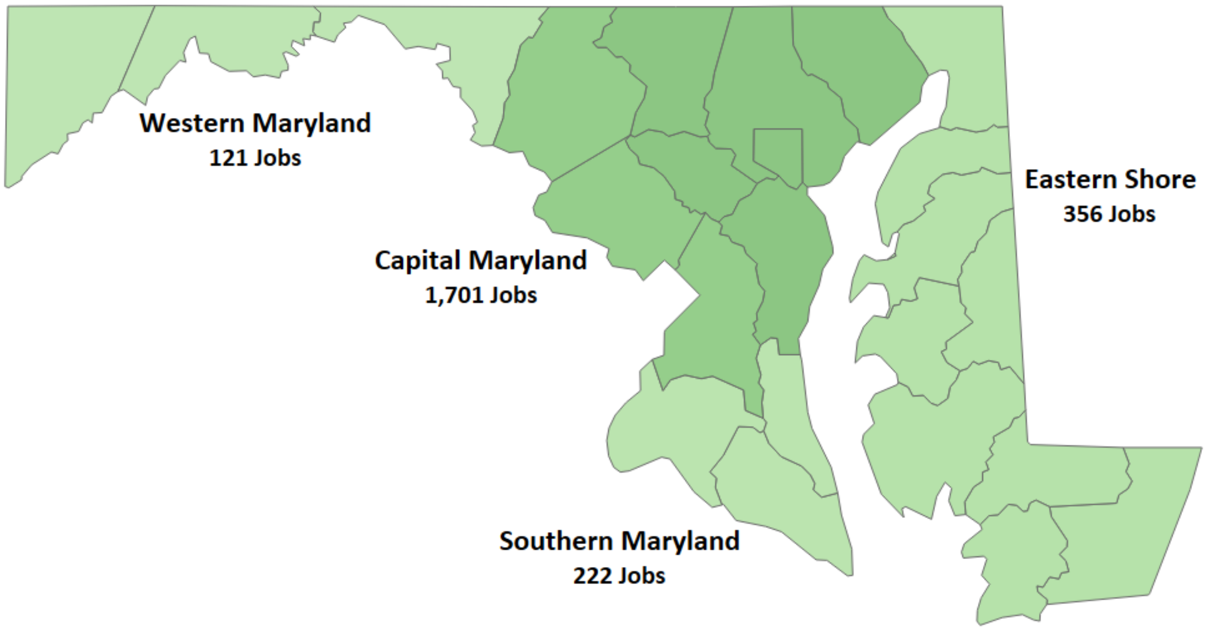
Sources: E3, MDE, MDOT, RESI

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 3,620 fewer jobs annually compared to the scenario with MDOT spending.

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 23, no region within the state experiences job losses on average through 2030, relative to the reference case. Central Maryland has the largest gains with 2,163 jobs while the smallest gains of 121 jobs are found in Western Maryland. In terms of percentage growth, job gains are roughly distributed in line with Maryland's workforce; each of the regions experiences a 0.1 percent increase in employment on average between 2019 and 2030.

Figure 23: Average Annual Employment Impacts by Region for Policy Scenario One, 2019 - 2030



Sources: E3, MDE, RESI

Figure 24 outlines the composition of employment gains by industry.

Figure 24: Average Annual Employment by Industry for Policy Scenario One, 2019 - 2030

NAICS	Industry	Average Annual Jobs Through 2030
11	Agriculture, Forestry, Fishing and Hunting	72
21	Mining, Quarrying, and Oil and Gas Extraction	-21
22	Utilities	245
23	Construction	5,156
31-33	Manufacturing	47
42	Wholesale Trade	-2
44-45	Retail Trade	-557
48-49	Transportation and Warehousing	3
51	Information	-12
52	Finance and Insurance	-58
53	Real Estate and Rental and Leasing	-44
54	Professional, Scientific, and Technical Services	89
55	Management of Companies and Enterprises	-7
56	Administrative and Support and Waste	6

NAICS	Industry	Average Annual Jobs Through 2030
	Management and Remediation Services	
61	Educational Services	-16
62	Health Care and Social Assistance	-174
71	Arts, Entertainment, and Recreation	-42
72	Accommodation and Food Services	-104
81	Other Services (except Public Administration)	-169
92	Public Administration	153
Total		**4,564**

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

As detailed above, the vast majority of these jobs are estimated to be in the construction industry, and is likely reflective of the transportation infrastructure projects. Conversely, Retail Trade posts the largest declines of 557 jobs, followed by Health Care and Social Assistance (loss of 174 jobs) and Other services (decrease of 169 jobs). 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 25 below shows the distribution of employment impacts by occupation. Please note that the total average number jobs may not match the industry total due to rounding.

Figure 25: Employment by Occupation for Policy Scenario One

SOC Code	SOC Description	Average Jobs Through 2030
11	Management Occupations	308
13	Business and Financial Operations Occupations	170
15	Computer and Mathematical Occupations	25
17	Architecture and Engineering Occupations	95
19	Life, Physical, and Social Science Occupations	8
21	Community and Social Service Occupations	-8
23	Legal Occupations	8
25	Education, Training, and Library Occupations	36
27	Arts, Design, Entertainment, Sports, and Media Occupations	-8
29	Healthcare Practitioners and Technical Occupations	-52
31	Healthcare Support Occupations	-40
33	Protective Service Occupations	15

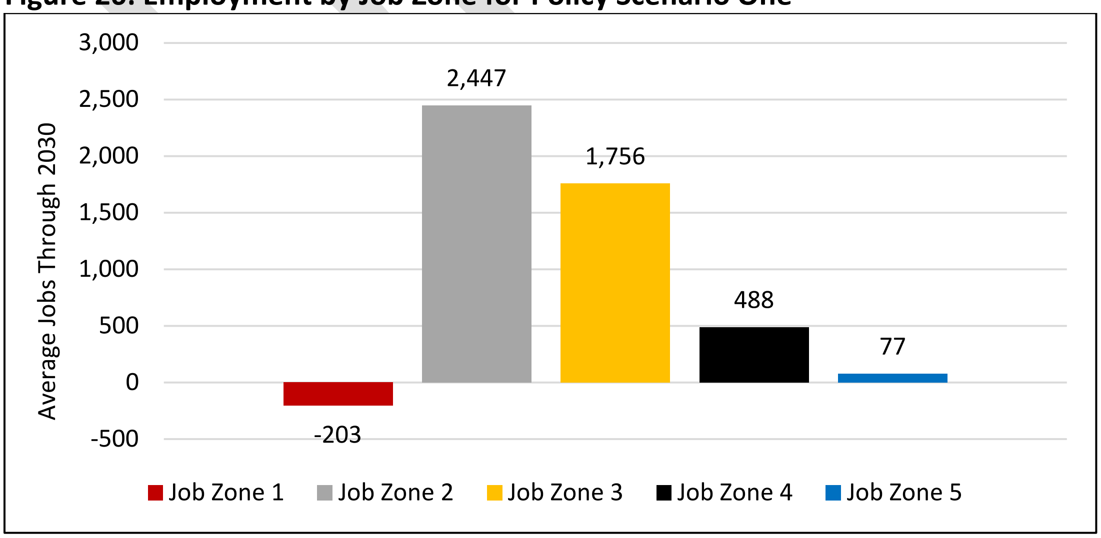
SOC Code	SOC Description	Average Jobs Through 2030
35	Food Preparation and Serving Related Occupations	-108
37	Building and Grounds Cleaning and Maintenance Occupations	7
39	Personal Care and Service Occupations	-99
41	Sales and Related Occupations	-211
43	Office and Administrative Support Occupations	368
45	Farming, Fishing, and Forestry Occupations	41
47	Construction and Extraction Occupations	3,245
49	Installation, Maintenance, and Repair Occupations	494
51	Production Occupations	131
53	Transportation and Material Moving Occupations	140
Total		**4,564**

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

The greatest employment gains are projected to be in Construction and Extraction Occupations with an estimated 3,245 jobs, and are likely supported by the marked increase in construction activity. The second-highest increase is shown in Installation, Maintenance, and Repair Occupations (494 jobs), driven by the increase in self-supplied renewable energy production. Additionally, workers in Office and Administrative Support Occupations (368); Management Occupations (308); and Business and Financial Operations Occupations (170) are also expected to have significant job gains.

Figure 26 below shows the distribution of employment changes by job zone, as previously defined in Section 7.5.2.

Figure 26: Employment by Job Zone for Policy Scenario One

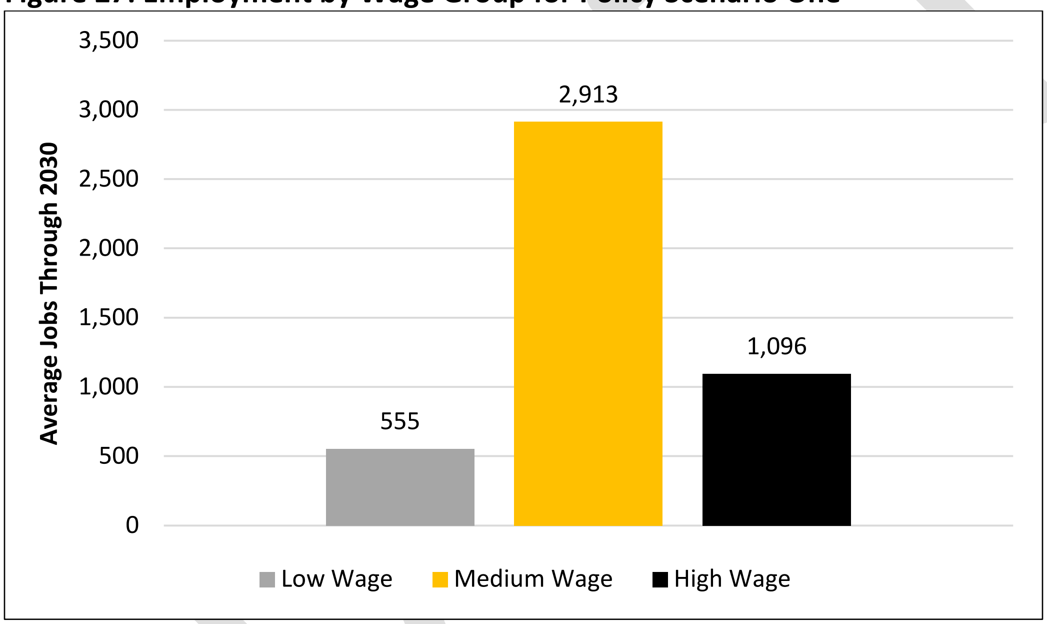


Sources: E3, MDE, O*Net, REMI PI+, RESI

Simulations for Policy Scenario One indicate robust job growth for occupations in Job Zones 2 and 3, with small losses occurring in Job Zone 1, generally representing a loss of cashiers associated with gas stations. This indicates that while jobs requiring the lowest levels of preparation are lost, the most-substantial increases are in jobs that typically require modest preparation (typically ranging from a high school diploma or equivalent to vocational school or an associate degree).[40] These results are largely being driven by the transportation projects and the growing wind and solar power generation sectors. The growth in jobs in job zones 2 and 3 mean that retraining and repositioning workers for the new economy in Maryland will be less burdensome than if jobs were created that required extensive training or education. In that case, Maryland would likely fill the job openings through recruiting talent from out-of-state, as opposed to boosting employment of current residents.

Figure 27 illustrates employment results by wage group, as previously outlined in Section 7.5.2.

Figure 27: Employment by Wage Group for Policy Scenario One



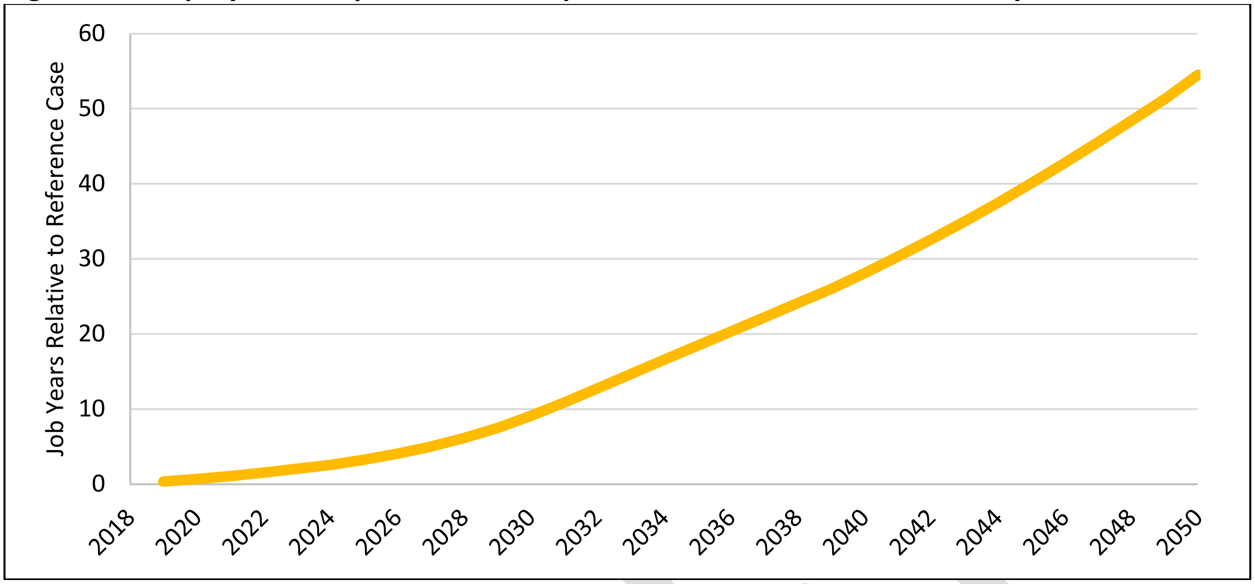
Sources: E3, MDE, REMI PI+, RESI, U.S. BLS

The graph above indicates that the jobs supported by Policy Scenario One are largely medium-wage jobs, but there are also significant gains in high-wage jobs as well. Low-wage jobs represent the smallest proportion of employment gains. These shifts are likely due to the slightly increased preparation required for new employment opportunities, as shown in the distribution of occupations by Job Zone.

Figure 28 details the expected employment impacts resulting from changes in health outcomes, as described in Section 7.5.2.

[40] "O*NET OnLine Help: Job Zones," O*NET OnLine.

Figure 28: Employment Impacts Due to Improved Health Outcomes for Policy Scenario One



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

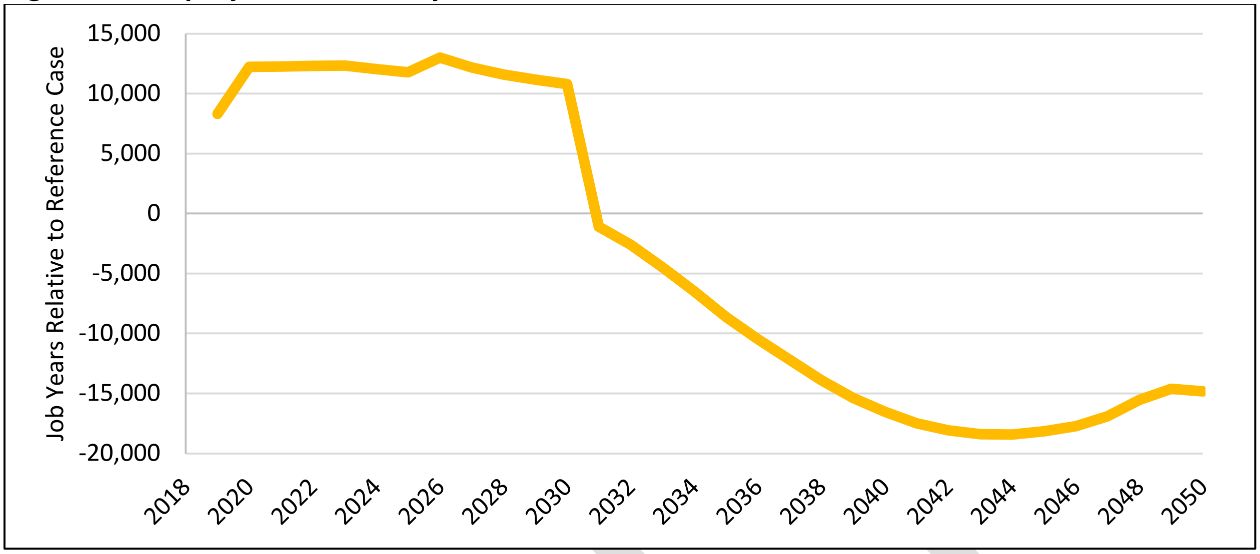
As illustrated above, the number of jobs due to improved health outcomes from Policy Scenario One grows exponentially, averaging approximately 4 jobs per year through 2030 and 20 jobs per year through 2050. This exponential growth is due to the cumulative effects of air pollution reduction. Detailed results for health impacts are found in Appendix C.5.

7.5.2.2 Employment in Policy Scenario Two

Total employment in Policy Scenario Two follows a similar trend as in Policy Scenario One, but with more extreme highs and more extreme lows. On average, Policy Scenario Two supports approximately 11,665 jobs annually through 2030, with these impacts largely resulting from transportation strategies implemented by MDOT. Specifically, the Traffic Relief Plan Implementation, Intermodal Freight Centers Access Improvement, and Transit Capacity/Service Expansion are responsible for most of the near-term transportation-related jobs.

Figure 29 shows employment changes in Policy Scenario Two, with declines observed around 2025 and 2030. 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 29: Employment for Policy Scenario Two

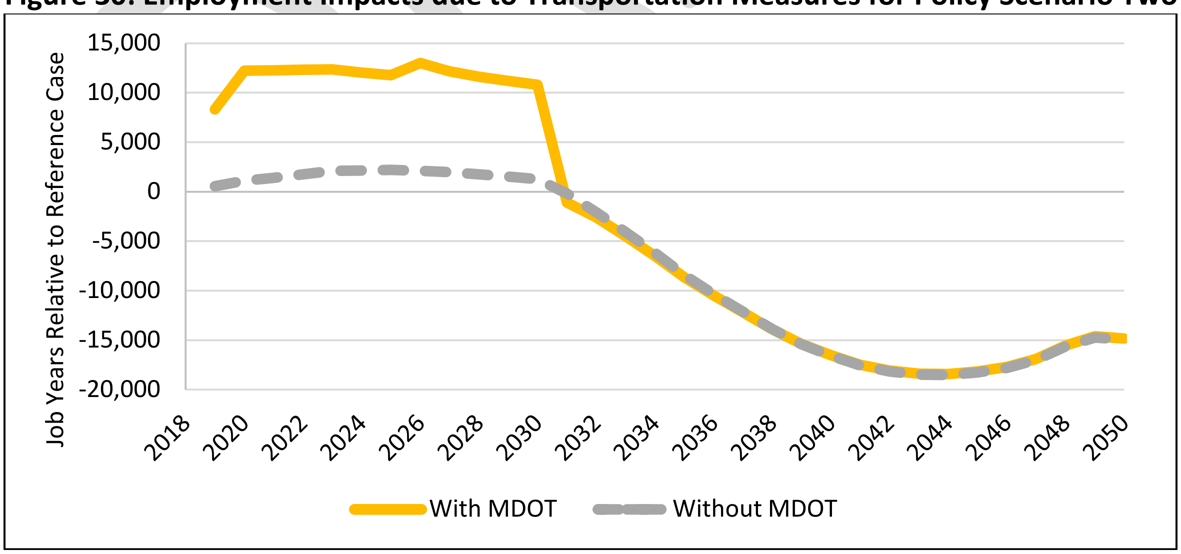


Sources: REMI PI+, E3, MDE, MDOT, RESI

In the years beyond 2030, employment levels drop relative to the reference case. This is mainly due to the more aggressive emissions assumptions for Policy Scenario Two. Consumers and businesses are spending more on capital relative to their fuel savings, producing a net cost to the economy. However, this divergence becomes less pronounced in the long-term as the total costs (referenced in Section 7.5.1) approach zero.

Figure 30 shows the difference in employment effects with and without funding directed towards transportation measures.

Figure 30: Employment Impacts due to Transportation Measures for Policy Scenario Two

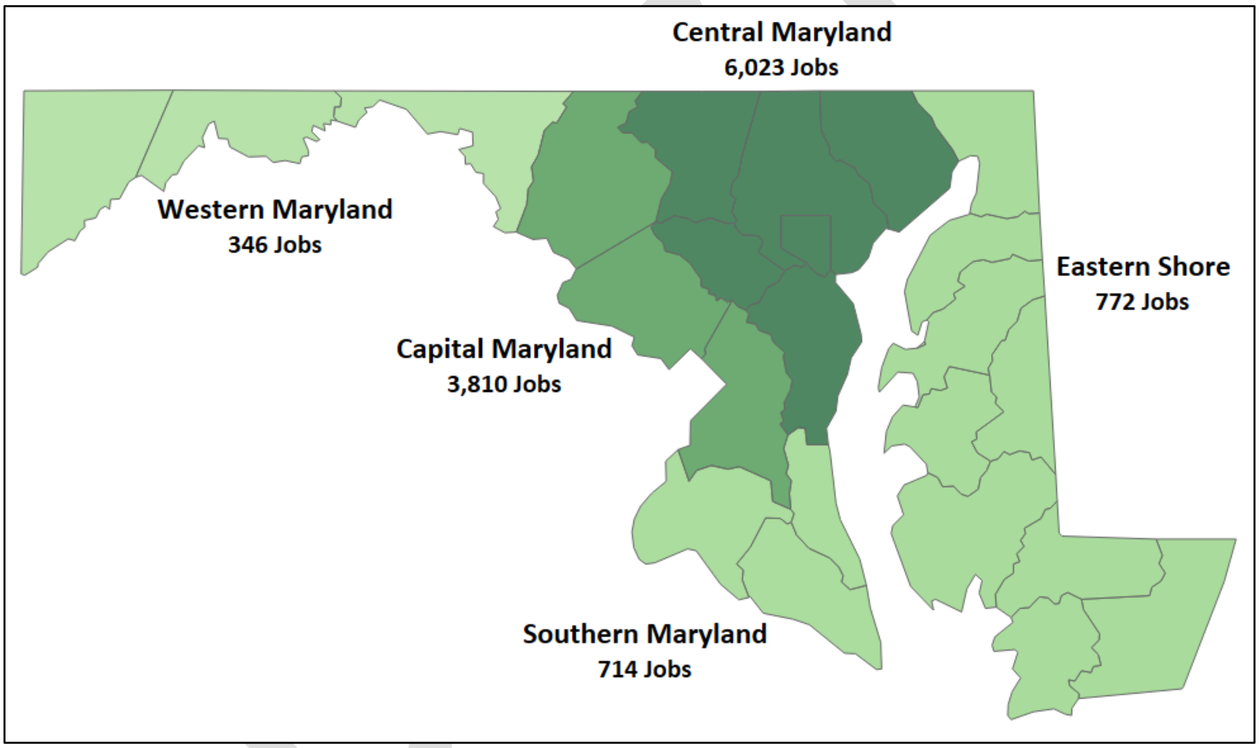


Sources: REMI PI+, E3, MDE, MDOT, RESI

Similar to Policy Scenario One, there is a large divergence in the near-term between the scenarios with and without MDOT projects, with the effects becoming virtually identical after 2030 as the MDOT measures are set to expire. On average through 2030, the scenario without MDOT spending supports 10,013 fewer jobs annually compared to the scenario with MDOT spending. Compared to Policy Scenario One and Three, this is the greatest difference between MDOT spending scenarios.

As was the case for Policy Scenario One, no region of Maryland loses jobs on average through 2030 under Policy Scenario Two. Figure 31 shows the regional distribution of jobs under Policy Scenario Two, with darker-shaded areas having greater average employment gains.

Figure 31: Average Annual Employment Impacts by Region for Policy Scenario Two, 2019-2030



Sources: E3, MDE, RESI

Central Maryland continues to show the largest gains with 6,023 jobs, followed by Capital Maryland with 3,810 jobs. However, on a percentage basis, Southern Maryland experiences the highest levels of growth, with employment increasing by 0.4 percent. Job gains in other regions are similarly modest, ranging from a 0.2 percent increase in Western Maryland to 0.3 percent in the other three regions of the state. Figure 31 illustrates that even in the most aggressive policy scenario with regards to reducing carbon emissions, all regions of Maryland benefit, not just urban centers or rural areas.

Employment distributions by major NAICS industries are outlined in Figure 32. As shown below, Construction is responsible for almost three quarters of the jobs supported by Policy Scenario Two, creating an average of 8,331 jobs through 2030. Significant gains are also observed in Public Administration with an increase of 700 jobs, and Transportation and Warehousing with 574 additional positions.

Figure 32: Employment Impacts by Industry for Policy Scenario Two, 2019-2030

NAICS	Industry	Annual Average Number of Jobs, 2019-2030
11	Agriculture, Forestry, Fishing and Hunting	131
21	Mining, Quarrying, and Oil and Gas Extraction	-39
22	Utilities	154
23	Construction	8,331
31-33	Manufacturing	210
42	Wholesale Trade	98
44-45	Retail Trade	47
48-49	Transportation and Warehousing	574
51	Information	17
52	Finance and Insurance	30
53	Real Estate and Rental and Leasing	297
54	Professional, Scientific, and Technical Services	286
55	Management of Companies and Enterprises	22
56	Administrative and Support and Waste Management and Remediation Services	231
61	Educational Services	41
62	Health Care and Social Assistance	278
71	Arts, Entertainment, and Recreation	2
72	Accommodation and Food Services	183
81	Other Services (except Public Administration)	73
92	Public Administration	700
Total		**11,665**

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

In contrast to Policy Scenario One, only one industry experiences job losses relative to the reference case. Those losses that do occur are in Mining, Quarrying, and Oil and Gas Extraction, with a decrease of 39 jobs, and reflect the aggressive push to lower dependency on fossil-fuel generated energy.

The occupational distributions of employment changes within Policy Scenario Two are detailed in Figure 33.

Figure 33: Employment Impacts by Occupation for Policy Scenario Two

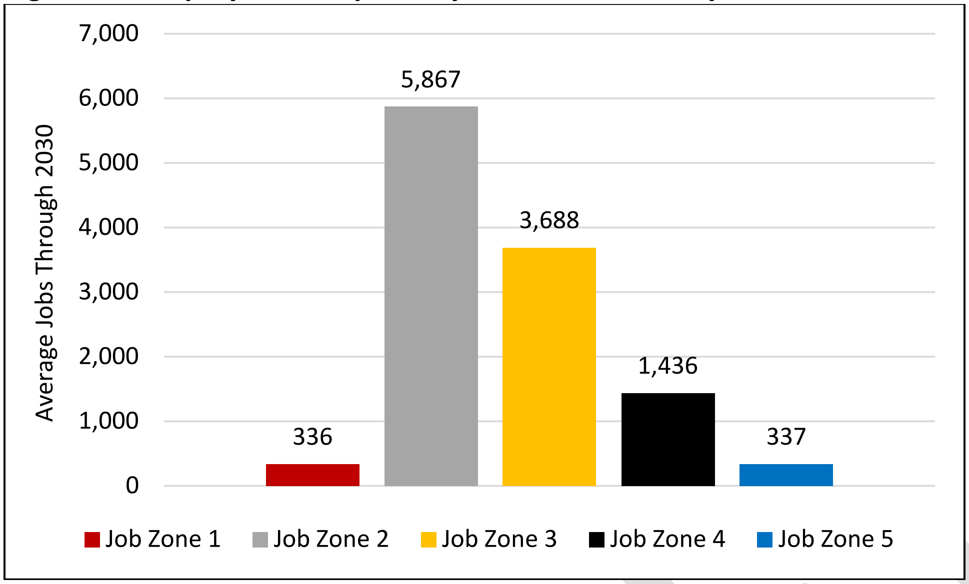
SOC Code	SOC Description	Annual Average Number of Jobs, 2019-2030
11	Management Occupations	703
13	Business and Financial Operations Occupations	434
15	Computer and Mathematical Occupations	114
17	Architecture and Engineering Occupations	169
19	Life, Physical, and Social Science Occupations	30
21	Community and Social Service Occupations	46
23	Legal Occupations	34
25	Education, Training, and Library Occupations	278
27	Arts, Design, Entertainment, Sports, and Media Occupations	38
29	Healthcare Practitioners and Technical Occupations	143
31	Healthcare Support Occupations	63
33	Protective Service Occupations	114
35	Food Preparation and Serving Related Occupations	195
37	Building and Grounds Cleaning and Maintenance Occupations	185
39	Personal Care and Service Occupations	101
41	Sales and Related Occupations	351
43	Office and Administrative Support Occupations	1,232
45	Farming, Fishing, and Forestry Occupations	76
47	Construction and Extraction Occupations	5,258
49	Installation, Maintenance, and Repair Occupations	963
51	Production Occupations	315
53	Transportation and Material Moving Occupations	825
Total		**11,665**

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

On average, no major occupational group experiences losses in Policy Scenario Two. Construction and Extraction Occupations post the largest gains at 5,258 jobs on average through 2030, followed by Office and Administrative Support Occupations with average increases of 1,232 positions. Life, Physical, and Social Science Occupations and Legal Occupations show the smallest gains of 30 and 34 jobs, respectively. A substantial portion of the jobs in the Life, Physical, and Social Science Occupations are in the Chemical Manufacturing or Oil and Gas Extraction industries. Given this, gains to these occupations resulting from the push towards renewable energy generation will likely be diminished by losses in those industries.

As illustrated in Figure 34, no occupations in any of the five job zones experience losses on average through 2030.

Figure 34: Employment Impacts by Job Zone for Policy Scenario Two

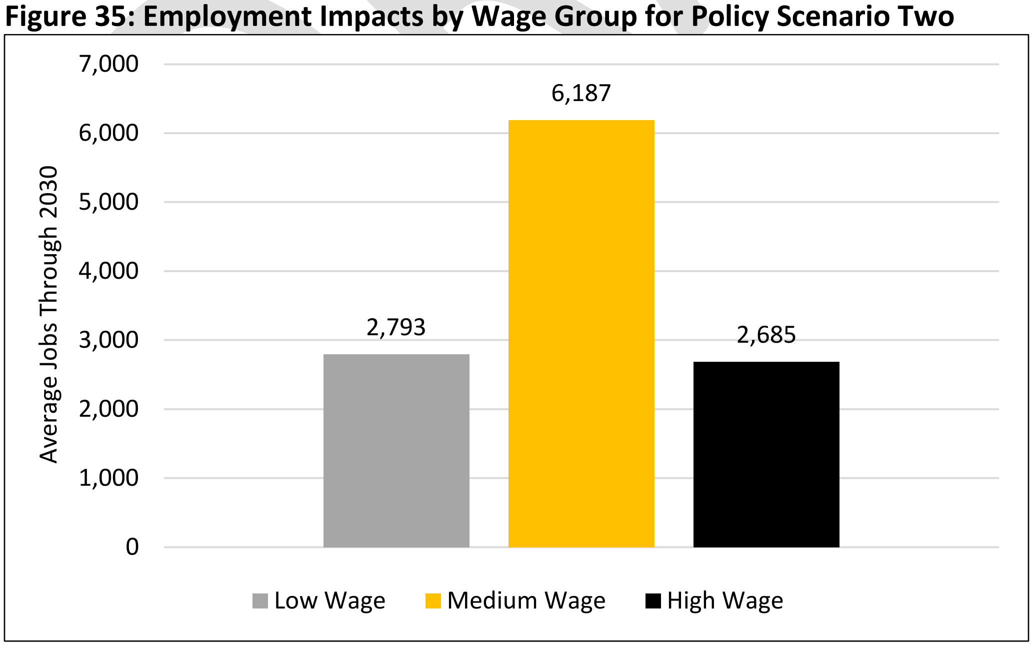


Sources: E3, MDE, O*Net, REMI PI+, RESI

Similar to the results for Policy Scenario One, the simulation results for Policy Scenario Two 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 work to increase the labor force participation rate in the state, as these jobs have fewer barriers to entry.

Employment distributions by wage group for Policy Scenario Two are illustrated in Figure 35 below.

Figure 35: Employment Impacts by Wage Group for Policy Scenario Two

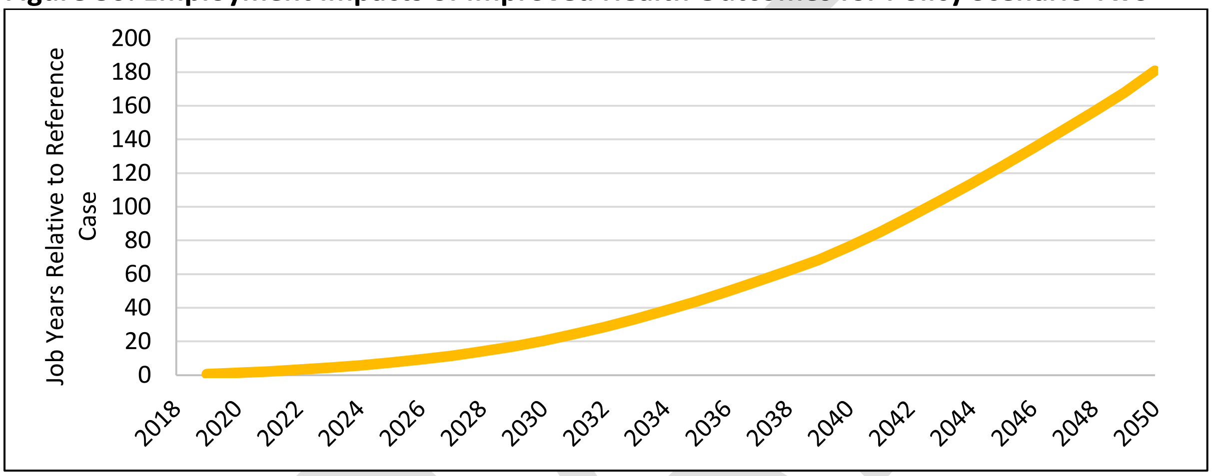


Sources: E3, MDE, REMI PI+, RESI, U.S. BLS

As in Policy Scenario One, medium-wage occupations show the largest gains under Policy Scenario Two. However, unlike in Policy Scenario One, low-wage jobs are estimated to form a slightly higher proportion of the supported occupations relative to high-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 Policy Scenario Two, illustrated in Figure 36, show a similar pattern as in Policy Scenario One.

Figure 36: Employment Impacts of Improved Health Outcomes for Policy Scenario Two



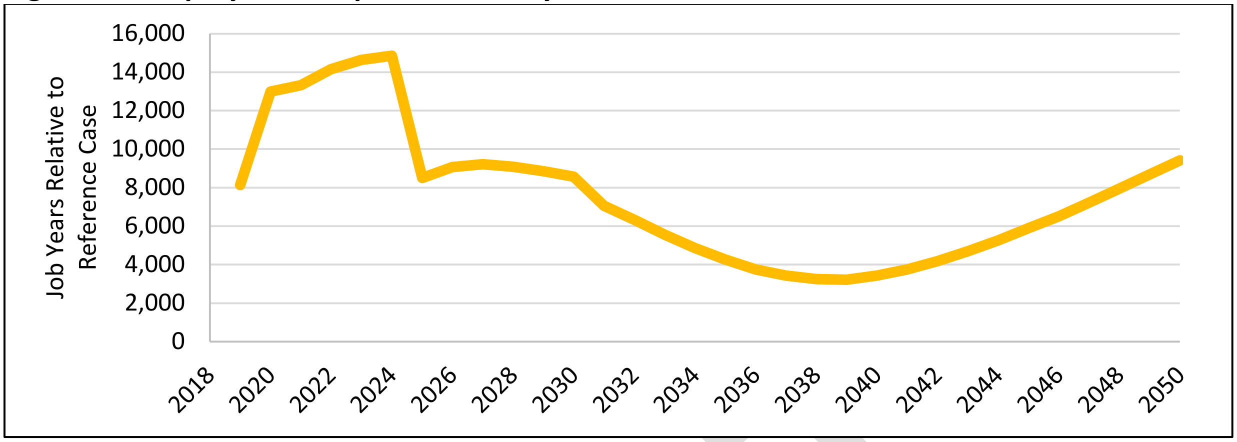
Sources: E3, MDE, MDOT, RESI, U.S. EPA

Notably, because emissions reductions are more substantial in Policy Scenario Two as compared to Policy Scenario One, the magnitude of job gains are larger—supporting an average of 8 jobs through 2030 and 59 jobs through 2050. Detailed results for health impacts are found in Appendix C.5.

7.5.2.3 Employment in Policy Scenario Three

Policy Scenario Three supports, on average, 10,950 jobs through 2030 relative to the reference case. The general trends remain similar to the other two policy scenarios, with the increase in the near-term but then leveling out over the long-term. The spike in employment before 2025, shown in Figure 37 below, is due to the transportation infrastructure projects as well as additional mitigation measures funded by carbon fee revenues.

Figure 37: Employment Impacts for Policy Scenario Three

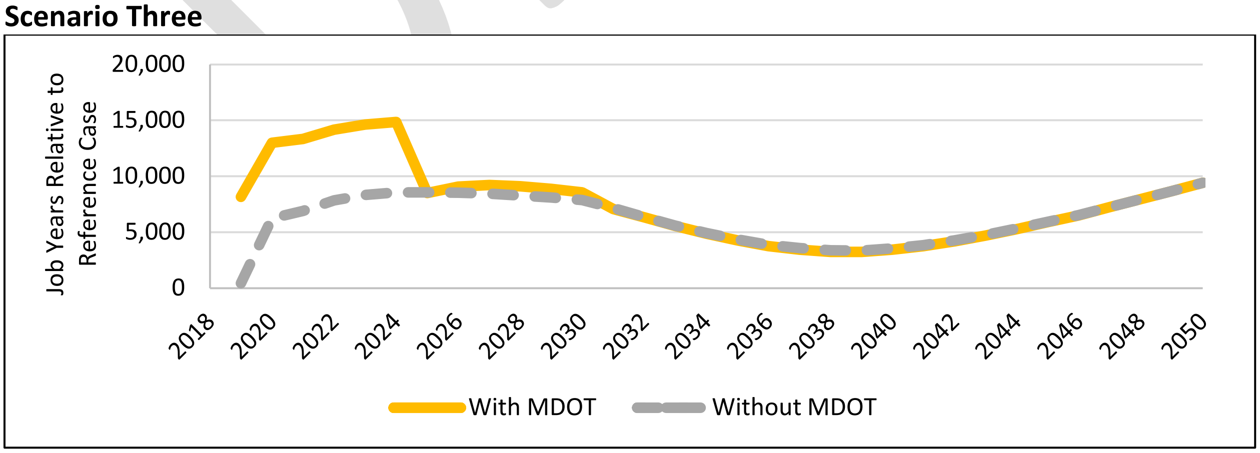


Sources: REMI PI+, E3, MDE, MDOT, RESI

The carbon fee in this policy scenario effectively acts as a transfer mechanism. Because Maryland is a net importer of energy, revenue is generally derived from out-of-state businesses. The revenue is then spent mostly within Maryland, either through rebates to consumers, job training programs, additional mitigation measures, or on adaptation and resilience funds for local governments. If employment outside of Maryland were considered in this report, job gains would likely be more modest. However, Maryland's unique structure enables the pattern illustrated in Figure 37. This transfer effect due to the carbon fee may also be visualized by comparing employment impacts between Policy Scenario Two and Policy Scenario Three. While in Policy Scenario Two there was a dip in employment after 2030, the carbon fee revenue is able to boost employment in the long-run for Policy Scenario Three through the mechanisms described above.

Figure 38 shows how the incorporation of the MDOT transportation measures impacts the simulation results.

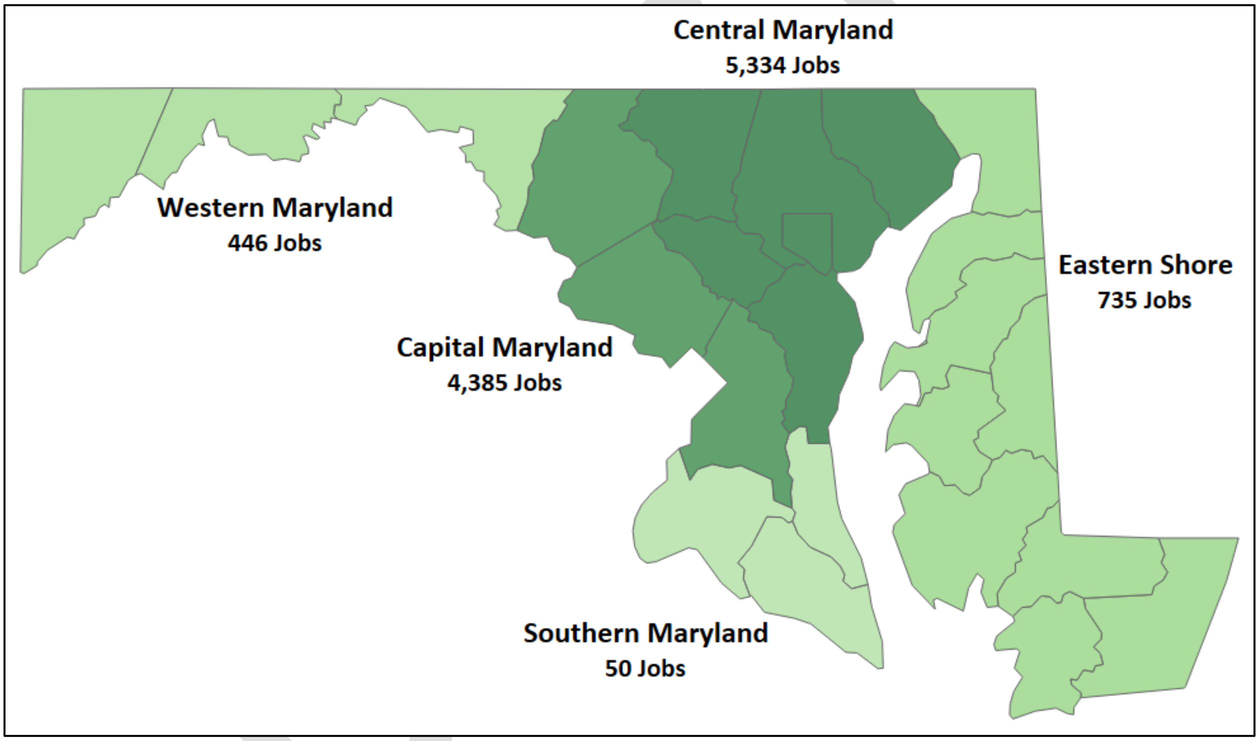
Figure 38: Employment Impacts With and Without Transportation Measures for Policy Scenario Three



Sources: REMI PI+, E3, MDE, MDOT, RESI
Compared to the other two scenarios, the MDOT spending impacts are similar to Policy Scenario One with these measures supporting, on average, 3,614 more jobs through 2030 compared to the scenario without MDOT spending. This is illustrated above in Figure 38 as the difference between the two lines. Once again, the employment changes are observed between the two spending scenarios as the majority of MDOT projects are completed in 2025, with additional projects being completed in 2030.

On average, as seen in Figure 39, no region of Maryland experiences job losses relative to the reference case through 2030 for Policy Scenario Three. As with the other two policy scenarios, Central Maryland sustains the largest gains at 5,334 jobs.

Figure 39: Employment Impacts by Region for Policy Scenario Three



Sources: E3, MDE, RESI

Significant employment increases are also observed in Capital Maryland, with 4,385 jobs. On a percentage basis, job gains are very similar in all regions except for Southern Maryland. All other regions experience a 0.3 percent increase in employment through 2030 under Policy Scenario Three, while employment in Southern Maryland remains more or less constant, only seeing an increase of 50 jobs. Notably, while average job gains are generally comparable between Policy Scenario Two and Policy Scenario Three through 2030, job gains differ slightly regionally. Capital Maryland, consisting of the Washington, D.C. suburbs, experiences higher rates of job growth in Policy Scenario Three than in Policy Scenario Two (4,385 jobs compared to 3,810). The Eastern Shore and Southern Maryland experience declines, largely due to the effect of carbon pricing on the farming industry. As noted in Section 7.3.6, the farming industry is impacted by changes in the price of gasoline and diesel applied only in Maryland, making rural areas of Maryland more impacted by this policy bundle.

Employment changes by major industry are shown below in Figure 40. The Construction industry, which captures an average of 7,534 annual jobs, represents nearly 69 percent of the jobs supported by Policy Scenario Three.

Figure 40: Employment Impacts by Industry for Policy Scenario Three

NAICS	Industry	Annual Average Number of Jobs, 2019-2030
11	Agriculture, Forestry, Fishing and Hunting	-171
21	Mining, Quarrying, and Oil and Gas Extraction	-77
22	Utilities	-312
23	Construction	7,534
31-33	Manufacturing	-13
42	Wholesale Trade	108
44-45	Retail Trade	995
48-49	Transportation and Warehousing	-73
51	Information	14
52	Finance and Insurance	18
53	Real Estate and Rental and Leasing	127
54	Professional, Scientific, and Technical Services	229
55	Management of Companies and Enterprises	2
56	Administrative and Support and Waste Management and Remediation Services	117
61	Educational Services	30
62	Health Care and Social Assistance	1,196
71	Arts, Entertainment, and Recreation	-2
72	Accommodation and Food Services	88
81	Other Services (except Public Administration)	35
92	Public Administration	1,106
Total		**10,950**

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

The increase in Construction jobs are due not only to the transportation measures by MDOT, but also the additional mitigation measures funded by the carbon fee revenues. Notable increases are also found in the Health Care and Social Assistance industry and Public Administration industry, with increases of 1,196 and 1,106 jobs, respectively. Relative to the reference case, Utilities; Agriculture, Forestry, Fishing, and Hunting; and Transportation and Warehousing industries experience the largest declines, on average, through 2030. While the previous two scenarios showed increases to Agriculture, Forestry, Fishing, and Hunting, the employment losses in Policy Scenario Three are due to the effect of the carbon fee on farming. As discussed earlier, the increase in the cost of gasoline and diesel as a result of the carbon pricing impacts the price-sensitive farming industry, but its application only in Maryland leaves farms in surrounding states unaffected, causing Maryland farms to lose business to competitors elsewhere in the region. Job losses in the broader Agriculture, Forestry, and Fishing sector as seen in Figure 40 are balanced out slightly by investments in adaptation and resilience programs funded by carbon fee revenues.

The occupational distribution of jobs follows a similar pattern to the effects by industry for Policy Scenario Three, as illustrated in Figure 41. Construction and Extraction Occupations post the largest gains of 4,720 jobs created on average through 2030, followed by Office and Administrative Support Occupations with 1,148 jobs.

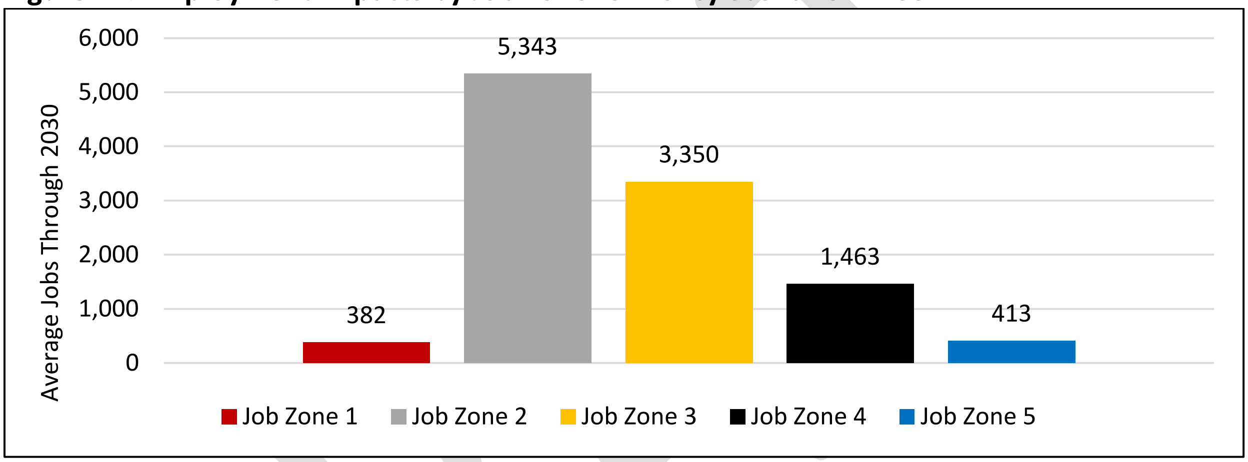
Figure 41: Employment Impacts by Occupation for Policy Scenario Three

SOC Code	SOC Description	Annual Average Number of Jobs, 2019-2030
11	Management Occupations	589
13	Business and Financial Operations Occupations	337
15	Computer and Mathematical Occupations	72
17	Architecture and Engineering Occupations	86
19	Life, Physical, and Social Science Occupations	3
21	Community and Social Service Occupations	171
23	Legal Occupations	29
25	Education, Training, and Library Occupations	564
27	Arts, Design, Entertainment, Sports, and Media Occupations	41
29	Healthcare Practitioners and Technical Occupations	201
31	Healthcare Support Occupations	136
33	Protective Service Occupations	134
35	Food Preparation and Serving Related Occupations	169
37	Building and Grounds Cleaning and Maintenance Occupations	141
39	Personal Care and Service Occupations	458
41	Sales and Related Occupations	779
43	Office and Administrative Support Occupations	1,148
45	Farming, Fishing, and Forestry Occupations	-39
47	Construction and Extraction Occupations	4,720
49	Installation, Maintenance, and Repair Occupations	721
51	Production Occupations	135
53	Transportation and Material Moving Occupations	354
Total		**10,950**

Sources: E3, MDE, REMI PI+, RESI, U.S. BLS
During this same period, Farming, Fishing, and Forestry occupations show the largest average annual declines of 39 jobs—the only major occupational group with an average negative impact. These 39 jobs being lost are largely due to the effect of the carbon fee on the farming industry. As described previously, these impacts are offset somewhat by investments in state forestry programs, as well as adaptation and resilience programs. Despite the offsets from these investments, the net effect in the broader industry are still negative, on average.

The employment impacts by job zone for Policy Scenario Three are similar in distribution to Policy Scenario Two, as illustrated in Figure 42.

Figure 42: Employment Impacts by Job Zone for Policy Scenario Three

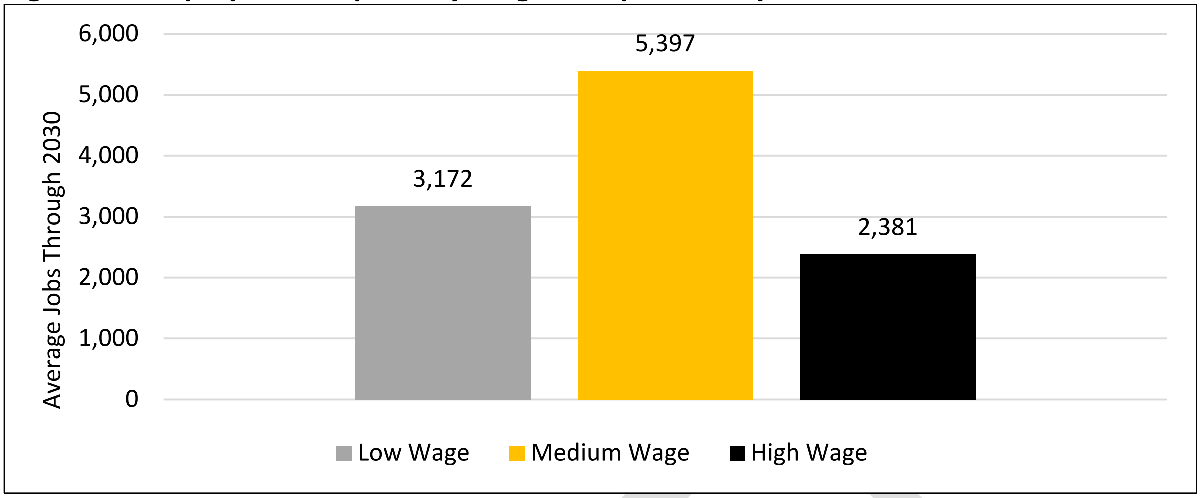


Sources: E3, MDE, O*Net, REMI PI+, RESI

Approximately 5,343 of the 10,950 jobs sustained in Policy Scenario Three will fall into Job Zone 2, which as previously described in Section 7.5.2, typically require a high school diploma or equivalent. The second- and third-highest increases are seen in Job Zones 3 and 4, respectively, which require increasing levels of preparation. On average, under Policy Scenario 3, no job zone is expected to have negative impacts through 2030.

Employment distributions for Policy Scenario Three by wage group are outlined in Figure 43 below.

Figure 43: Employment Impacts by Wage Group for Policy Scenario Three

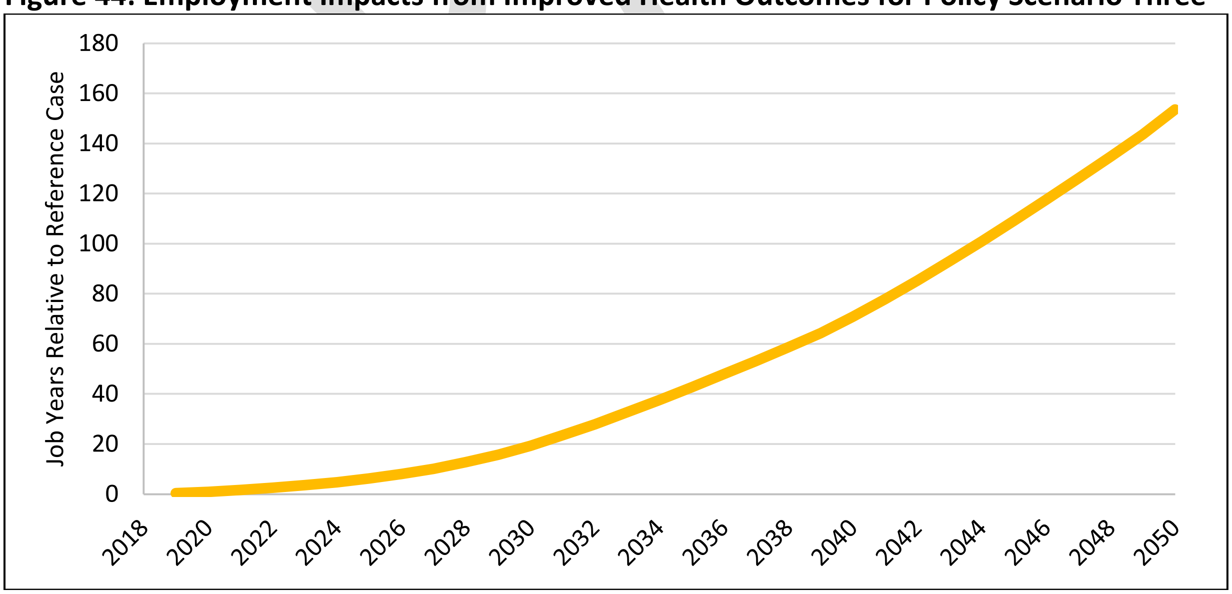


Sources: E3, MDE, REMI PI+, RESI, U.S. BLS

The distribution of the jobs supported by Policy Scenario Three are also similar to those in Policy Scenario Two, with roughly half the jobs being in medium-wage occupations. Contrary to the results in Policy Scenario One, more jobs will be supported in the low-wage group than in the high-wage group.

The effects of improved health outcomes on employment for Policy Scenario Three are illustrated in Figure 44.

Figure 44: Employment Impacts from Improved Health Outcomes for Policy Scenario Three



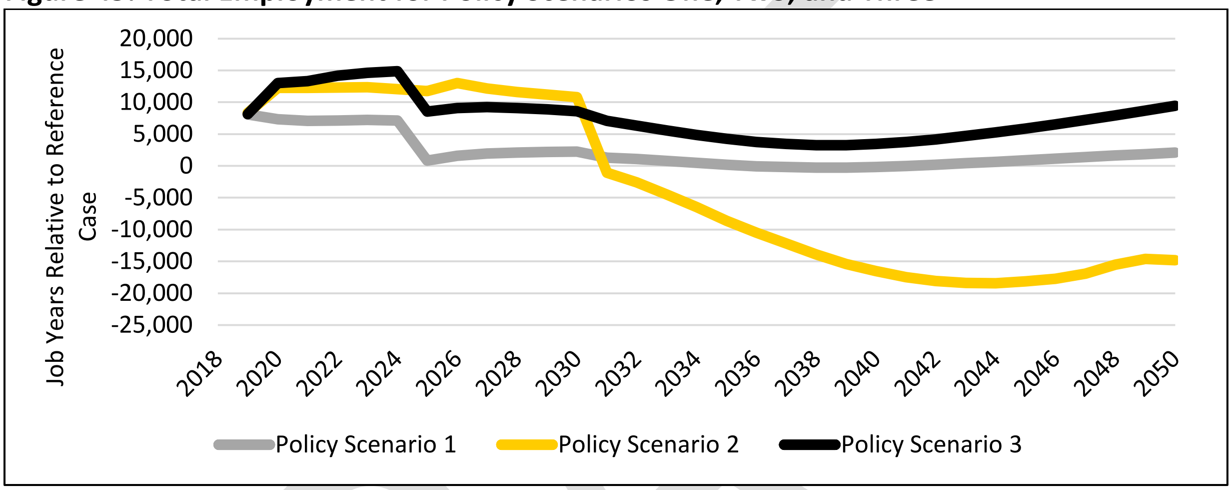
Sources: E3, MDE, MDOT, RESI, U.S. EPA

On average, between 2019 and 2030 Policy Scenario Three will sustain seven jobs. By 2050 this figure increases to nearly 53 jobs annually. The magnitudes of the employment impacts vary with the levels of emissions reductions. Thus, Policy Scenario One, which has the lowest emission reductions, supports the least amount of jobs while Policy Scenario Two, which aggressively targets emissions, supports the most. Policy Scenario Three falls in the middle of these two scenarios.

7.5.2.4 Comparison of Employment Levels Across Policy Scenarios

Overall, as illustrated in Figure 45, all three policy scenarios exhibit average positive job growth through 2030.

Figure 45: Total Employment for Policy Scenarios One, Two, and Three



Sources: REMI PI+, E3, MDE, MDOT, RESI

Policy Scenario Two produces the most jobs between 2019 and 2030, averaging 11,665 jobs while Policy Scenario One produces the least at 4,564 jobs. By 2050, these numbers are significantly lower across all policy scenarios, with Policy Scenario Two losing an average of 3,811 jobs between 2019 and 2050, but Policy Scenarios One and Three still maintaining positive job growth.

To summarize, these results are due to a number of aspects contained in each bundle of policies:

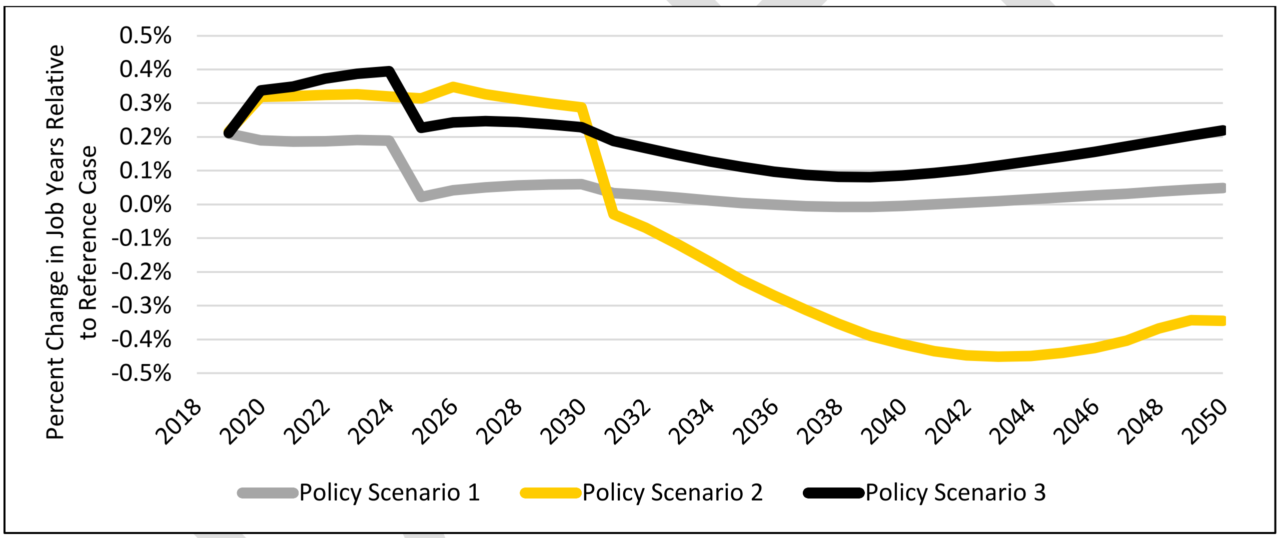
- **Transportation infrastructure spending**
  Policy Scenario Two, in particular, shows large near-term employment increases due to the I-495 and I-270 lane expansion projects. Both Policy Scenario One and Three begin the same, but the divergence in 2020 is due to the presence of the carbon fee as a funding source for infrastructure projects.
- **Carbon fee and dividend**
  The carbon fee plays a pivotal role in boosting employment numbers for Policy Scenario Three in the long run. The revenue from this fee is able to mitigate some of the negative effects of Policy Scenario One by providing rebates to consumers for increased energy prices, as well as the provision of funding for additional job-creating mitigation measures. The rationale behind this job-creating policy is that the fee acts as a filter—

redirecting funds that would have previously flowed out of state towards job creation activities within the state.

- **In-state wind and solar generation**
  Because Maryland is traditionally a net importer of energy, increasing the percentage of self-supplied energy enables money that would have been spent out of the state, to stay within the state.

Although the employment impacts displayed in Figure 45 appear large, they in fact represent a very small proportion of Maryland's total economy. As seen in Figure 46, employment impacts, both positive and negative, do not vary more than one percentage point beyond the levels forecast in the reference case. Even under Policy Scenario Two, which contains aggressive policies aimed at reducing carbon emissions in the state, employment is expected to decline by less than 0.5 percent at its most extreme point. Given the scale of the spending occurring under each policy as described in Section 7.5.1, employment impacts are relatively muted.

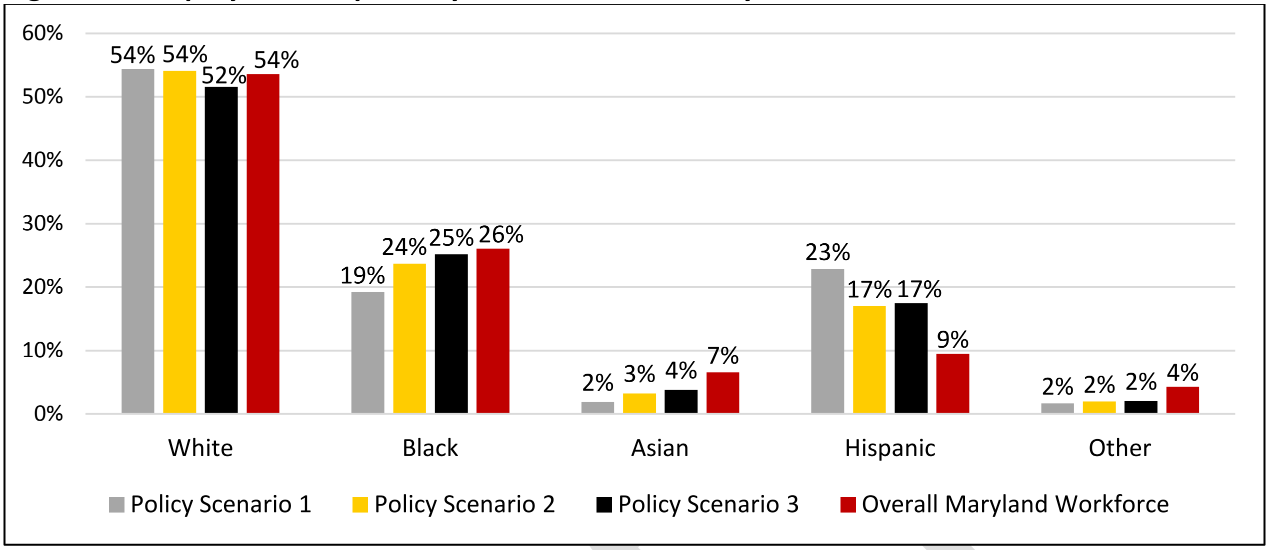
Figure 46: Percent Change in Employment Under Policy Scenarios One, Two, and Three Relative to the Reference Case



Sources: E3, MDE, REMI PI+, RESI

In addition to considering distribution of jobs across regions of the state, education and training requirements, and wage levels, the Project Team also considered the potential racial and ethnic distributions of jobs under each policy scenario. Estimated distributions are calculated using existing racial and ethnic composition by occupation as sourced from U.S. Census data. However, it should be stressed that these estimates, as presented below in Figure 47, are based off of current trends in the racial composition of Maryland's workforce. They are intended only to serve as a guide to see whether job gains will be in occupations that have traditionally experienced higher levels of segregation, or if job gains are more equitable.

Figure 47: Employment Impacts by Race Across All Policy Scenarios



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

As seen in Figure 47, Policy Scenario Two and Policy Scenario Three generally represent the most racially equitable scenarios, meaning employment shares in these scenarios are most similar to the distribution of jobs in Maryland's workforce overall. In Policy Scenario Three, jobs are projected to go to workers that are 52 percent White, 24 percent Black, 4 percent Asian, and 2 percent Other. Those of Hispanic origin account for 17 percent of the supported jobs. It is worth reiterating that this is only a forecast based on current trends in the racial composition of the workforce.

7.5.3 Personal Income

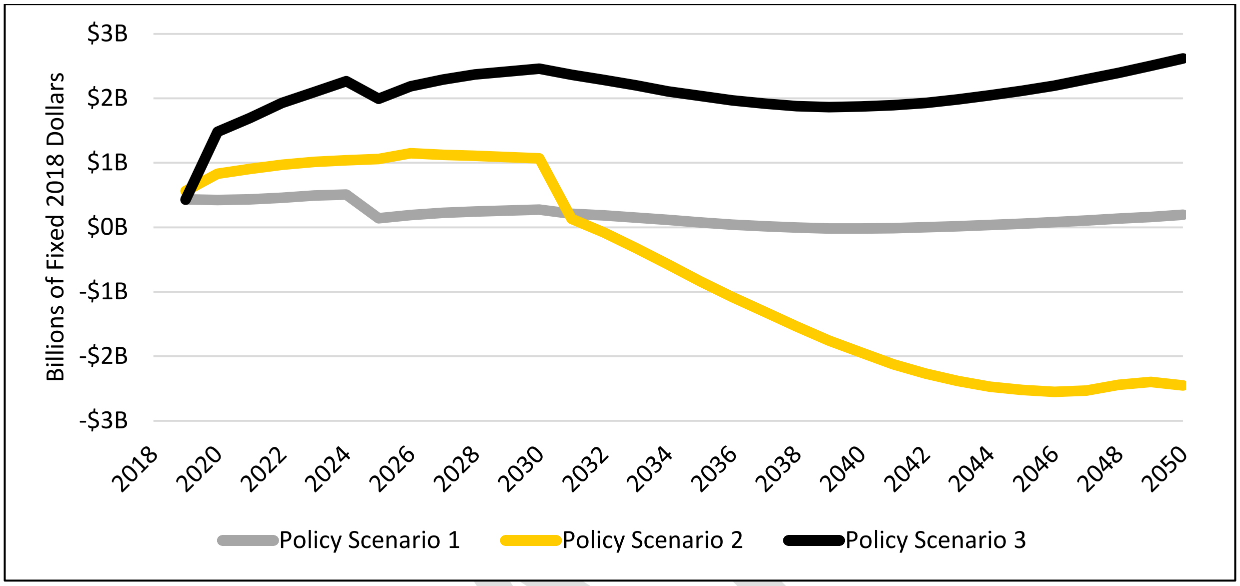
In addition to employment, it is also important to consider how personal income will be affected. Personal income within REMI is calculated as the sum of the total wages and salaries, supplements to these wages and salaries, property income, and personal current transfer receipts. Of these, wages and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

Relative to the reference case, changes to personal income remain positive through 2030 across all three scenarios. Policy Scenario Three posts the largest increases, averaging $2.0 billion between 2019 and 2030, while Policy Scenario One shows the smallest gains at $0.3 billion.[41] As illustrated in Figure 48, the trends over time vary considerably by policy scenario. Because Policy Scenario One is generally a continuation of current policies, it is expected that very little change from the reference case would be observed. Policy Scenario Three, while exhibiting a similar temporal distribution, is boosted largely due to the household rebates from the carbon fee revenue. Policy Scenario Two shows a large decrease after 2030, due to a

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

combination of the expiration of MDOT transportation projects as well as the increased expenditures on capital relative to fuel savings.

Figure 48: Personal Income in Policy Scenario One, Policy Scenario Two, and Policy Scenario Three Relative to the Reference Case



Source: E3, MDE, REMI PI+, RESI

Total wages and salaries, the largest components of personal income, are expected to rise across all three policy scenarios. In Policy Scenario Two and Policy Scenario Three, total wages and salaries rise by an average of 0.3 percent per year through 2030, compared to a 0.1 percent increase under Policy Scenario One.

7.5.4 Gross State Product (GSP)

The Project Team considered impacts to Maryland's economy across all three policy scenarios. These impacts are measured in terms of changes to Maryland's gross state product (GSP), which totaled nearly $400 billion dollars in 2017.[42] GSP is the sum of consumption, investment, government expenditures, and net exports for the state. 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 present value, a common way of comparing the return on investment when looking at the financial viability of multiple projects or policies. For this analysis, the Project Team used a discount rate of 3 percent.

Figure 49: Cumulative Net Present Value

	Policy Scenario One	Policy Scenario Two	Policy Scenario Three
2030	$5,938,647,263	$10,180,593,369	$7,213,211,643
2050	$8,205,244,837	-$7,666,122,560	$964,374,703

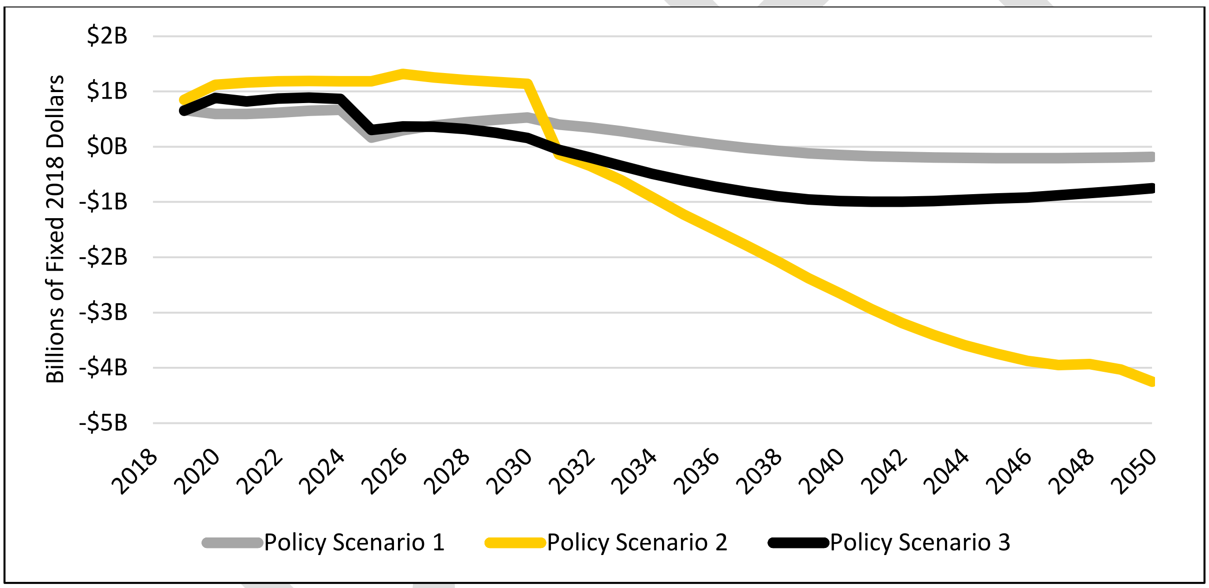
[42] "Total Gross Domestic Product for Maryland (MDNGSP)," FRED Federal Reserve Bank of St. Louis, last modified November 19, 2018, accessed February 14, 2019, https://fred.stlouisfed.org/series/MDNGSP.

Sources: E3, MDE, REMI, RESI

Across all three policy scenarios, contributions to GSP remain positive through 2030.[43] Policy Scenario Two shows the largest gains, adding an additional $10.2 billion to the state's GSP, while Policy Scenario One sees the smallest gains at $5.9 billion. Policy Scenario Three sees an increase of $7.2 billion. The large increases seen for Policy Scenario Two are due to near-term spending on transportation infrastructure projects as well as additional mitigation measures. Policy Scenario One, on the other hand, is largely a continuation of current policies, so smaller increases to the GSP should be expected. While Policy Scenario Three begins the same as Policy Scenario One, the divergence seen is due to the additional mitigation measures and household rebates funded by the carbon revenues.

Figure 50 below details changes to Maryland's GSP under the three policy scenarios through 2050.

Figure 50: Gross State Product in Policy Scenarios One, Two, and Three Relative to the Reference Case



Sources: E3, MDE, REMI PI+, RESI

While changes to Maryland's GSP are forecasted to be positive through 2030, this trend is not expected to continue through 2050. The large declines seen after 2030 for Policy Scenario Two reflect decreased exogenous final demand in the Utilities and Petroleum and Coal Products Manufacturing industries.

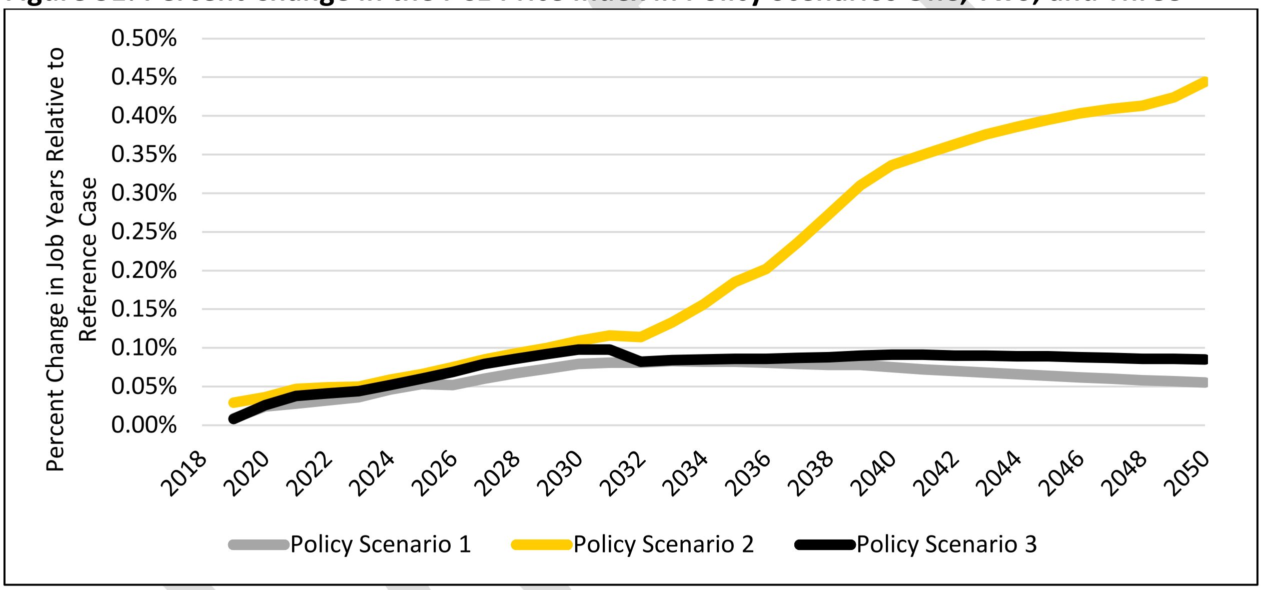
[43] Figures represent scenarios that include MDOT project spending.

7.5.5 Consumer Prices

The Project Team also considered how the policy scenarios could impact 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 51, Policy Scenarios One through Three show similar price increases through 2030, ranging from 0.05 percent to 0.08 percent, relative to the reference case through 2030.[44] After 2030, Policy Scenario One and Three plateau, rising by 0.06 percent and 0.12 percent, respectively, between 2019 and 2050. Policy Scenario Two sees a larger increase, averaging a 0.21 percent increase through 2050.

Figure 51: Percent Change in the PCE Price Index in Policy Scenarios One, Two, and Three

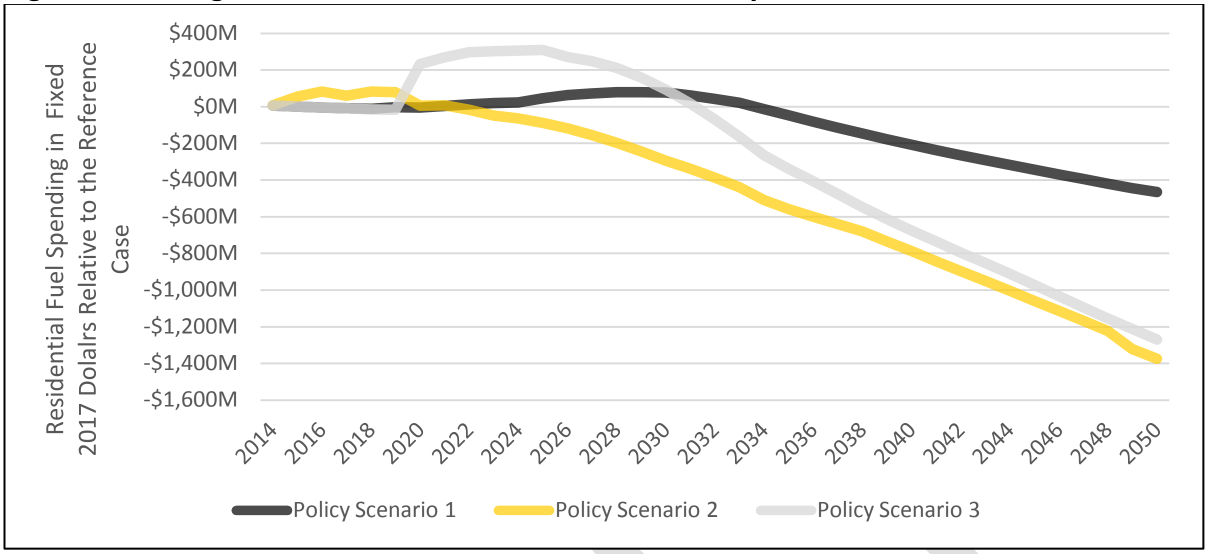


Sources: E3, MDE, REMI PI+, RESI

In addition to considering the impacts on overall prices to consumers resulting from the policy scenarios, the Project Team considered how the policy scenarios could affect the total cost of fuel for residential customers. A number of policies in each scenario will affect the price and consumption of various fuels, leading to changes in total costs. Figure 52 details the projected change in residential fuel costs until 2050 for Policy Scenarios One, Two, and Three.

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

Figure 52: Change in Total Residential Fuel Costs in Policy Scenarios One, Two, and Three



Source: E3, MDE, REMI PI+, RESI

In 2030, residential spending on non-transportation utilities is lower than in the reference case only in Policy Scenario Two. However, by 2050, residential spending is lower than the reference case for all scenarios. In all scenarios, spending on electricity increases, due to the increased cost of generation as well as increased usage of electricity instead of other fuels. Usage of electricity increases as consumers convert to using more energy efficient appliances. In Policy Scenario Three, increased fuel costs, especially between 2020 and 2030, are primarily due to carbon pricing, which raises the price of all fuel types. However, under this policy, almost fifty percent of all revenue raised by the carbon pricing is returned to consumers in the form of rebate, resulting in a mitigation of costs that is not captured by the chart.

7.6 Policy Scenario Four

After the emissions and economic impacts associated with Policy Scenario One, Policy Scenario Two, and Policy Scenario Three were estimated and analyzed, Policy Scenario Four 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. Policy Scenario Four uses Policy Scenario One, discussed in Section 7.4.1, as its foundation. Policy Scenario One represents a collection of policies that are either a continuation or extension of current programs. In addition to these measures, Policy Scenario Four consists of new programs explored in Policy Scenario Two, as discussed in Section 7.4.2. For example, as in Policy Scenario Two, Policy Scenario Four includes a 75 percent Clean and Renewable Energy Standards (CARES) goal by 2040 instead of the renewable portfolio standard (RPS) modeled in Policy Scenario One.[45] Other policies modeled similarly to Policy Scenario Two include bus electrification, transportation programs, and forest management and healthy soils initiatives.

[45] However, the CARES program modeled in Policy Scenario Four contains different carveouts than the CARES program modeled in Policy Scenario Two. In Policy Scenario Two, carveouts include 12.5 percent for in-state solar,

7.6.1 Policy Scenario Four Results

Similar to Policy Scenario One, Policy Scenario Two, and Policy Scenario Three, Policy Scenario Four meets the economic goals outlined in Section 7.3.7. As shown in Figure 53, all four policy scenarios achieve the 2030 economic goals and three policy scenarios meet both the 2020 and 2030 emissions targets as well.

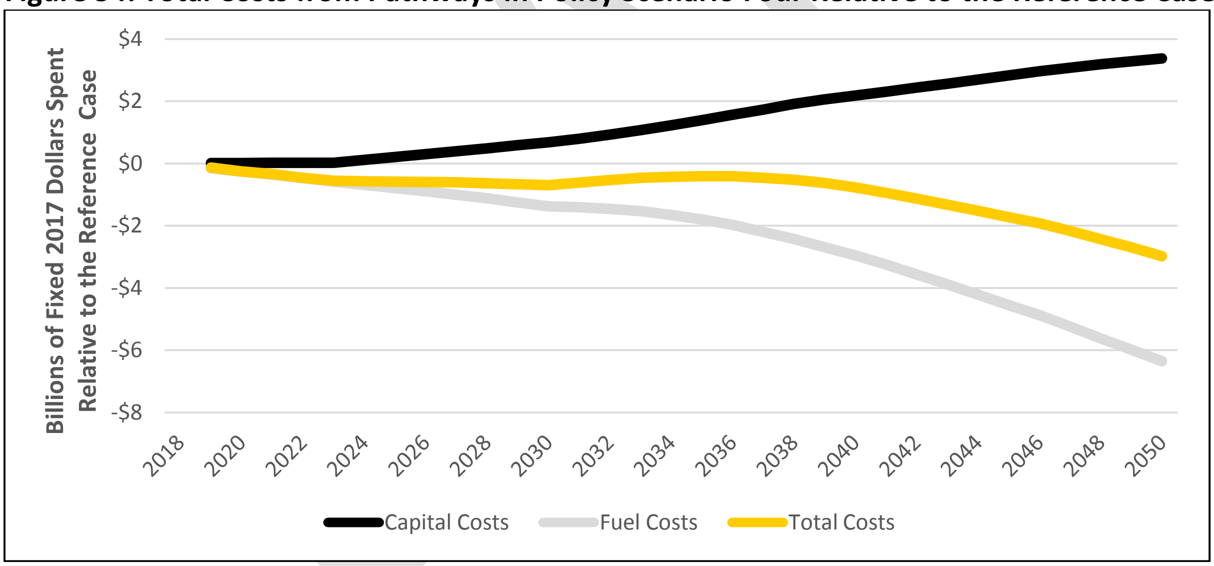
Figure 53: Summary of Policy Scenarios

Policy Scenario	Achieve 2020 Emissions Goal?	Achieve 2030 Emissions Goal?	Achieve 2030 Economic Goal?
Policy Scenario One	Yes	No	Yes
Policy Scenario Two	Yes	Yes	Yes
Policy Scenario Three	Yes	Yes	Yes
Policy Scenario Four	Yes	Yes	Yes

Source: RESI

Notably, Policy Scenario Four achieves these goals with low levels of spending. As illustrated in Figure 54, in every year in Policy Scenario Four, consumers and businesses spend less on capital costs and fuel costs relative to the reference case.

Figure 54: Total Costs from Pathways in Policy Scenario Four Relative to the Reference Case



Sources: E3, MDE, RESI

As seen in Figure 54, although consumers and businesses are spending more on capital costs (e.g., new energy-efficient appliances or new electric vehicles) in Policy Scenario Four than in the reference case, fuel savings exceed this amount every year. This is in contrast to the other policy scenarios as discussed in Section 7.5.1. This result is attributable to two general trends:

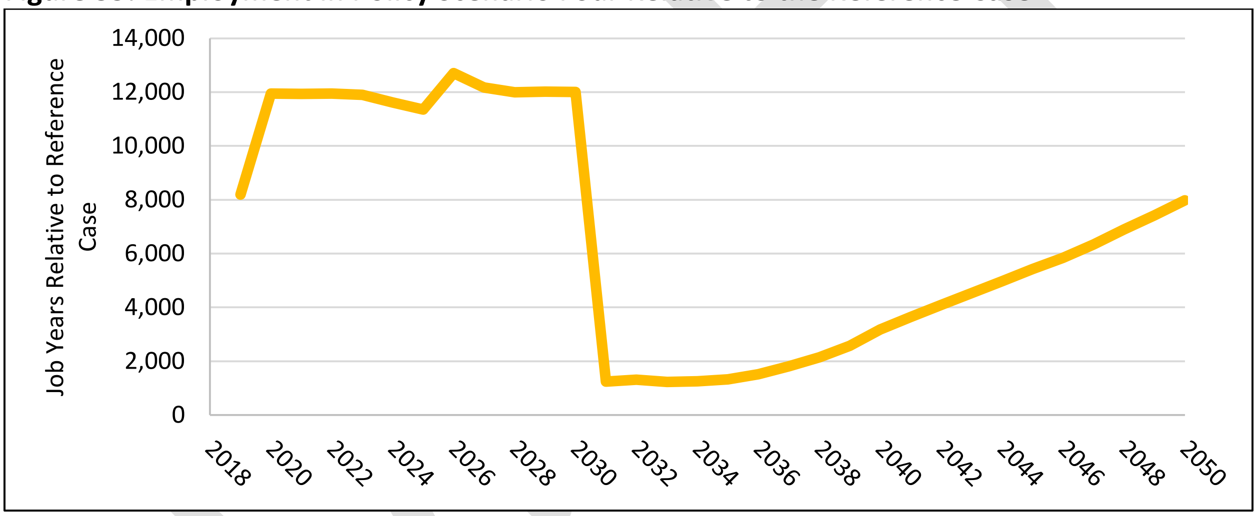
12.5 percent for offshore wind, and 25 percent for tier one renewables. In Policy Scenario Four, the carveouts include 15 percent for in-state solar, 10 percent for offshore wind, and 20 percent for tier one renewables.

- Spending on transportation infrastructure projects is high in Policy Scenario Four. These projects are generally due to policies aimed at reducing fuel usage through behavioral changes (e.g., increased mass transit usage or increased use of bike lanes) as well as more direct capital outlays (e.g., truck stop electrification or bus electrification). The level of spending on these projects is the highest in Policy Scenario Four, and is equal to the level in Policy Scenario Two.
- Capital costs are generally low. Through 2025, capital costs in Policy Scenario Four are equal to those in Policy Scenario One, the scenario with the lowest spending on capital costs. Although capital expenditures after 2025 are higher than in Policy Scenario One, they never approach those in Policy Scenario Two or Policy Scenario Three.

7.6.1.1 Employment in Policy Scenario Four

The impacts of infrastructure spending and capital costs can both be seen when examining the economic impacts of Policy Scenario Four. As seen in Figure 55, Policy Scenario Four supports an average of 11,649 jobs each year through 2030 relative to the reference case.

Figure 55: Employment in Policy Scenario Four Relative to the Reference Case

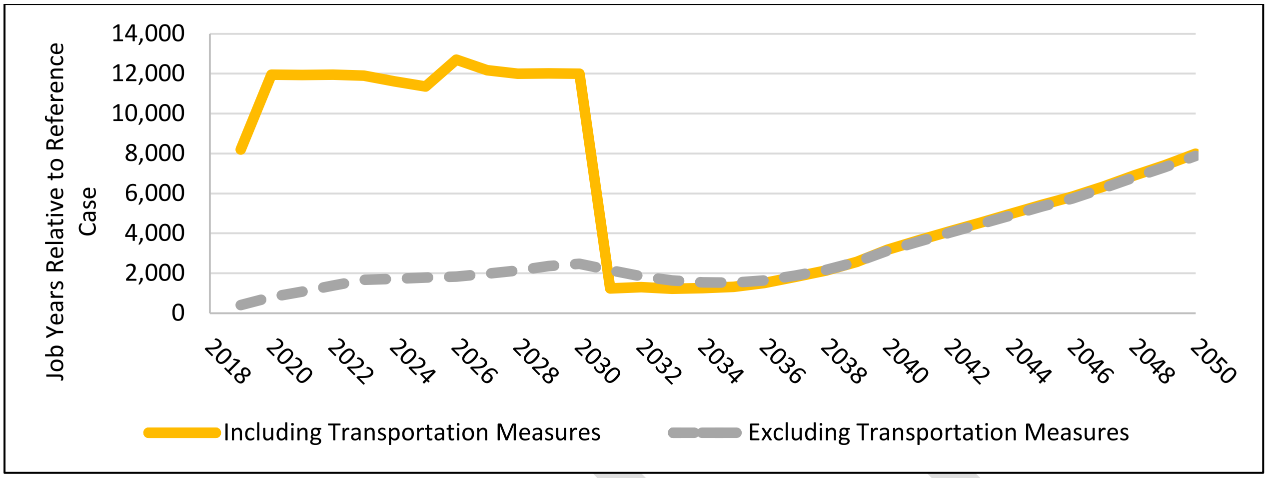


Sources: E3, MDE, REMI PI+, RESI

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. The steady increase in employment after 2030 is due in part to the relatively low capital costs seen in Policy Scenario Four. Because spending on capital is lower, consumers have more money to spend on other goods and services, and businesses are more profitable. These positive impacts, coupled with reductions in spending on fuel, result in a slow albeit steady increase in jobs supported relative to the reference case.

To visualize the impact of spending on transportation infrastructure on the economic impact results for Policy Scenario Four, Figure 56 below shows employment differences in Policy Scenario Four with and without this spending.

Figure 56: Employment in Policy Scenario Four With and Without Transportation Spending Relative to the Reference Case

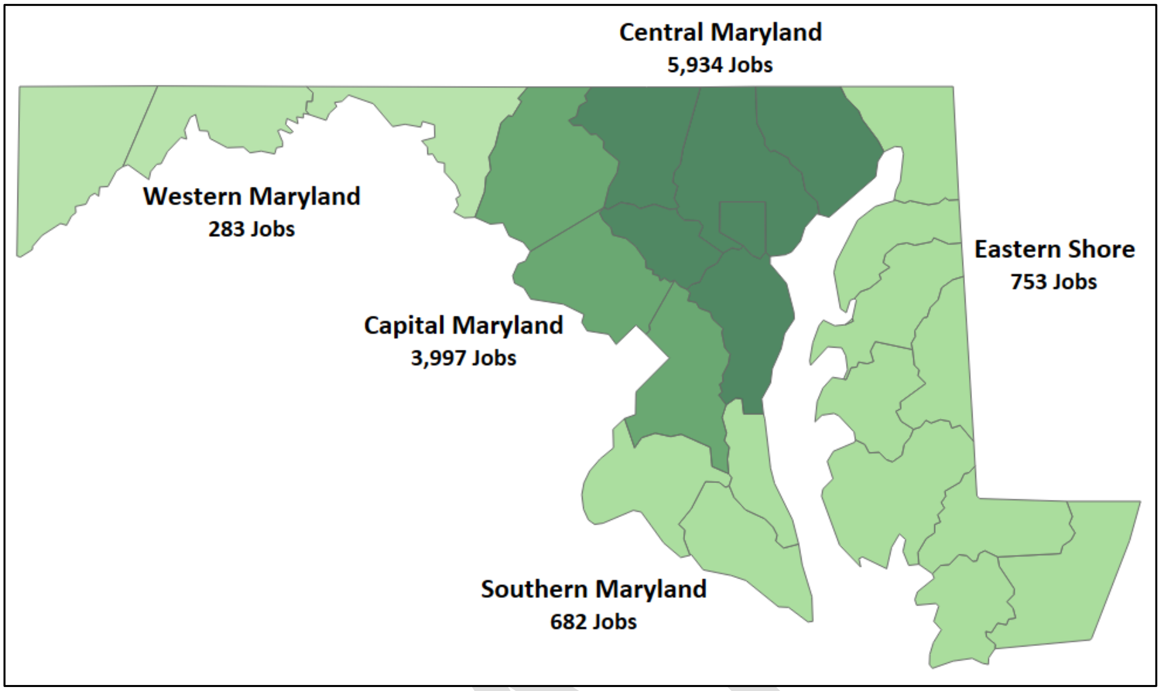


Sources: E3, MDE, REMI PI+, RESI

The impact of transportation spending in Policy Scenario Four is similar to the impacts in the other three policy scenarios. On average through 2030, transportation infrastructure measures support 10,013 more jobs compared to the scenario without this spending. This is illustrated above as the difference between the two lines. Regardless of the status of the transportation spending, however, employment impacts are steadily positive for Policy Scenario Four.

As shown in Figure 57, all regions of Maryland experience positive job growth relative to the reference case through 2030 for Policy Scenario Four.

Figure 57: Employment Impacts by Region for Policy Scenario Four



Sources: E3, MDE, REMI PI+, RESI

Following a similar pattern as with the other policy scenarios, Central Maryland sustains the largest employment gains of 5,934 jobs. The Capital Maryland region also shows significant employment increases of 3,997 jobs. However, as with other policy scenarios, these large gains are primarily due to the large workforce already existing within the regions. When considered in terms of percentage changes, job gains are similarly modest, ranging between a 0.2 percent in Western Maryland to a 0.4 percent increase in Southern Maryland.

Figure 58 below details employment impacts under Policy Scenario Four through 2030 by industry. Of the annual average of 11,649 jobs, the Construction industry comprises 8,456 positions, or nearly 73 percent, and is driven largely by spending on transportation infrastructure policies during this period.

Figure 58: Employment Impacts by Industry for Policy Scenario Four, 2019 Through 2030

NAICS	Industry	Annual Average Number of Jobs, 2019-2030
11	Agriculture, Forestry, Fishing and Hunting	131
21	Mining, Quarrying, and Oil and Gas Extraction	-27
22	Utilities	173
23	Construction	8,456
31-33	Manufacturing	126
42	Wholesale Trade	84
44-45	Retail Trade	-169
48-49	Transportation and Warehousing	99
51	Information	27
52	Finance and Insurance	107
53	Real Estate and Rental and Leasing	162
54	Professional, Scientific, and Technical Services	311
55	Management of Companies and Enterprises	21
56	Administrative and Support and Waste Management and Remediation Services	216
61	Educational Services	63
62	Health Care and Social Assistance	573
71	Arts, Entertainment, and Recreation	45
72	Accommodation and Food Services	303
81	Other Services (except Public Administration)	279
92	Public Administration	671
Total		**11,649**

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

Under Policy Scenario Four, the Public Administration industry and Health Care and Social Assistance industry have the second- and third-highest gains of 671 and 573 jobs, respectively. Moderate employment increases are also estimated in Professional, Scientific, and Technical Services (311 jobs), Accommodation and Food Services (303 jobs), and Other Services (279 jobs). Employment decreases are seen in two industries; Retail Trade falls by 169 positions annually, while Mining, Quarrying, and Oil and Gas Extraction declines by an average of 27 positions.

No major occupational group is expected to have an annual decline under Policy Scenario Four, as shown in Figure 59 below. Once again, the greatest impacts are seen in Construction and Extraction Occupations, with an increase of 5,337 jobs estimated annually through 2030.

Figure 59: Employment Impacts by Occupation for Policy Scenario Four

SOC	SOC Description	Average Jobs

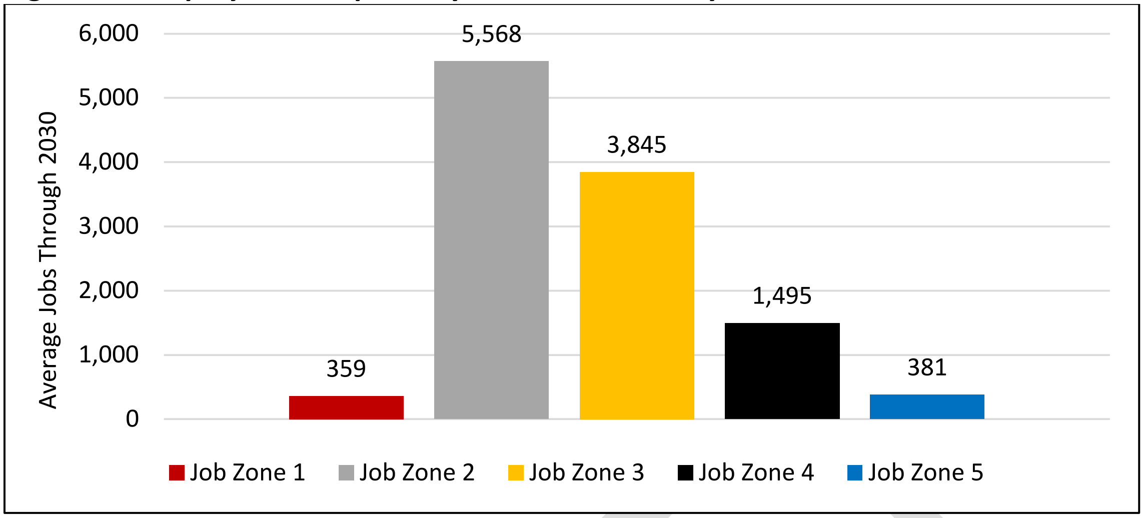
Code		Through 2030
11	Management Occupations	700
13	Business and Financial Operations Occupations	461
15	Computer and Mathematical Occupations	121
17	Architecture and Engineering Occupations	164
19	Life, Physical, and Social Science Occupations	33
21	Community and Social Service Occupations	66
23	Legal Occupations	36
25	Education, Training, and Library Occupations	292
27	Arts, Design, Entertainment, Sports, and Media Occupations	51
29	Healthcare Practitioners and Technical Occupations	221
31	Healthcare Support Occupations	128
33	Protective Service Occupations	105
35	Food Preparation and Serving Related Occupations	291
37	Building and Grounds Cleaning and Maintenance Occupations	187
39	Personal Care and Service Occupations	229
41	Sales and Related Occupations	233
43	Office and Administrative Support Occupations	1,215
45	Farming, Fishing, and Forestry Occupations	76
47	Construction and Extraction Occupations	5,337
49	Installation, Maintenance, and Repair Occupations	934
51	Production Occupations	289
53	Transportation and Material Moving Occupations	479
Total		**11,649**

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

Office and Administrative Support Occupations have the second-highest growth at 1,215 positions annually, followed by Installation, Maintenance, and Repair Occupations with 934 jobs. Significant gains are also seen in Management Occupations (700 jobs), Transportation and Material Moving Occupations (479 jobs), and Business and Financial Operations Occupations (461 jobs). Life, Physical, and Social Science Occupations and Legal Occupations have the lowest levels of growth at 33 and 36 jobs, respectively. Similar to findings in Policy Scenario Two, gains made in Life, Physical, and Social Science Occupations due to renewable energy generation are likely diminished by losses within the Chemical Manufacturing and Oil and Gas Extraction industries, resulting in a low net positive effect.

The estimated employment effects by job zone under Policy Scenario Four are shown in Figure 60. As illustrated below, the plurality of occupational growth occurs in in Job Zone 2, and represents nearly half of the jobs gained annually.

Figure 60: Employment Impacts by Job Zone for Policy Scenario Four

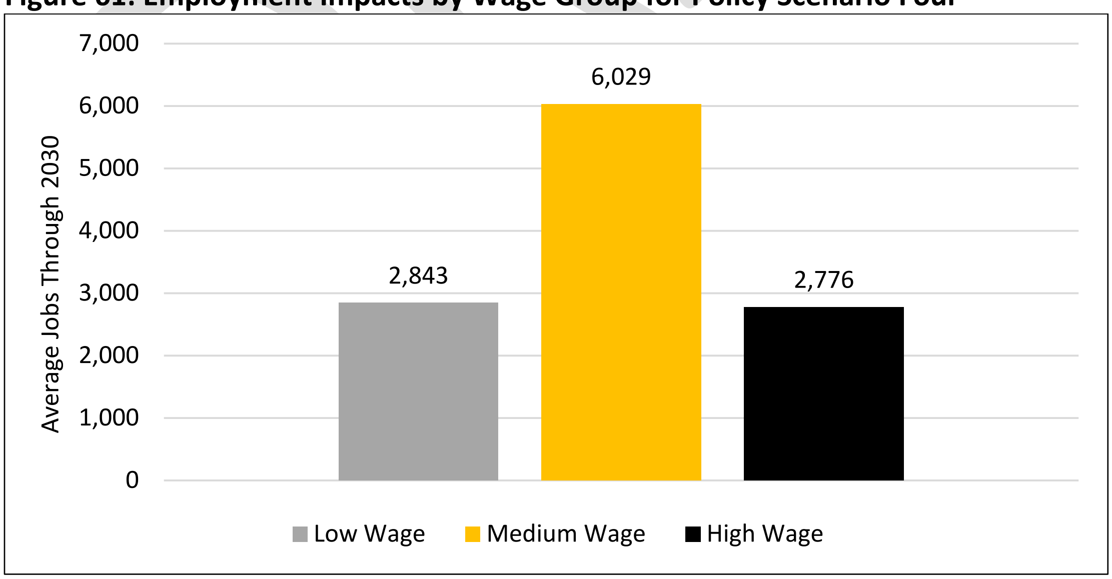


Sources: E3, MDE, O*Net, REMI PI+, RESI

The distribution of employment by job zone in Policy Scenario Four closely resembles that of Policy Scenarios Two and Three, 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 Policy Scenario Four, with the smallest annual increases represented in Job Zone 1.

Employment distribution by wage groups for Policy Scenario Four are shown in Figure 61 below.

Figure 61: Employment Impacts by Wage Group for Policy Scenario Four

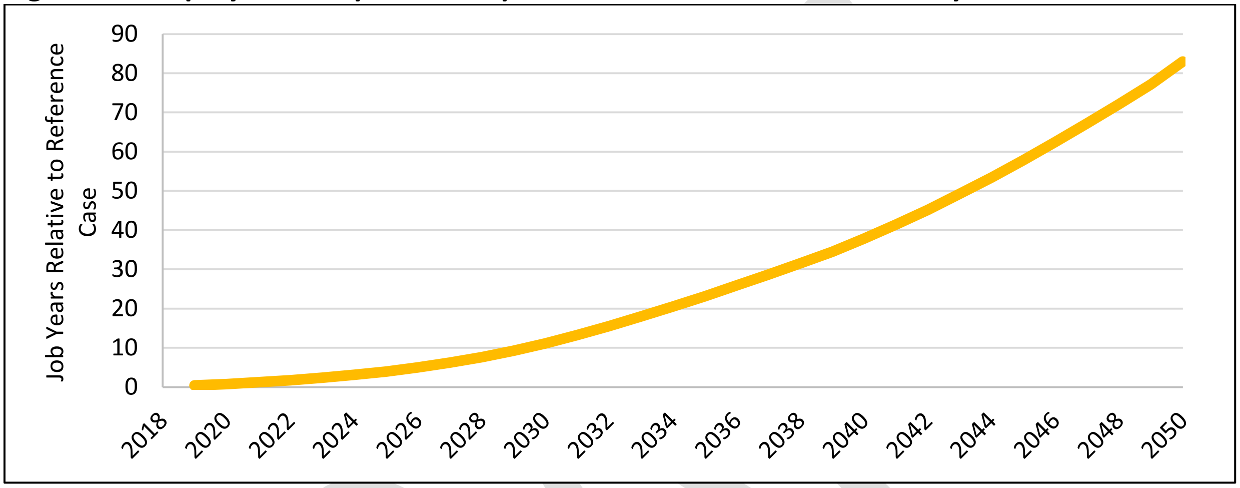


Sources: E3, MDE, REMI PI+, RESI, U.S. BLS

Over half of the employment impacts under Policy Scenario Four, 6,029 jobs, are found in medium-wage occupations earning between $35,000 and $65,000 annually. A slightly higher number of positions are found in low-wage jobs than high-wage jobs, though the difference between the two groups is less than 100 positions annually.

Figure 62 shows the employment impacts that result specifically from improved health outcomes in Policy Scenario Four.

Figure 62: Employment Impacts of Improved Health Outcomes for Policy Scenario Four



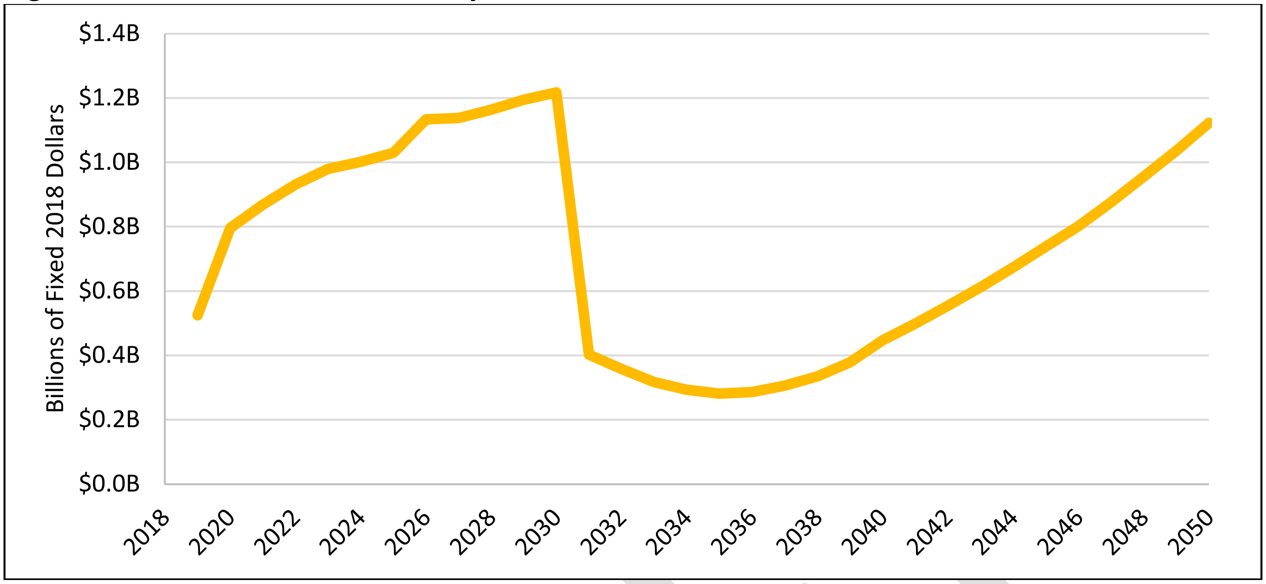
Sources: E3, MDE, MDOT, RESI, U.S. EPA

Between 2019 and 2030, improved health outcomes from Policy Scenario Four will support an average of four jobs annually. This average increases to 28 jobs when extended to 2050. Detailed results for health impacts are found in Appendix C.5.

7.6.1.2 Personal Income in Policy Scenario Four

As previously noted, personal income within REMI PI+ is calculated as the sum of total wages and salaries, supplements to these wages and salaries, property income, and personal current transfer receipts. Figure 63 below shows changes in personal income levels under Policy Scenario Four, which remain positive through 2030.

Figure 63: Personal Income in Policy Scenario Four Relative to the Reference Case



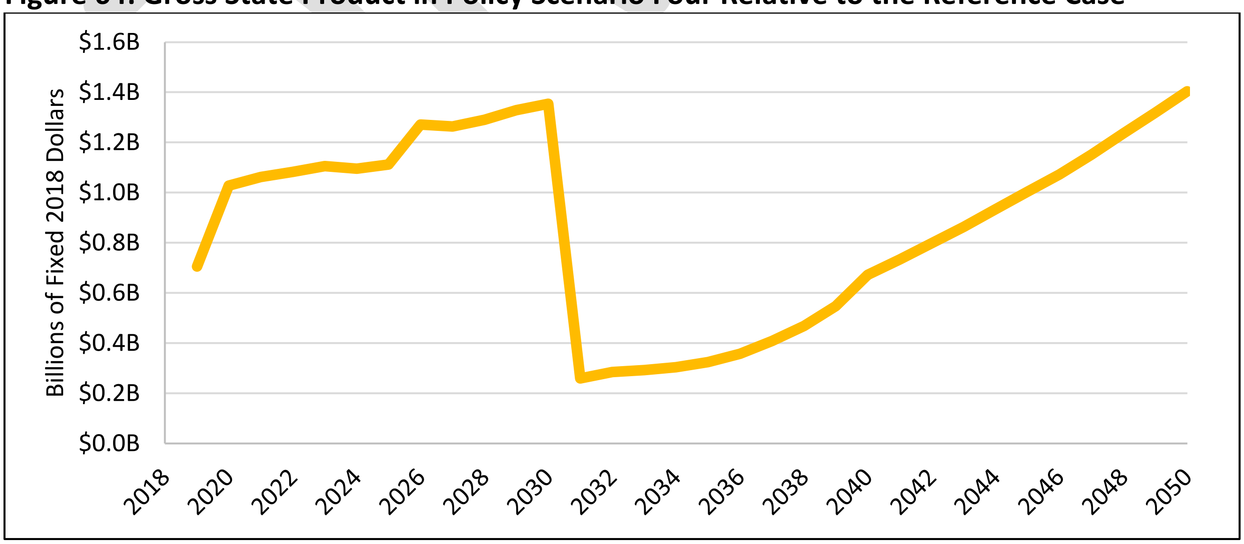
Sources: E3, MDE, REMI PI+, RESI

Personal income is expected to rise under Policy Scenario Four. Between 2019 and 2030, personal income exceeds the reference scenario by an average of $1.0 billion. A significant portion of this increase is due to spending on transportation infrastructure projects.

7.6.1.3 Gross State Product in Policy Scenario Four

Gross state product (GSP) is the sum of consumption, investment, government spending, and net exports out of the state in a given year. Figure 64 shows the expected changes to Maryland's GSP under Policy Scenario Four, presented in billions of fixed 2018 dollars.

Figure 64: Gross State Product in Policy Scenario Four Relative to the Reference Case



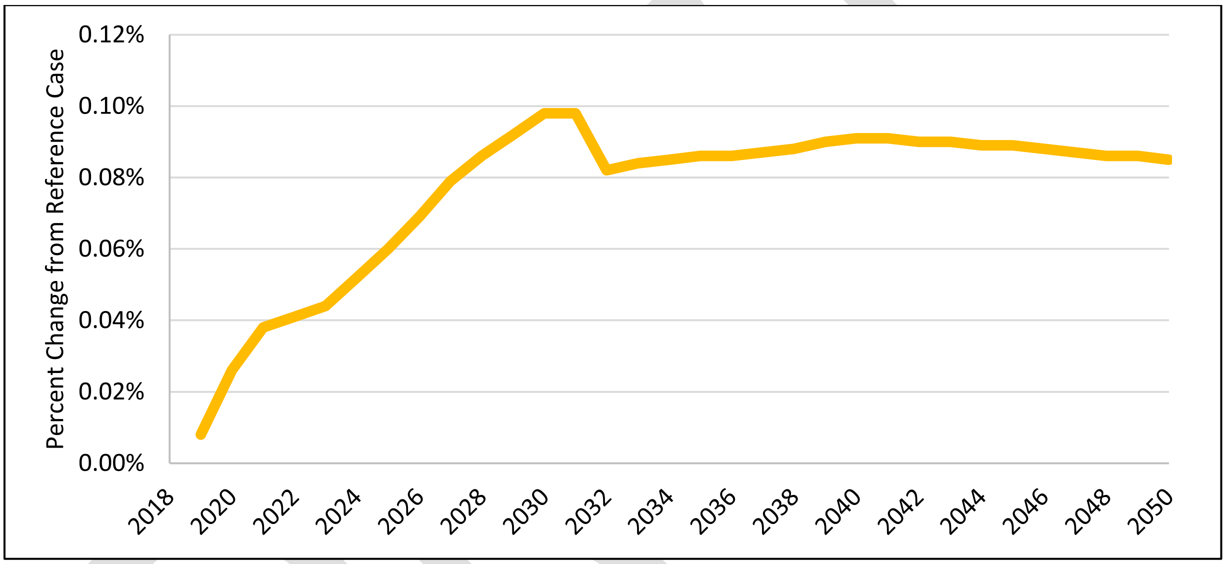
Sources: E3, MDE, REMI PI+, RESI

Under Policy Scenario Four, Maryland's GSP is forecasted to increase relative to the reference case in every year between 2019 and 2050. The change remains positive even after transportation infrastructure spending ends in 2030.

7.6.1.4 Consumer Prices in Policy Scenario Four

Consumer prices are only expected to rise modestly under Policy Scenario Four. As illustrated in Figure 65, on average--between 2019 and 2030--prices will rise 0.06 percent per year relative to the reference case. Through 2050, prices will rise 0.08 percent relative to the reference case. This implies that a good or service that costs $1.00 in 2019 will cost less than one additional penny per year above inflation through both 2030 and 2050.

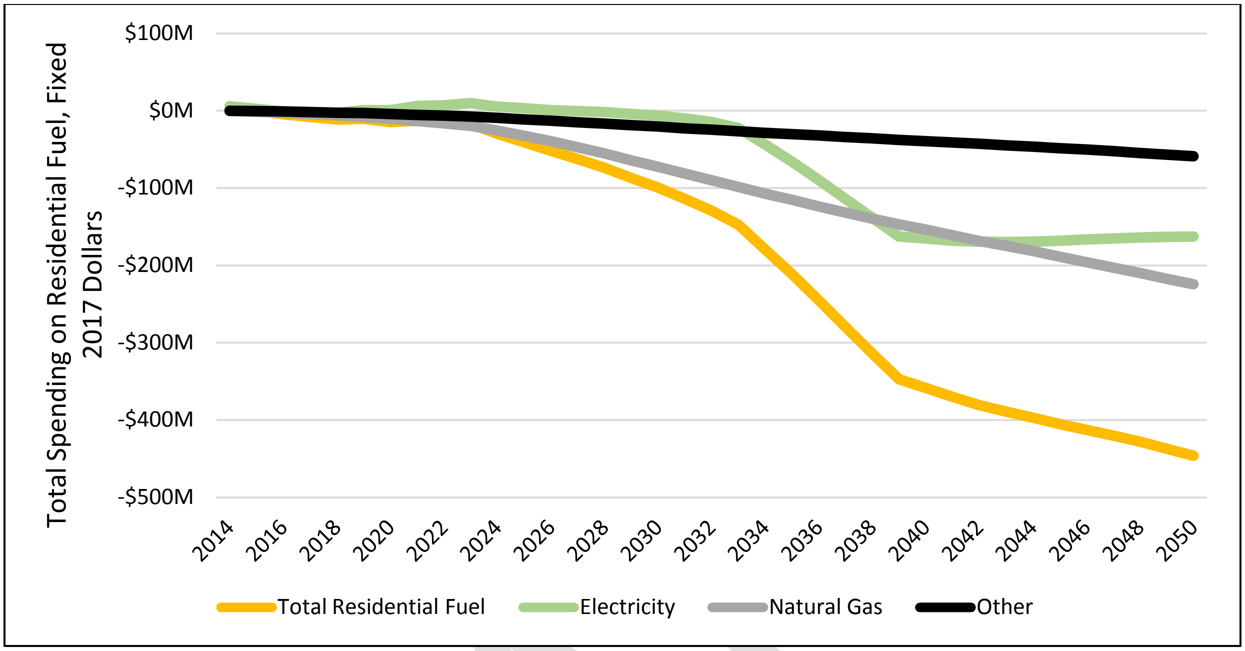
Figure 65: Percent Change in Consumer Prices In Policy Scenario Four Relative to the Reference Case



Sources: E3, MDE, REMI PI+, RESI

When considering policies to reduce greenhouse gas emissions, one of the most relevant spending categories for consumers is utilities. Figure 66 shows residential non-transportation fuel spending in Policy Scenario Four.

Figure 66: Total Residential Spending on Non-Transportation Fuel By Fuel Type in Policy Scenario Four, Relative to the Reference Case



Sources: E3, MDE, RESI

As seen in Figure 66, total non-transportation fuel spending declines over time. Before 2028, consumers generally spend slightly more for electricity, as consumers substitute from using natural gas and other fuels. However, this increase in spending is not enough to counteract the savings consumers experience. After 2028, policies designed to increase energy efficiency lead to consumers spending less on electricity relative to the reference case, even as they substitute away from other fuels into electricity.

7.6.2 Sensitivity Analyses

Any modeling of future policies involves uncertainty. A number of factors, including consumer adoption, changes in federal policy, and state or regional program shifts can greatly impact the policies considered in Policy Scenario Four. Given that Policy Scenario Four meets the emissions and economic goals, the Project Team modeled various sensitivities to understand the robustness of these results. In total, the Project Team modeled five different sensitivities:

1. A decrease in future renewable energy credit (REC) prices. This sensitivity does not impact overall emissions levels, and therefore is not captured in the chapter on emissions modeling.
2. A rollback of the federal level Corporate Average Fuel Economy (CAFE) program. Removing the CAFE standards for fuel efficiency means an increase in emissions from vehicles and less pressure for consumers to purchase zero emissions vehicles.
3. Reduced consumer adoption of energy efficient appliances and zero emission vehicles. Under this sensitivity, consumer purchases of efficient appliances and zero emission

vehicles are 50 percent lower than originally modeled, leading to increased emissions, reduced capital costs, and reduced fuel savings.
4. A sensitivity analysis combining the rollback of the CAFE standards with the reduced consumer adoption sensitivity.
5. A non-renewal of the Calvert Cliffs Nuclear Power Plant. This sensitivity, while considered in the emissions modeling, was not considered in the economic modeling.

A summary of the four sensitivities modeled are presented below in Figure 67.

Figure 67: Summary of Sensitivity Analyses

Sensitivity	Achieve 2020 Emissions Goal?	Achieve 2030 Emissions Goal?	Achieve 2030 Economic Goal?
REC Price	Yes	Yes	Yes
Low CAFE	Yes	Yes	Yes
Low Adoption	Yes	Yes	Yes
Low CAFE and Adoption	Yes	Yes	Yes

Sources: E3, MDE, REMI PI+, RESI

The difference in employment between the sensitivity results in this section and Policy Scenario Four should not be interpreted as the economic impact to Maryland of the policy in question. The economic modeling is done by considering all policies together. If one policy is removed, the change in economic impacts should only be interpreted relative to the original bundle, in this case Policy Scenario Four. Were the same sensitivity to be applied to the reference case, the economic impacts would be different, because the economic modeling is dynamic and captures the interactions between policies.

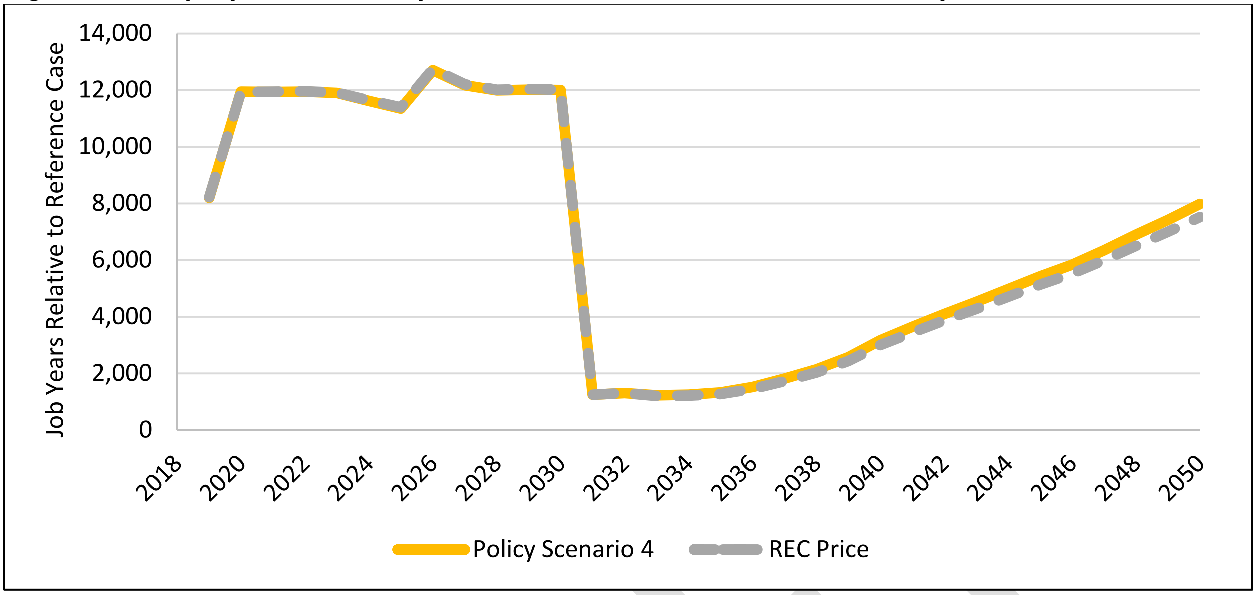
Sensitivity 1: Decrease in Future Renewable Energy Credits (REC) Prices

The first sensitivity analyzed involved the altering of the price of renewable energy credits (RECs). For the reference case and Policy Scenario One, Two, Three, and Four, the REC price is modeled according to projections from ICF International. For this sensitivity, the REC price is modeled based on the futures market for REC prices. This change in forecasting on net leads to REC prices being lower than in Policy Scenario Four. This has two main effects:

- Producers of renewable energy receive less revenue and
- Consumers and businesses spend less on electricity.

The results of this analysis are presented below in Figure 68.

Figure 68: Employment in Policy Scenario Four and REC Price Sensitivity



Sources: E3, MDE, RESI

Overall, the change in REC prices leads to minimal changes in employment in the sensitivity relative to Policy Scenario Four. The reduced REC price sensitivity, on average, produces 17 more jobs through 2030, but loses 114 jobs through 2050. Under this sensitivity, the economic goals are still met.

Sensitivity 2: Rollback of the Federal CAFE Standards

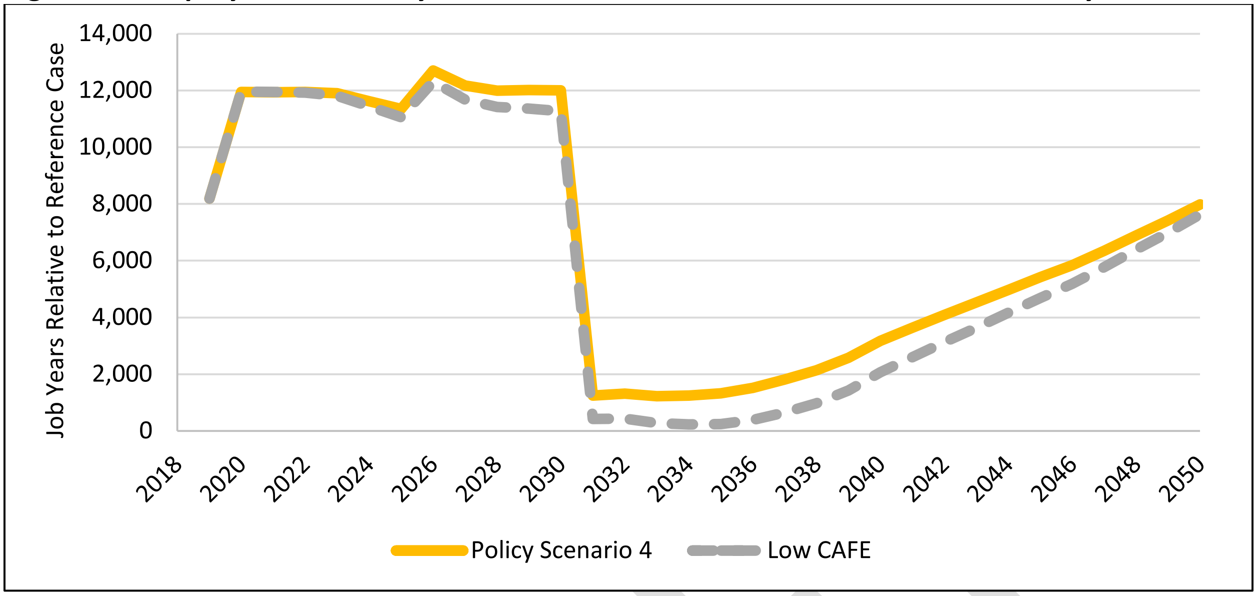
The second sensitivity analysis conducted focuses on possible changes to the CAFE standards set forth by the National Highway Traffic Safety Administration (NHTSA). CAFE standards regulate the minimum number of miles per gallon (MPG) that new vehicles must adhere to.[46] In this sensitivity, continued advancements to the light-duty vehicle program standards are rolled back to current requirements. That is, instead of extending the CAFE standards through 2026, they are only modelled through 2021.

The primary channel through which the CAFE standards rollback affects economic outcomes is through an increase in fuel costs. On average, through 2030, fuel costs will increase three percent per year and 11 percent per year through 2050.

Figure 69 presents the results of this sensitivity analysis.

[46] "Corporate Average Fuel Economy," NHTSA, December 26, 2018, accessed May 13, 2019, https://www.nhtsa.gov/laws-regulations/corporate-average-fuel-economy.

Figure 69: Employment in Policy Scenario Four and Low CAFE Standards Sensitivity



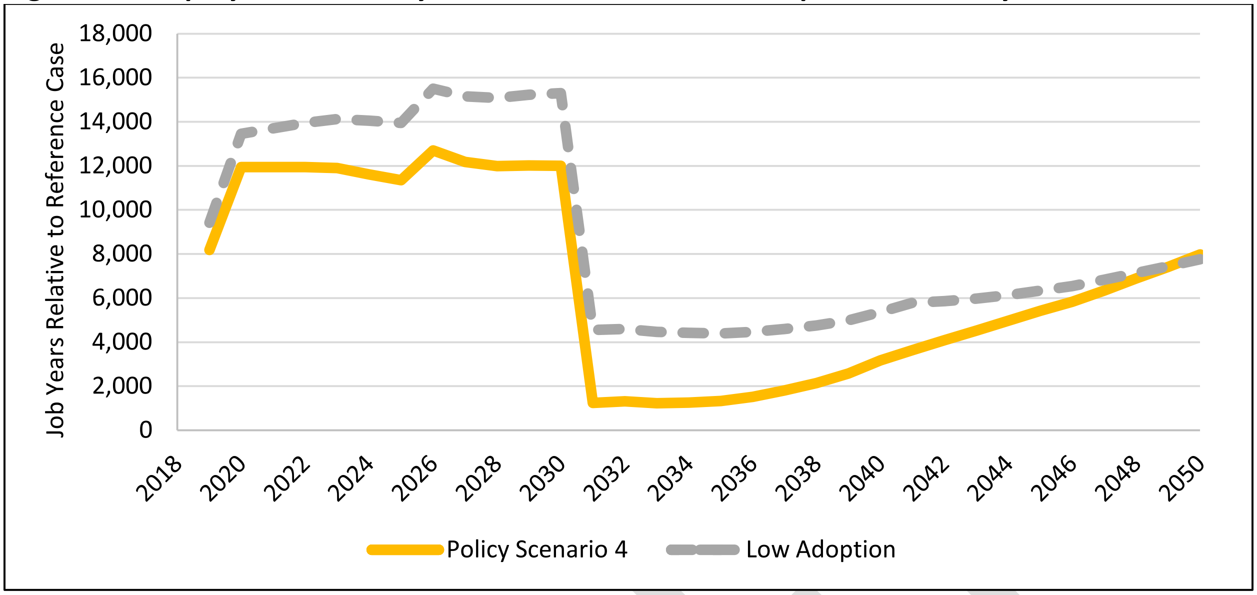
Sources: E3, MDE, RESI

As in the case of the REC price sensitivity, rolling back the CAFE standards has a very small effect on employment through 2030. Should the standards be rolled back, Maryland would still meet the economic goals, though, on average, producing 287 fewer jobs through 2030.

In the long-run, the lower CAFE standards sensitivity produces even fewer jobs. By 2050, Policy Scenario Four produces more than 650 additional job years compared to the sensitivity.

Sensitivity 3: Reduced Consumer Adoption of Energy Efficient Appliances and ZEVs
Under the Low Adoption sensitivity, instead of 50 percent high efficiency electric sales, 15 percent increase in sales of electric heat pumps, and 530,000 additional ZEV sales by 2030 as in Policy Scenario Four, these numbers are halved. Thus, in this analysis, only 25 percent high efficiency electric sales, 7.5 percent increase in electric heat pump sales, and 260,000 additional ZEV sales are modelled. The results are shown below in Figure 70.

Figure 70: Employment in Policy Scenario Four and Low Adoption Sensitivity



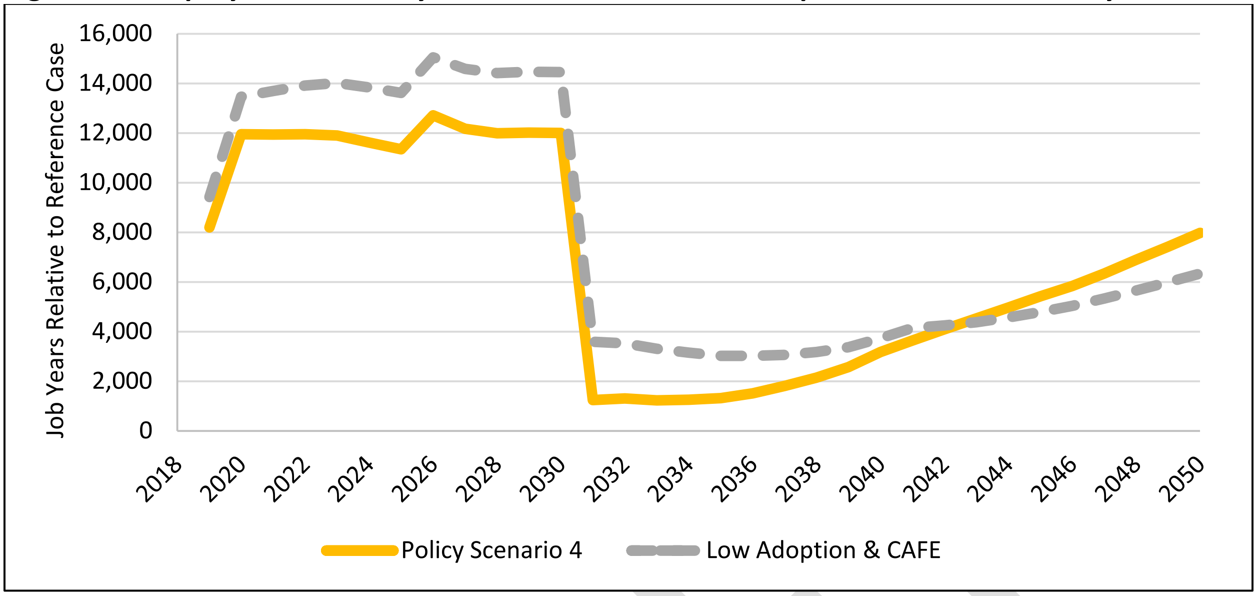
Sources: E3, MDE, RESI

Under these parameters, employment is expected to rise in the short-run relative to the reference case but then drop in the long-run. On average, through 2030, the Low Adoption sensitivity produces 2,425 more jobs. These results are largely being driven by the nature of capital investments. Lower employment numbers are present in the short-run because consumers are not spending more on high efficiency appliances and ZEVs. By 2050, after all fuel savings are realized economy-wide, Policy Scenario Four produces an additional 214 job years compared to the Low Adoption sensitivity.

Sensitivity 4: Combination of the CAFE rollback and Reduced Consumer Adoption

The fourth sensitivity combines both the rollback in CAFE standards as well as the reduced consumer adoption of high efficiency appliances and ZEVs. These results are presented below in Figure 71.

Figure 71: Employment in Policy Scenario Four and Low Adoption & CAFE Sensitivity



Sources: E3, MDE, RESI

On average through 2030, 2,092 jobs are sustained above Policy Scenario Four levels in this sensitivity. However, in 2043, employment under Policy Scenario Four relative to the reference case exceeds levels under the sensitivity relative to the reference case. In 2050, Policy Scenario Four produces 1,648 more job years relative to the sensitivity case.

7.7 References

Abt Associates. "Analysis of the Public Health Impacts of the Regional Greenhouse Gas Initiative, 2009-2014." 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.

Agency for Healthcare Research and Quality. "HCUPnet, Healthcare Cost and Utilization Project." Accessed August 15, 2018. https://hcupnet.ahrq.gov.

Carreras-Sospedra, Marc 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). Accessed January 20, 2019. https://www.arb.ca.gov/research/rsc/1-30-15/item6dfr11-307.pdf.

Chesapeake Climate Action Network. "B21-0650—Renewable Portfolio Standard Expansion Amendment Act of 2016." May 23, 2016. Accessed August 9, 2018. http://chesapeakeclimate.org/wp/wp-content/uploads/2016/05/CCAN_B21-0650_testimony_DC-RPS.pdf.

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

Hasset, Kevin A., Aparna Mathur, and Gilbert Metcalf. "The Incidence of a U.S. Carbon Tax: A Lifetime and Regional Analysis." *The Energy Journal* 30, no. 2 (April 2009): 155-178. DOI: 10.5547/ISSN0195-6574-EJ-Vol30-No2-8.

Hou, Lifang, Kai Zhang, Moira A. Luthin, and Andrea A. Baccarelli. "Public Health Impact and Economic Costs of Volkswagon's Lack of Compliance with the United States' Emission Standards." *International Journal of Environmental Research and Public Health* 13, no. 9 (2016): 1-6. Accessed August 9, 2018. DOI: 10.3390/ijerph13090891.

Nystrom, Scott, Katie O'Hare, and Ken Ditzel. "The Economic, Fiscal, and Emissions Impacts of a Revenue-Neutral Carbon Tax." FTI Consulting (July 2018). Accessed January 14, 2019. https://www.fticonsulting.com/~/media/Files/us-files/insights/reports/impacts-revenue-neutral-carbon-tax.pdf.

O*NET OnLine. "O*NET OnLine Help: Job Zones." Accessed February 13, 2019. https://www.onetonline.org/help/online/zones.

Regional Carbon Cost Collection Initiative, H.B. 939. Maryland General Assembly 2018 Session. (2018). http://mgaleg.maryland.gov/2018RS/fnotes/bil_0009/hb0939.pdf.

Sands, Ronald and Paul Westcott. "Impacts of Higher Energy Prices on Agriculture and Rural Economies." United States Department of Agriculture Economic Research Service (August 2011). Accessed November 19, 2018. https://www.ers.usda.gov/webdocs/publications/44894/6814_err123_1_.pdf?v=41432.

United States Bureau of Labor Statistics. "Standard Occupational Classification." Accessed February 14, 2019. https://www.bls.gov/soc/home.htm.

United States Census Bureau. "North American Industry Classification System." Accessed February 14, 2019. https://www.census.gov/eos/www/naics/.

United States Energy Information Administration. "British Thermal Units (BTU)." Accessed January 20, 2019. https://www.eia.gov/energyexplained/index.php?page=about_btu.

United States Environmental Protection Agency. "Avoided Emissions Factors Generated from AVERT." June 1, 2018. Accessed January 20, 2019. https://www.epa.gov/statelocalenergy/avoided-emission-factors-generated-avert.

United States Environmental Protection Agency. "CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool." Accessed August 9, 2018. https://www.epa.gov/statelocalenergy/co-benefits-risk-assessment-cobra-health-impacts-screening-and-mapping-tool.

United States Environmental Protection Agency. "Natural Gas Combustion." Accessed January 20, 2019. https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s04.pdf.

United States Environmental Protection Agency. "Particulate Matter (PM) Basics." Last updated November 14, 2018. Accessed December 12, 2018. https://www.epa.gov/pm-pollution/particulate-matter-pm-basics.

United States Environmental Protection Agency. "Particulate Matter Emissions." Accessed August 9, 2018. https://cfpub.epa.gov/roe/indicator_pdf.cfm?i=19.

United States Environmental Protection Agency. "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)." May 2018. Accessed August 9, 2018. https://www.epa.gov/sites/production/files/2018-05/documents/cobra_user_manual_may2018_508.pdf.

Washington State Department of Commerce. “Carbon Policy and Strategies—Washington State Department of Commerce.” Accessed September 19, 2018. https://www.commerce.wa.gov/growing-the-economy/energy/washington-state-energy-office/carbon-tax/.

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.

EITHER INCLUDE TABLE FROM E3 TO ENSURE CONSISTENCY ACROSS CHAPTERS OR CREATE A SEPARATE APPENDIX REFERENCED BY BOTH CHAPTERS.

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 6.

B.1 REMI PI+

To quantify the economic impacts of economic events or policy changes, RESI uses the Regional Economic Models, Inc. (REMI) PI+ model version 2.2. The REMI PI+ model is a high-end dynamic modeling tool used by various federal and state government agencies in economic policy analysis. Utilization of REMI PI+ helps RESI to 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 PI+ model reports economic impacts above the economic activity that would have occurred without the policy change or event.

As a dynamic model, REMI PI+ 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 the regional constraint is built in to account 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 PI+ 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.[47,48]

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),

[47] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 3.
[48] "CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool," U.S. Environment Protection Agency.

ammonia (NH_3), and volatile organic compounds (VOCs).[49] Baseline emission estimates are included for both 2017 and 2025, allowing users to change emissions in either year.[50] 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.[51] 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.[52] For example, SO_2 will create sulfates in the atmosphere while NO_x will form nitrates, both of which are forms of $PM_{2.5}$.[53]

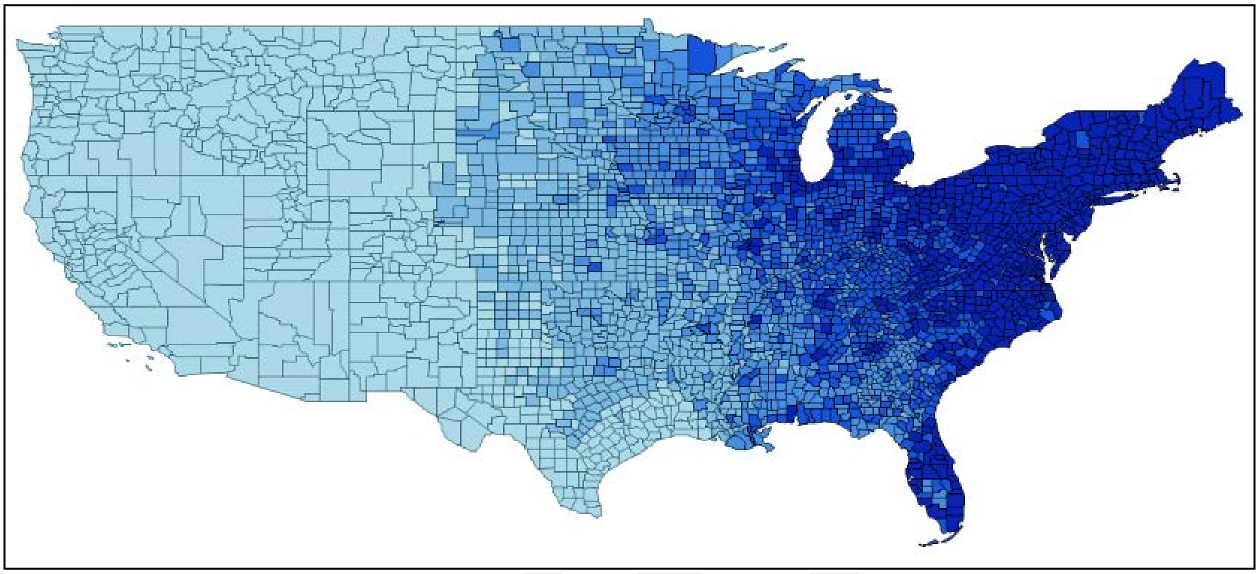
The changes in ambient $PM_{2.5}$ are then further translated into health impacts, which cover a wide range of effects from mortality and non-fatal heart attacks to work days missed and minor restricted activity days (MRADs).[54] Finally, these various health impacts are assigned economic values in 2017 dollars.[55] 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 $PM_{2.5}$."[56] 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

---

[49] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 18.
[50] COBRA also contains the ability to import a custom emissions baseline for any other year, however this functionality was not used for this analysis.
[51] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 6-14.
[52] U.S. Environment Protection Agency, "Particulate Matter Emissions," accessed August 9, 2018, 1, https://cfpub.epa.gov/roe/indicator_pdf.cfm?i=19.
[53] U.S. Environment Protection Agency, "Particulate Matter Emissions," 1.
[54] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 43-44.
[55] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 7-8.
[56] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," 23.

county lines. Figure 63 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 72: 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 whenever the car underwent emissions testing.[57] 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."[58]

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.[59,60] 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.

[57] 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.
[58] Hou et al., "Public Health Impact and Economic Costs of Volkswagen's Lack of Compliance with the United States' Emission Standards," 2.
[59] Hou et al., "Public Health Impact and Economic Costs of Volkswagen's Lack of Compliance with the United States' Emission Standards," 4.
[60] Values in this study are in 2010 dollars.

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.[61]

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.[62] Notably, Abt found significant health and economic benefits both in RGGI states and in neighboring states that did not participate in RGGI.[63]

[61] 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.

[62] 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.

[63] 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 73: Total Employment Impacts by Policy Scenario without Transportation Measures by Year Relative to the Reference Case, 2019-2050

Year	PS 1	PS 2	PS 3	PS 4
Average through 2030	944	1,652	7,336	1,636
Average through 2050	794	-7,515	6,188	3,002
2019	333	537	436	412
2020	541	1,096	6,231	810
2021	660	1,394	6,901	1,085
2022	774	1,750	7,827	1,380
2023	900	2,109	8,330	1,675
2024	822	2,147	8,545	1,723
2025	889	2,198	8,553	1,781
2026	1,008	2,118	8,514	1,828
2027	1,150	1,965	8,452	1,971
2028	1,276	1,742	8,279	2,136
2029	1,414	1,519	8,088	2,365
2030	1,555	1,252	7,873	2,470
2031	1,346	-198	7,152	2,146
2032	1,073	-2,053	6,350	1,847
2033	774	-4,069	5,591	1,643
2034	505	-6,181	4,924	1,552
2035	244	-8,409	4,360	1,532
2036	56	-10,347	3,860	1,648
2037	-63	-12,126	3,567	1,882
2038	-152	-13,866	3,378	2,166
2039	-167	-15,412	3,352	2,566
2040	-60	-16,569	3,557	3,139
2041	93	-17,540	3,843	3,585
2042	278	-18,152	4,257	4,027
2043	476	-18,473	4,758	4,455
2044	690	-18,508	5,314	4,895
2045	913	-18,250	5,921	5,339
2046	1,129	-17,823	6,528	5,750
2047	1,370	-17,011	7,242	6,254
2048	1,620	-15,648	7,953	6,797
2049	1,859	-14,735	8,681	7,318
2050	2,101	-14,944	9,409	7,872

Sources:

Figure 74: Total Employment Impacts by Policy Scenario with Transportation Measures by Year Relative to the Reference Case, 2019-2050

Year	PS 1	PS 2	PS 3	PS 4
Average through 2030	4,564	11,665	10,950	11,649
Average through 2050	2,116	-3,811	7,504	6,703
2019	8,054	8,314	8,145	8,190
2020	7,303	12,236	12,985	11,949
2021	7,092	12,248	13,325	11,938
2022	7,113	12,318	14,159	11,947
2023	7,206	12,337	14,629	11,903
2024	7,130	12,043	14,852	11,618
2025	841	11,766	8,505	11,348
2026	1,574	12,998	9,074	12,707
2027	1,915	12,170	9,211	12,175
2028	2,095	11,596	9,090	11,990
2029	2,193	11,172	8,859	12,018
2030	2,256	10,785	8,565	12,004
2031	1,268	-1,100	7,065	1,245
2032	1,061	-2,592	6,329	1,309
2033	756	-4,486	5,563	1,227
2034	457	-6,482	4,868	1,252
2035	163	-8,616	4,271	1,324
2036	-51	-10,479	3,745	1,515
2037	-186	-12,196	3,438	1,810
2038	-279	-13,887	3,244	2,143
2039	-290	-15,399	3,223	2,576
2040	-171	-16,529	3,441	3,174
2041	-2	-17,481	3,744	3,639
2042	201	-18,080	4,176	4,093
2043	416	-18,392	4,694	4,529
2044	646	-18,421	5,266	4,976
2045	882	-18,158	5,887	5,423
2046	1,110	-17,729	6,506	5,836
2047	1,360	-16,912	7,230	6,344
2048	1,617	-15,545	7,947	6,892
2049	1,862	-14,625	8,681	7,419
2050	2,107	-14,826	9,413	7,981

Sources:

C.2 Gross State Product (GSP)

Figure 75: Gross State Product Impacts by Policy Scenario without Transportation Measures by Year Relative to the Reference Case, 2019-2050 (in Billions of 2018 Dollars)

Year	PS 1	PS 2	PS 3	PS 4
Average through 2030	$0.21	$0.25	$0.27	$0.23
Average through 2050	$0.06	-$1.46	-$0.36	$0.56
2019	$0.04	$0.19	$0.04	$0.05
2020	$0.05	$0.17	$0.35	$0.08
2021	$0.07	$0.22	$0.31	$0.12
2022	$0.09	$0.25	$0.35	$0.15
2023	$0.12	$0.28	$0.37	$0.19
2024	$0.12	$0.29	$0.33	$0.20
2025	$0.19	$0.30	$0.33	$0.23
2026	$0.26	$0.30	$0.33	$0.26
2027	$0.32	$0.29	$0.31	$0.30
2028	$0.38	$0.26	$0.25	$0.35
2029	$0.43	$0.24	$0.19	$0.40
2030	$0.47	$0.20	$0.11	$0.42
2031	$0.42	$0.00	-$0.03	$0.40
2032	$0.36	-$0.25	-$0.19	$0.38
2033	$0.29	-$0.53	-$0.33	$0.37
2034	$0.21	-$0.85	-$0.48	$0.37
2035	$0.14	-$1.17	-$0.59	$0.38
2036	$0.07	-$1.46	-$0.70	$0.40
2037	$0.00	-$1.75	-$0.79	$0.44
2038	-$0.05	-$2.04	-$0.88	$0.50
2039	-$0.10	-$2.36	-$0.93	$0.57
2040	-$0.13	-$2.63	-$0.96	$0.69
2041	-$0.15	-$2.92	-$0.98	$0.75
2042	-$0.17	-$3.18	-$0.98	$0.81
2043	-$0.18	-$3.39	-$0.97	$0.88
2044	-$0.19	-$3.58	-$0.95	$0.94
2045	-$0.20	-$3.74	-$0.93	$1.01
2046	-$0.20	-$3.87	-$0.91	$1.08
2047	-$0.20	-$3.95	-$0.88	$1.16
2048	-$0.20	-$3.93	-$0.84	$1.24
2049	-$0.19	-$4.03	-$0.79	$1.32
2050	-$0.18	-$4.25	-$0.75	$1.40

Sources:

Figure 76: Gross State Product Impacts by Policy Scenario with Transportation Measures by Year Relative to the Reference Case, 2019-2050 (in Billions of 2018 Dollars)

Year	PS 1	PS 2	PS 3	PS 4
Average through 2030	$0.51	$1.16	$0.56	$1.14
Average through 2050	$0.16	-$1.14	-$0.26	$0.88
2019	$0.66	$0.85	$0.65	$0.71
2020	$0.59	$1.12	$0.88	$1.03
2021	$0.59	$1.16	$0.82	$1.06
2022	$0.62	$1.18	$0.87	$1.08
2023	$0.65	$1.19	$0.89	$1.11
2024	$0.67	$1.19	$0.86	$1.10
2025	$0.16	$1.19	$0.30	$1.11
2026	$0.30	$1.32	$0.37	$1.27
2027	$0.38	$1.25	$0.36	$1.26
2028	$0.44	$1.21	$0.32	$1.29
2029	$0.49	$1.17	$0.25	$1.33
2030	$0.53	$1.14	$0.16	$1.35
2031	$0.40	-$0.14	-$0.05	$0.26
2032	$0.35	-$0.35	-$0.20	$0.29
2033	$0.28	-$0.61	-$0.35	$0.29
2034	$0.20	-$0.91	-$0.49	$0.30
2035	$0.12	-$1.23	-$0.61	$0.32
2036	$0.04	-$1.50	-$0.72	$0.36
2037	-$0.02	-$1.78	-$0.82	$0.41
2038	-$0.08	-$2.07	-$0.90	$0.47
2039	-$0.12	-$2.38	-$0.95	$0.55
2040	-$0.15	-$2.65	-$0.98	$0.67
2041	-$0.17	-$2.94	-$1.00	$0.73
2042	-$0.19	-$3.19	-$0.99	$0.80
2043	-$0.20	-$3.40	-$0.98	$0.86
2044	-$0.20	-$3.59	-$0.96	$0.93
2045	-$0.21	-$3.74	-$0.94	$1.00
2046	-$0.21	-$3.87	-$0.92	$1.07
2047	-$0.21	-$3.95	-$0.88	$1.15
2048	-$0.20	-$3.93	-$0.84	$1.24
2049	-$0.20	-$4.03	-$0.80	$1.32
2050	-$0.19	-$4.25	-$0.75	$1.40

Sources:

C.3 Personal Income

Figure 77: Personal Income Impacts by Policy Scenario without Transportation Measures by Year Relative to the Reference Case, 2019-2050 (in Billions of 2018 Dollars)

Year	PS 1	PS 2	PS 3	PS 4
Average through 2030	$0.11	$0.15	$1.74	$0.15
Average through 2050	$0.09	-$1.03	$1.99	$0.37
2019	$0.02	$0.07	$0.03	$0.03
2020	$0.03	$0.08	$1.10	$0.05
2021	$0.05	$0.11	$1.32	$0.08
2022	$0.06	$0.14	$1.54	$0.10
2023	$0.08	$0.17	$1.69	$0.13
2024	$0.08	$0.18	$1.84	$0.14
2025	$0.10	$0.19	$1.96	$0.16
2026	$0.12	$0.19	$2.12	$0.17
2027	$0.15	$0.18	$2.22	$0.20
2028	$0.17	$0.17	$2.30	$0.22
2029	$0.19	$0.15	$2.35	$0.25
2030	$0.22	$0.12	$2.40	$0.27
2031	$0.20	-$0.02	$2.36	$0.25
2032	$0.17	-$0.21	$2.28	$0.23
2033	$0.15	-$0.42	$2.20	$0.22
2034	$0.11	-$0.65	$2.11	$0.21
2035	$0.08	-$0.90	$2.04	$0.22
2036	$0.05	-$1.14	$1.98	$0.23
2037	$0.03	-$1.36	$1.93	$0.26
2038	$0.01	-$1.59	$1.90	$0.29
2039	$0.00	-$1.80	$1.88	$0.34
2040	$0.00	-$1.98	$1.89	$0.41
2041	$0.00	-$2.16	$1.91	$0.46
2042	$0.01	-$2.30	$1.95	$0.52
2043	$0.03	-$2.42	$2.00	$0.58
2044	$0.05	-$2.50	$2.06	$0.64
2045	$0.07	-$2.55	$2.13	$0.71
2046	$0.09	-$2.58	$2.21	$0.77
2047	$0.11	-$2.57	$2.31	$0.84
2048	$0.14	-$2.48	$2.40	$0.92
2049	$0.17	-$2.44	$2.51	$1.00
2050	$0.20	-$2.49	$2.62	$1.08

Sources:

Figure 78: Personal Income Impacts by Policy Scenario with Transportation Measures by Year Relative to the Reference Case, 2019-2050 (in Billions of 2018 Dollars)

Year	PS 1	PS 2	PS 3	PS 4
Average through 2030	$0.34	$0.99	$1.97	$1.00
Average through 2050	$0.17	-$0.67	$2.06	$0.73
2019	$0.43	$0.56	$0.43	$0.53
2020	$0.42	$0.83	$1.48	$0.80
2021	$0.43	$0.90	$1.70	$0.87
2022	$0.46	$0.97	$1.93	$0.93
2023	$0.49	$1.02	$2.10	$0.98
2024	$0.51	$1.04	$2.27	$1.00
2025	$0.14	$1.06	$1.99	$1.03
2026	$0.19	$1.15	$2.19	$1.13
2027	$0.22	$1.12	$2.29	$1.14
2028	$0.25	$1.11	$2.37	$1.16
2029	$0.26	$1.09	$2.41	$1.19
2030	$0.28	$1.07	$2.46	$1.22
2031	$0.21	$0.13	$2.36	$0.40
2032	$0.18	-$0.08	$2.29	$0.36
2033	$0.15	-$0.32	$2.20	$0.32
2034	$0.11	-$0.57	$2.11	$0.29
2035	$0.08	-$0.84	$2.04	$0.28
2036	$0.04	-$1.08	$1.97	$0.29
2037	$0.02	-$1.31	$1.92	$0.31
2038	-$0.01	-$1.54	$1.88	$0.34
2039	-$0.02	-$1.76	$1.86	$0.38
2040	-$0.02	-$1.94	$1.87	$0.45
2041	-$0.01	-$2.12	$1.89	$0.50
2042	$0.00	-$2.27	$1.93	$0.55
2043	$0.02	-$2.38	$1.98	$0.61
2044	$0.03	-$2.47	$2.05	$0.67
2045	$0.06	-$2.52	$2.12	$0.74
2046	$0.08	-$2.55	$2.20	$0.80
2047	$0.11	-$2.53	$2.30	$0.88
2048	$0.13	-$2.44	$2.39	$0.96
2049	$0.16	-$2.40	$2.50	$1.04
2050	$0.19	-$2.45	$2.62	$1.12

Sources:

C.4 Producer Consumption Expenditures (PCE)

Figure 79: PCE-Price Index (2009=100) Under Policy Scenario 4

Year	With Transportation Measures	Without Transportation Measures
Average through 2030	0.078	0.037
Average through 2050	0.128	0.109
2019	0.010	0.004
2020	0.031	0.005
2021	0.046	0.010
2022	0.051	0.011
2023	0.056	0.014
2024	0.067	0.024
2025	0.079	0.035
2026	0.092	0.046
2027	0.108	0.057
2028	0.120	0.068
2029	0.132	0.079
2030	0.143	0.089
2031	0.145	0.100
2032	0.125	0.109
2033	0.130	0.118
2034	0.133	0.125
2035	0.138	0.132
2036	0.141	0.136
2037	0.146	0.142
2038	0.151	0.148
2039	0.157	0.154
2040	0.161	0.159
2041	0.164	0.162
2042	0.166	0.164
2043	0.169	0.167
2044	0.171	0.169
2045	0.173	0.172
2046	0.175	0.174
2047	0.177	0.176
2048	0.180	0.178
2049	0.182	0.180
2050	0.184	0.182

Sources:

C.5 Health Impacts

Figure 80: Jobs Due to Health Impacts by Policy Scenario

Year	Policy Scenario 1	Policy Scenario 2	Policy Scenario 3	Policy Scenario 4
Average Through 2030	3.60	8.10	7.15	4.38
Average Through 2050	20.46	58.88	52.70	28.45
2019	0.36	0.63	0.41	0.37
2020	0.67	1.32	0.91	0.73
2021	1.07	2.20	1.63	1.21
2022	1.52	3.22	2.50	1.76
2023	2.02	4.40	3.53	2.38
2024	2.57	5.69	4.68	3.07
2025	3.25	7.41	6.24	3.96
2026	4.03	9.29	8.00	4.97
2027	4.97	11.50	10.13	6.17
2028	6.13	14.13	12.73	7.61
2029	7.47	16.98	15.69	9.22
2030	9.09	20.41	19.36	11.14
2031	10.88	24.28	23.49	13.27
2032	12.73	28.53	27.92	15.55
2033	14.66	33.28	32.70	18.01
2034	16.55	38.36	37.61	20.54
2035	18.43	43.78	42.64	23.16
2036	20.33	49.59	47.86	25.88
2037	22.20	55.64	53.18	28.66
2038	24.09	61.97	58.64	31.53
2039	25.98	68.48	64.20	34.44
2040	28.08	76.45	70.80	37.82
2041	30.27	85.01	77.80	41.39
2042	32.56	94.18	85.18	45.17
2043	34.96	103.90	92.97	49.21
2044	37.45	113.84	100.91	53.42
2045	40.05	124.11	109.09	57.84
2046	42.75	134.65	117.48	62.46
2047	45.54	145.54	126.08	67.25
2048	48.38	156.59	134.77	72.15
2049	51.28	167.89	143.63	77.19
2050	54.51	180.81	153.56	82.94

Sources: Sources: E3, MDE, REMI PI+, RESI, U.S. EPA

Figure 81: Avoided Mortality and Estimated Value by Policy Scenario

	Policy Scenario 1		Policy Scenario 2		Policy Scenario 3		Policy Scenario 4	
Year	Mortality Avoided	Value	Mortality Avoided	Value	Mortality Avoided	Value	Mortality Avoided	Value
Average Through 2030	6.27	$62,361,822	14.07	$139,947,620	13.38	$133,137,885	7.68	$76,455,728
Average Through 2050	19.37	$192,733,991	59.84	$595,298,539	52.58	$523,141,762	28.10	$279,586,443
2019	1.47	$14,575,643	3.04	$30,293,325	2.34	$23,256,339	1.67	$16,610,412
2020	2.13	$21,237,190	4.56	$45,368,665	3.67	$36,520,196	2.49	$24,795,131
2021	2.80	$27,836,131	6.13	$61,034,769	5.15	$51,228,051	3.34	$33,256,082
2022	3.39	$33,710,966	7.59	$75,473,587	6.57	$65,375,276	4.12	$41,025,741
2023	3.99	$39,695,156	9.06	$90,184,099	8.02	$79,792,111	4.92	$48,941,437
2024	4.60	$45,788,701	10.57	$105,166,306	9.50	$94,478,559	5.73	$57,003,171
2025	5.68	$56,473,849	13.56	$134,924,965	12.26	$121,962,592	7.23	$71,895,059
2026	6.94	$69,067,151	16.31	$162,299,104	15.19	$151,085,278	8.76	$87,144,836
2027	8.40	$83,608,742	19.34	$192,363,644	18.50	$184,093,004	10.48	$104,253,535
2028	10.06	$100,098,622	22.63	$225,118,584	22.21	$220,985,769	12.39	$123,221,155
2029	11.75	$116,868,400	25.65	$255,164,931	25.84	$257,100,384	14.23	$141,559,719
2030	14.01	$139,381,314	30.35	$301,979,468	31.34	$311,777,063	16.86	$167,762,453
2031	15.58	$155,034,649	34.67	$344,898,965	35.58	$354,009,968	18.98	$188,788,218
2032	17.02	$169,329,684	39.25	$390,451,372	39.78	$395,792,550	21.08	$209,680,209
2033	18.32	$182,266,419	44.09	$438,636,688	43.94	$437,124,809	23.16	$230,438,424
2034	19.28	$191,820,848	48.59	$483,410,585	47.38	$471,341,432	24.95	$248,258,011
2035	20.25	$201,503,312	53.17	$528,938,514	50.87	$506,095,384	26.77	$266,357,008
2036	21.24	$211,313,811	57.82	$575,220,477	54.42	$541,386,665	28.62	$284,735,415
2037	22.24	$221,252,345	62.54	$622,256,474	58.02	$577,215,275	30.50	$303,393,231
2038	23.25	$231,318,914	67.35	$670,046,504	61.67	$613,581,213	32.40	$322,330,456

Year	Policy Scenario 1 Mortality Avoided	Policy Scenario 1 Value	Policy Scenario 2 Mortality Avoided	Policy Scenario 2 Value	Policy Scenario 3 Mortality Avoided	Policy Scenario 3 Value	Policy Scenario 4 Mortality Avoided	Policy Scenario 4 Value
2039	24.28	$241,513,518	72.23	$718,590,567	65.38	$650,484,480	34.33	$341,547,092
2040	26.04	$259,109,344	82.07	$816,529,541	72.80	$724,275,900	37.75	$375,596,895
2041	27.46	$273,244,009	89.21	$887,592,463	78.10	$777,013,618	40.51	$403,023,230
2042	28.93	$287,778,998	96.46	$959,719,317	83.44	$830,127,671	43.36	$431,390,147
2043	30.43	$302,714,313	103.82	$1,032,910,104	88.82	$883,618,060	46.31	$460,697,646
2044	31.70	$315,342,711	109.46	$1,089,059,609	92.87	$923,954,200	48.80	$485,528,495
2045	32.98	$328,128,189	115.19	$1,145,996,203	96.98	$964,810,497	51.33	$510,709,279
2046	34.28	$341,070,745	120.99	$1,203,719,887	101.14	$1,006,186,949	53.90	$536,239,997
2047	35.60	$354,170,381	126.87	$1,262,230,660	105.35	$1,048,083,557	56.50	$562,120,650
2048	36.93	$367,427,096	132.83	$1,321,528,522	109.61	$1,090,500,322	59.14	$588,351,237
2049	38.28	$380,840,889	138.87	$1,381,613,474	113.93	$1,133,437,243	61.81	$614,931,760
2050	40.60	$403,965,667	150.45	$1,496,831,881	122.01	$1,213,841,956	66.86	$665,180,052

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

END OF DOCUMENT