Economic and Fiscal Impacts of Maryland's Greenhouse Gas Reduction Policies

Prepared for
The Center for Global Sustainability at
The University of Maryland, College Park

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2.0 Introduction

The Center for Global Sustainability at University of Maryland, College Park (CGS) has requested that RESI of Towson University (RESI) conduct economic and fiscal impact analyses of proposed policies to reduce greenhouse gas emissions in Maryland.

3.0 Methodology

To estimate the impacts of the Current + Planned Policies scenario, RESI translated the outputs from the Global Change Analysis Model (GCAM) and the Co-benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) into inputs for REMI. This section outlines the methodology in greater detail.

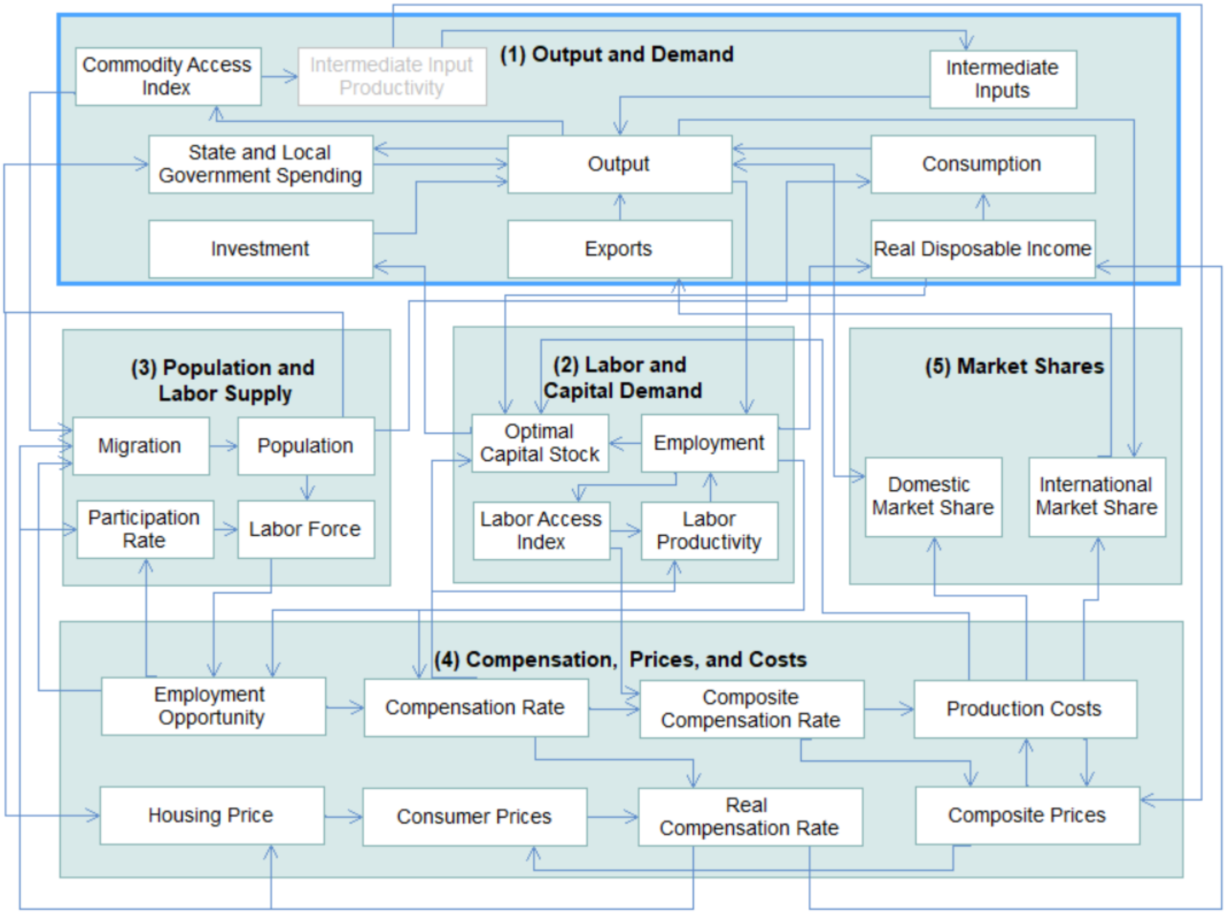
3.1 REMI

Regional Economic Models, Inc. (REMI) is a dynamic hybrid general equilibrium and input-output model used by various federal and state government agencies in economic policy analysis. Specifically, the Current + Planned Policies scenario presented here was modeled using REMI PI+ Version 2.3. With REMI PI+, RESI was able to use a model specifically calibrated to the economic and demographic structure of Maryland for this analysis.

The underlying structure of the REMI PI+ model is composed of linkages between five different components: output and demand; labor and capital demand; population and labor supply; compensation, prices, and costs; and market shares. These components—which can be thought of as policy injection points (i.e., policy variables)—are then linked by a large system of simultaneous equations. Thus, when a dollar is injected into the model, the economic impacts are spread through entire system.[1] This can be seen below in Figure 1.

[1] Regional Economic Models, Inc., "Model Equations," 3, accessed June 28, 2023, https://www.remi.com/wp-content/uploads/2018/06/Model-Equations-v2_2.pdf.

Figure 1: REMI Model Linkages



Source: REMI PI+

To generate these policy variable inputs, capital costs and energy consumption costs provided by CGS were translated into appropriate inputs for REMI. 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.

For example, a policy scenario that leads to an increase in the purchase of heat pumps will trigger two effects. On one hand, both retail establishments as well as manufacturers that sell heat pumps will experience higher demand and therefore higher sales. On the other hand, consumers of heat pumps will need to spend money and reallocate their budgets accordingly. Both of these effects are captured in REMI, allowing for a more complete accounting of both the benefits and costs of policies. Economic benefits are modeled in REMI as a change in consumer or business demand, while economic costs are modeled as the corresponding change in capital or fuel costs.

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

To assess specific impacts, REMI first constructs a baseline model of the local economy, which then allows policy variables to be layered on top to see how aspects of the new policy affect the economic outcomes. The difference between the policy scenario and baseline forecast represents the economic impact of the policy.

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 whether 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 cross-walked 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 2. 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 2: Top Five Intermediate Demand Industries for Base 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

3.2 Estimating Health Impacts with COBRA

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.[2]

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

[2] The amenity value measures non-economic improvements to quality of life in a region, which has an effect on migration patterns.

While most health impacts in COBRA are limited to occurrences within a single year, impacts on premature mortality are determined using a 20-year-lag structure. For any change in premature deaths resulting from a single year of emissions, 30 percent of those deaths are assumed to occur in the first year, 50 percent occurs evenly from years two to five after the emissions year, and the final 20 percent occurs over years six to twenty.[3] 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.[4] For each reduced incidence of hospital admittance in the COBRA model, RESI decreased medical revenue in the REMI model by an amount equal to the average hospital charge for that condition, reallocating the revenue to consumers, government, and private insurance in proportion to their contribution to the medical bill based on payer data also provided by HCUPnet.[5]

In many cases, a health incident involving hospital admission will result in an absence from work and decreased productivity. COBRA also measures missed workdays and restricted activity days not directly resulting from one of the other measured health impacts.[6] 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.[7]

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.[8] 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 were taken directly from COBRA's valuation of each of the four health impacts.

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[3] U.S. Environment Protection Agency, "User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)," F-6.

[4] "HCUPnet, Healthcare Cost and Utilization Project," Agency for Healthcare Research and Quality, accessed June 28, 2023, https://hcupnet.ahrq.gov/.

[5] Revenue was reallocated in the REMI model to insurance carriers, federal, state, and local government, and consumer spending.

[6] For RESI's model, a single restricted activity day is treated as 0.5 missed work days.

[7] Active working days exclude weekends and non-working holidays.

[8] The amenity value in REMI is a "willingness-to-pay" measure representing quality in life. For example, if a state A has cleaner air and water than state B, state A will have a higher amenity value. This higher amenity value means state A will have higher immigration rates with economic indicators changing through that avenue.

4.0 Results

To estimate the impacts of the Current + Planned Policies scenario in Maryland, RESI relied on data supplied from CGS, MDE, and MDOT. These estimates included:

1. Capital costs, fuel usage, fuel prices, and electric generation consistent with the current and proposed policies;
2. Solar and wind custom industries;
3. Health impacts;
4. MDOT transportation projects; and
5. Cap and invest revenue proceeds.

One billion dollars of revenue proceeds from cap and invest are distributed evenly at $250 million across four different areas: (1) consumer spending on electric vehicles, (2) consumer spending on housing and appliances, (3) commercial decarbonization, and (4) industrial decarbonization and forestry.[9] Within REMI, this triggers three types of policy variables: reductions in consumer spending for the respective commodities, reductions in commercial capital costs, and increased exogenous final demand for the *forestry and logging; fishing, hunting and trapping* industries.

All results in this section are presented as differences from the reference scenario. Specifically for these impacts, current as well as proposed policies were compared to the current policies reference case.

4.1 Overview

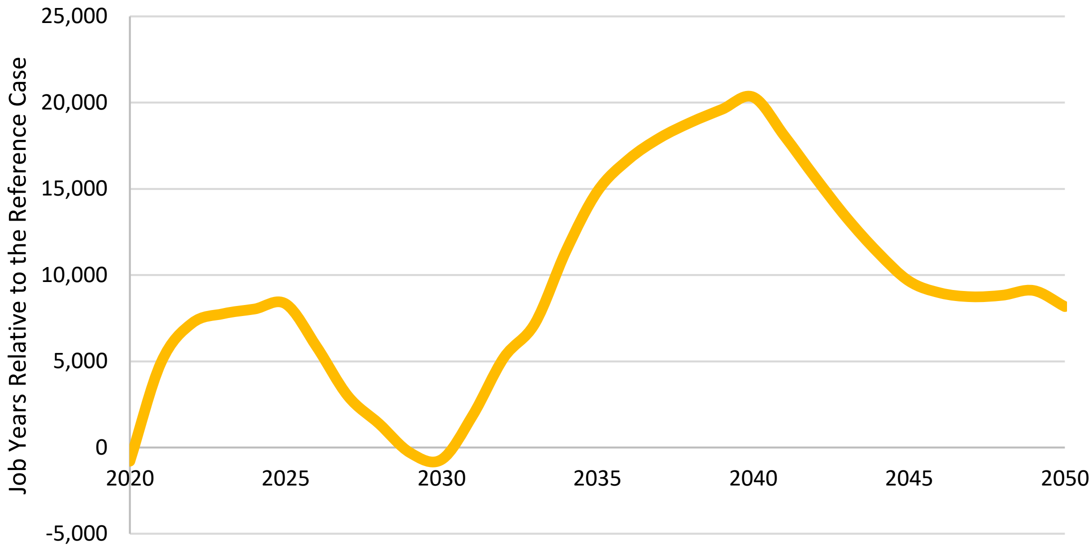
In order to assess the impact of the policies on the health of the Maryland economy, RESI relied on three important measures: employment, personal income, and gross state product (GSP). Together, these measures provide a more comprehensive look at how the policies will impact the economy.

Employment

REMI uses the Bureau of Economic Analysis's definition for employment, which includes full-time workers, part-time workers, and self-employed individuals. On average, over the first decade of implementation (2024 – 2035) roughly 5,505 jobs will be created annually relative to the reference case. Over the long term (2024 – 2050), approximately 10,048 jobs per year can be sustained with gains peaking in 2040 at 20,322 jobs. Figure 3 illustrates how these job gains trend over time.

[9] For the $250 million in the fourth spending area, approximately 80 percent of funds were allocated to industrial decarbonization and 20 percent to forestry.

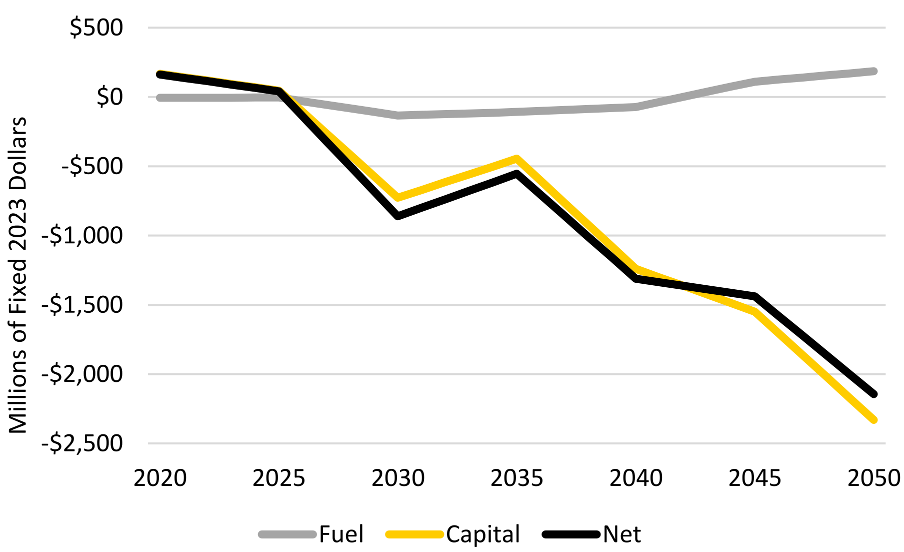
Figure 3: Employment for Current + Planned Policies Relative to Reference Case



Sources: CGS, MDE, REMI PI+, RESI

These impacts are largely due to the interplay between fuel costs and capital costs. In the near-term, as seen in Figure 4, capital costs are higher than fuel expenditures. During this period, transportation investments and cap and invest revenue proceeds are important source of job creation.

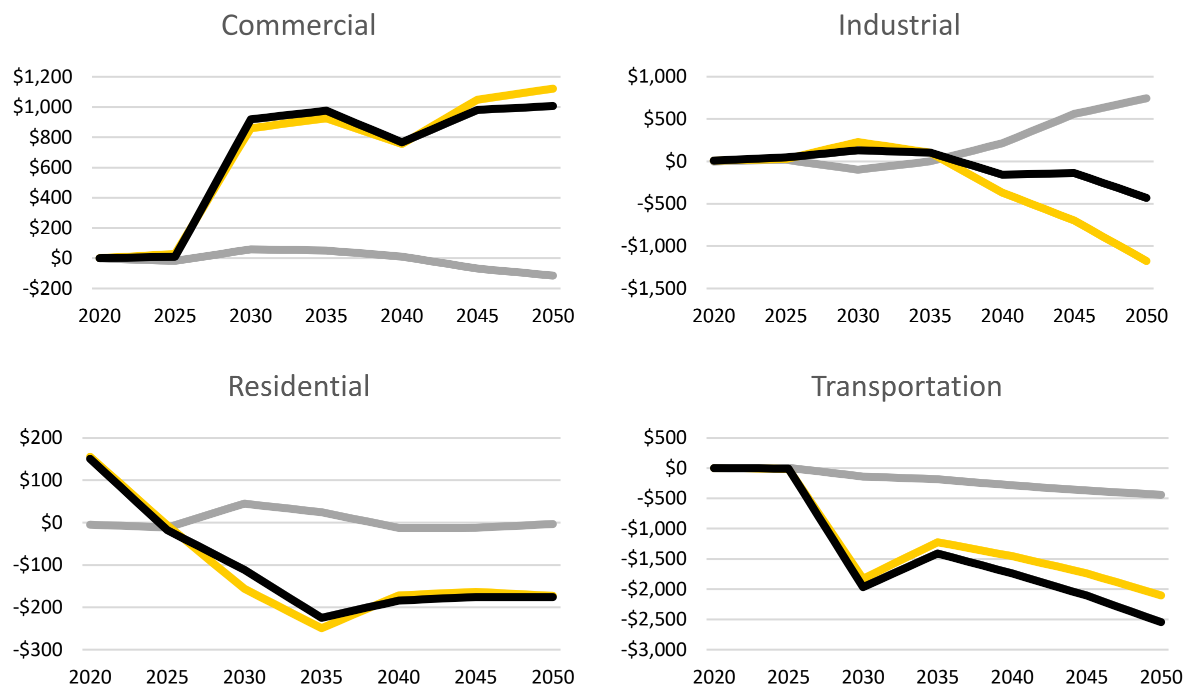
Figure 4: Aggregate Capital and Fuel Cost Scenario Differences



Sources: CGS, MDE, RESI

A closer look at the sectoral distribution of the net costs shows that while aggregate costs overall begin decreasing in 2025, both the commercial and industrial sectors experience increases during that period. Because Maryland is largely a service-providing commercial economy, this sector is particularly influential on overall trends. This is likely driving the employment declines observed through 2030 when commercial costs begin to stabilize again.

Figure 5: Capital and Fuel Cost Scenario Differences by Sector (Millions of Fixed 2023 Dollars)

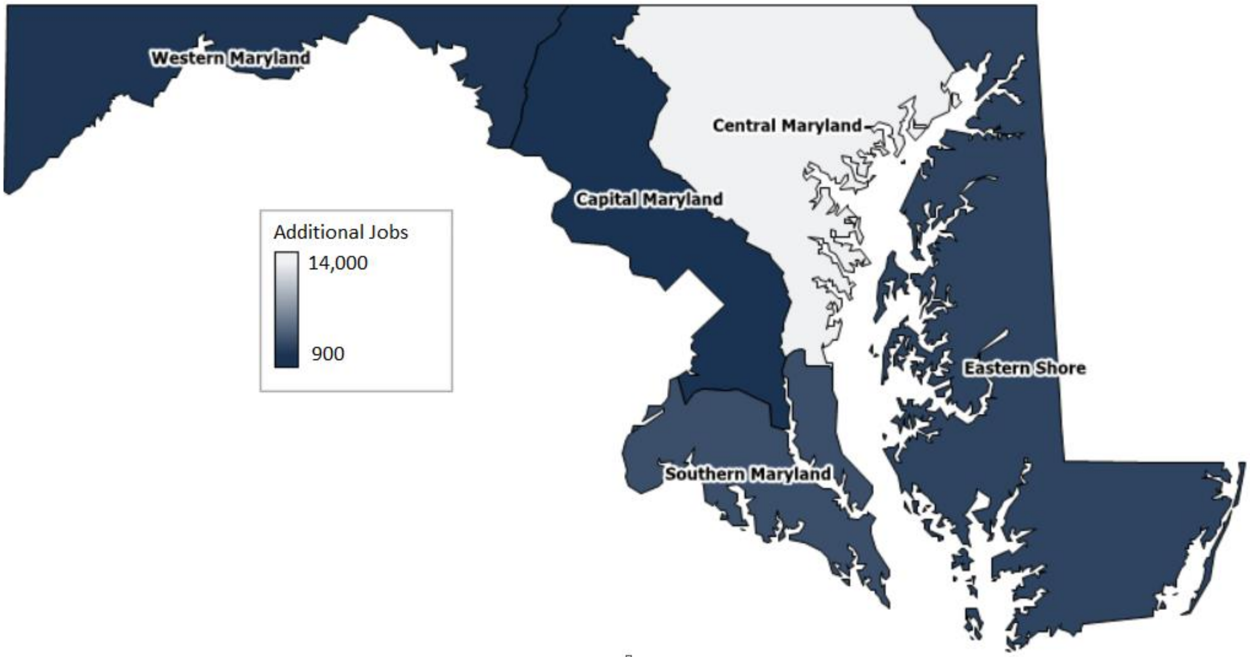


Sources: CGS, MDE, RESI

These impacts also vary geographically. Figure 6 illustrates the additional jobs sustained relative to the reference case in 2040.[10] Central Maryland has the highest number of job gains at 13,433 relative to the reference case while Capital Maryland has the lowest at 932. However, on a percentage basis, the Southern Maryland is expected to gain the most at 1.6 percent in 2040, while the Capital Maryland region has the lowest percentage gain at 0.1 percent.

[10] This year was selected to illustrate the number of jobs supported regionally during the most economically productive period.

Figure 6: Regional Employment Impacts in 2040

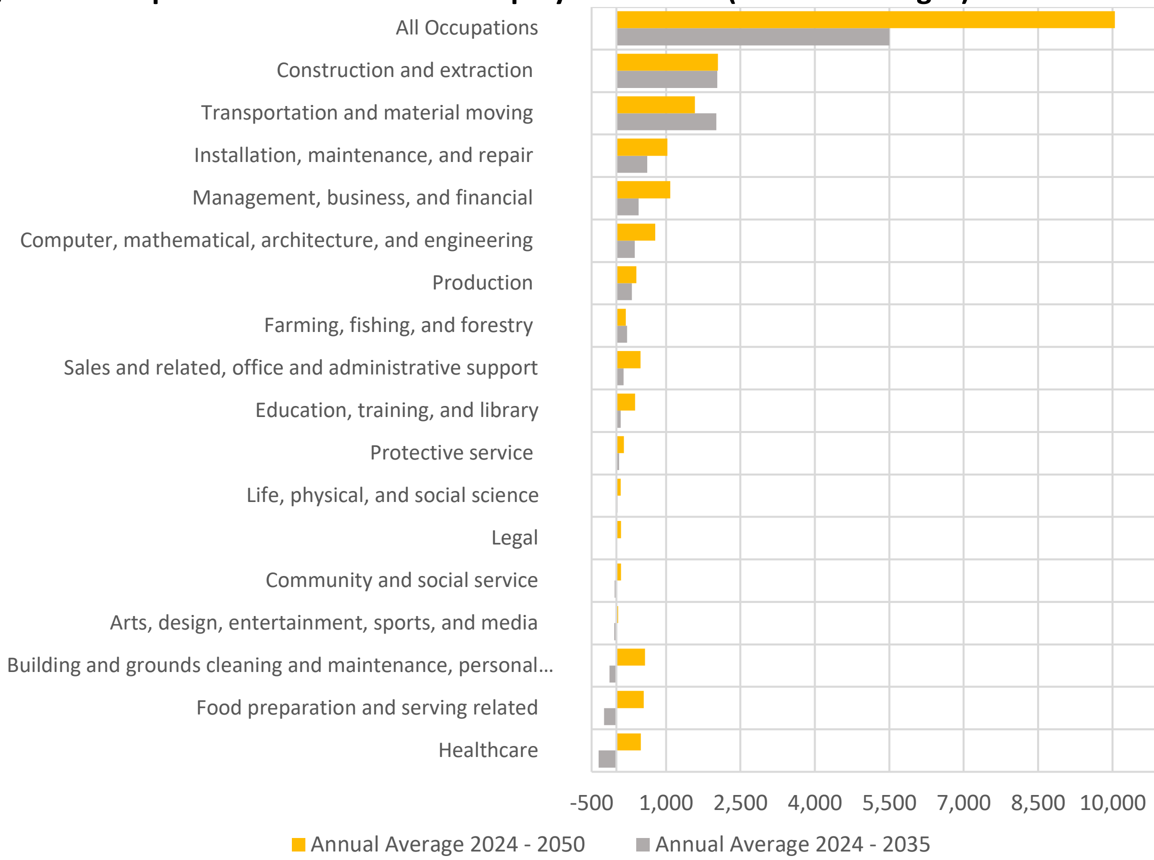


Sources: CGS, MDE, REMI PI+, RESI

These employment impacts can also be disaggregated into major occupation groups, as illustrated in

Figure **7**. Out of the annual average of 5,505 jobs generated through 2035, the majority are concentrated in the *Construction and extraction* (2,033) and *Transportation and material moving* (2,016) occupations. In contrast, occupations that are expected to sustain less jobs compared to the reference case include *Healthcare* (-358), *Food preparation and serving related* (-248), and *Building and grounds cleaning and maintenance, personal care and service* (-139).

Figure 7: Occupational Distribution of Employment Gains (Annual Averages)

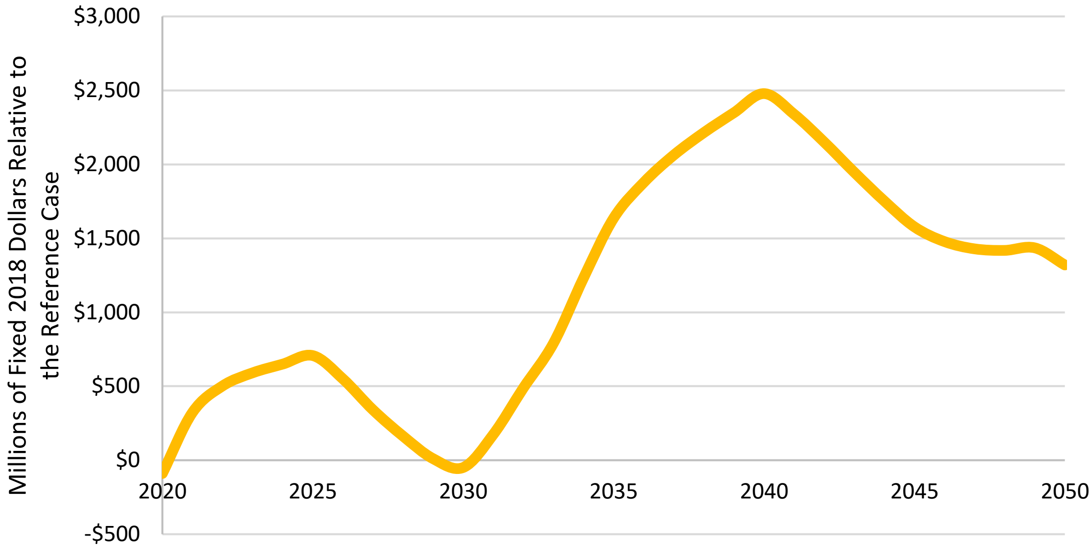


Sources: CGS, MDE, REMI PI+, RESI

Personal Income

Personal income represents the sum of total wages and salaries, supplements, property income, and personal current transfer receipts. These impacts follow a similar—but more muted–trajectory to employment. Between 2024 and 2035, an annual average of $0.6 billion in personal income is added relative to the reference case. Annual impacts peak in 2040 at $2.5 billion, with impacts generally declining through 2050.

Figure 8: Personal Income for Current + Planned Policies Relative to Reference Case

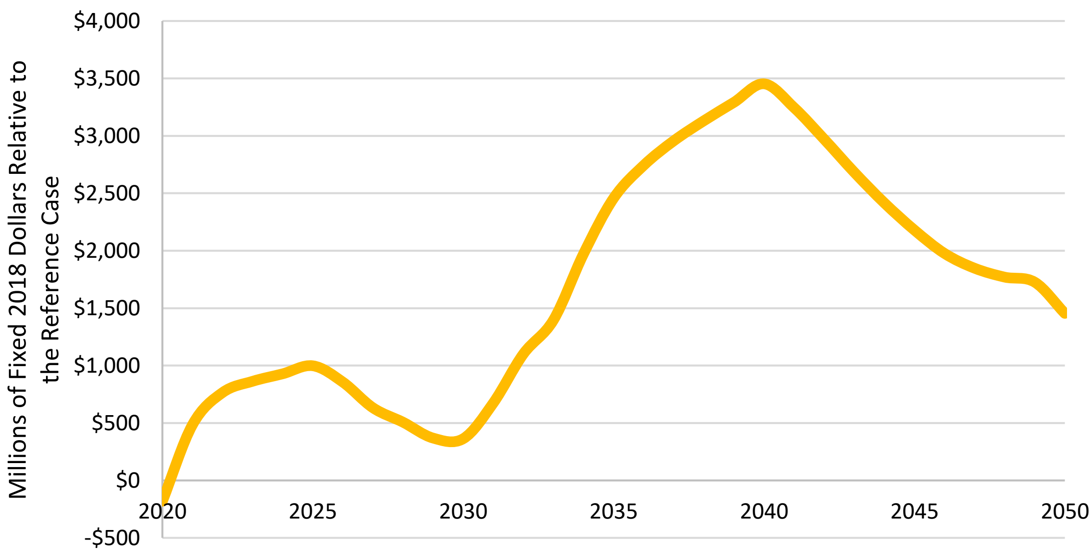


Sources: CGS, MDE, REMI PI+, RESI

Gross State Product

Gross state product (or Gross Domestic Product at the state level) is the value of all final goods and services produced in the state, or the sum of personal consumption expenditures, investment, government spending, and net exports. Over the next decade (2024 to 2035), an average of $1.0 billion will be added to the state's economy relative to the reference case, peaking in 2040 at $3.5 billion.

Figure 9: Gross State Product for Current + Planned Policies Relative to Reference Case

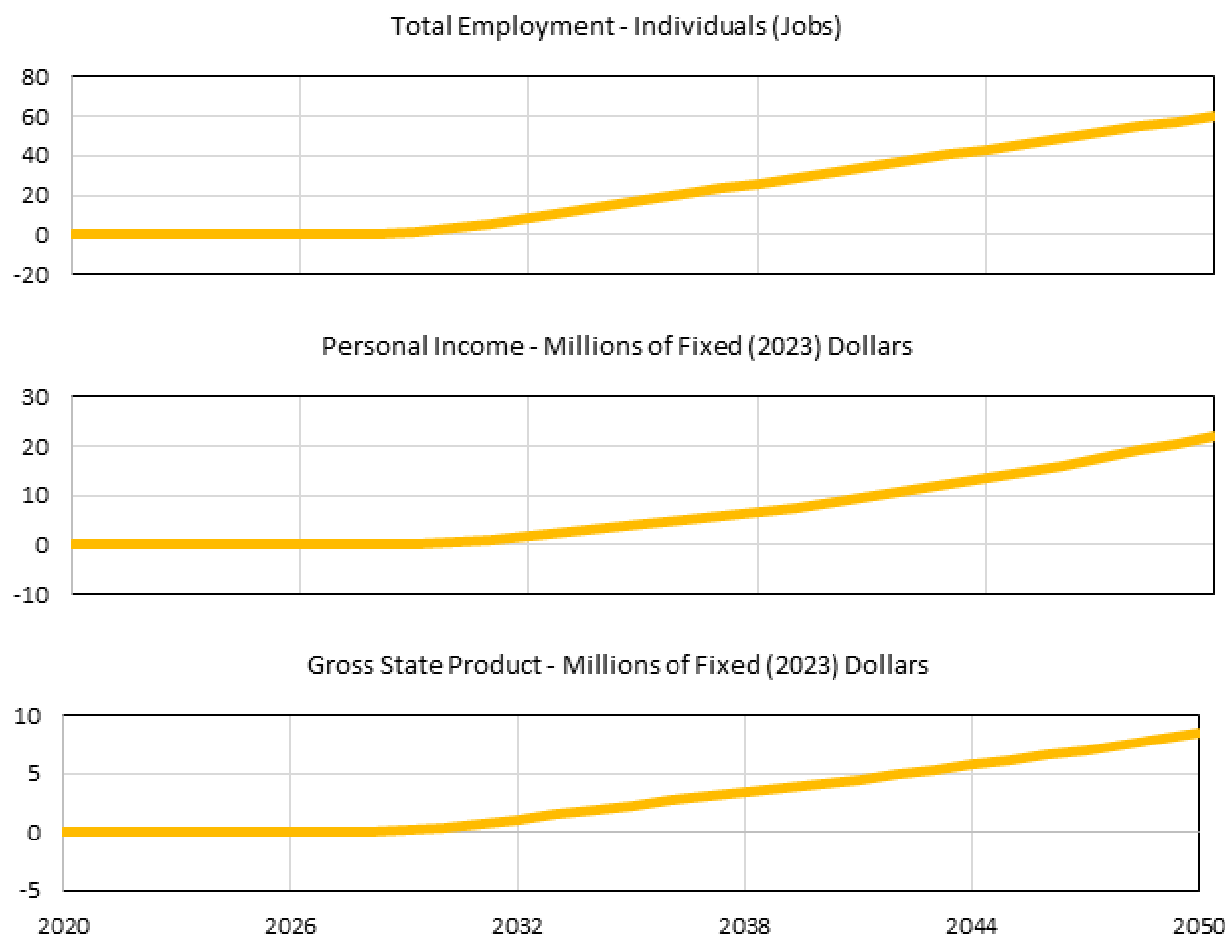


Sources: CGS, MDE, REMI PI+, RESI

4.2 Health Impacts

In addition to the broader economic impacts, RESI estimated the economic value of the reductions in emissions alone. By 2050, this will sustain over 60 jobs, almost $22.2 million in additional personal income, and $8.4 million added to gross state product. As seen in Figure 10, all three economic indicators follow a similar trajectory—relatively flat through 2030, then linearly accelerating through 2050.

Figure 10: Health Impacts for Current + Planned Policies Relative to Reference Case



Sources: CGS, MDE, REMI PI+, COBRA, RESI

One limitation of the REMI model is that it does not account for the associated value of mortality avoided from emissions reductions. Figure 11 presents the number of premature deaths prevented along with the associated value of that mortality.[11] On average, 11 deaths can be avoided through 2035 at an associated value of approximately $86 million, and 25 deaths can be avoided through 2050, valued at around $155 million. The cumulative estimated

[11] To calculate this value, RESI uses the Valuation of Statistical Life (VSL) to estimate the forgone mortality associated with the emissions reductions.

value of avoided mortality benefits is approximately $950 million through 2035, and over $4 billion through 2050.

Figure 11: Valuation of Avoided Mortality by Year

Year	Mortality Avoided	Estimated Value[12]
2025	-1	-$5,461,971
2026	0	$549,124
2027	1	$9,475,834
2028	2	$21,048,233
2029	4	$36,818,767
2030	11	$97,271,452
2031	15	$124,188,112
2032	18	$147,878,625
2033	21	$168,553,980
2034	22	$171,432,791
2035	24	$177,734,667
2036	25	$181,550,082
2037	27	$185,078,709
2038	28	$188,331,505
2039	29	$190,114,560
2040	32	$201,473,680
2041	33	$206,086,079
2042	35	$210,142,163
2043	37	$213,673,826
2044	38	$213,483,446
2045	39	$214,081,219
2046	40	$213,996,305
2047	41	$213,781,316
2048	42	$213,442,545
2049	43	$212,685,480
2050	45	$211,819,829
Annual Average, 2025 - 2035	**11**	**$86,317,238**
Annual Average, 2025 - 2050	**25**	**$154,585,783**
Cumulative Sum, 2025 - 2035	**-**	**$949,489,614**
Cumulative Sum, 2025 - 2050	**-**	**$4,019,230,357**

Sources: CGS, COBRA, MDE, RESI

5.0 Review of Select Topics

In addition to the quantitative analysis performed in the current report, several topics were identified for further discussion per requirements of the CSNA. These include how Maryland's

[12] Because COBRA returns nominal values, RESI used the net present value with a 3 percent discount rate. The short-term and long-term statistical summaries thus reflect the cumulative sum for 2025 to 2035 and 2025 to 2050, respectively.

greenhouse gas (GHG) reduction policies could impact the commercial aviation and agricultural industries in the state, how low- and moderate-income households are affected, and health and mortality benefits resulting from GHG mitigation policies. Each of these topics is outlined below.

Ability to Attract, Expand, and Retain Industries: Commercial Aviation

Greenhouse gases (GHG) produced by commercial aviation represent approximately 10 percent of transportation emissions and 3 percent of total emissions in the U.S.[13] While it was not the most substantial source overall, the highest and fastest growth category of individual GHG emissions prior to the COVID-19 pandemic was passenger air travel.[14] In 2016, the International Civil Aviation Organization (ICAO) accepted the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), a strategic plan designed to stabilize emissions at 2019 levels through offsetting measures while developing new technologies.[15] In 2021 and 2022, the U.S. Environmental Protection Agency (EPA) set GHG emission and particulate matter (PM) standards, respectively, that matched those set by the ICAO.[16] However, these standards have been criticized for not reducing emissions in a meaningful way.[17]

In October 2021, International Air Transport Association (IATA) member airlines passed a "Fly Net Zero" resolution that commits to achieving net-zero operational carbon emissions by 2050.[18] There are several avenues by which the aviation industry is seeking to reduce the environmental impact of flights, including the use of emerging technologies such as sustainable aviation fuels (SAFs), electric aircraft, and hydrogen-powered aircraft.[19] The IATA anticipates that SAFs will have the greatest impact in achieving Fly Net Zero goals by 2050, accounting for 65 percent of the reduction in emissions.[20] This is followed by offsets and carbon capture (19 percent), electric and hydrogen technologies (13 percent), and improved infrastructure and operational efficiencies (3 percent).[21]

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[13] Jeff Overton, "Issue Brief: The Growth in Greenhouse Gas Emissions from Commercial Aviation," Environmental and Energy Study Institute (2019, Revised June 2022): 1, accessed May 15, 2023, https://www.eesi.org/papers/view/fact-sheet-the-growth-in-greenhouse-gas-emissions-from-commercial-aviation.
[14] Overton, "Issue Brief: The Growth in Greenhouse Gas Emissions from Commercial Aviation," 1.
[15] Stefan Ellerbeck, "The Aviation Sector Wants to Reach Net Zero by 2050. How Will It Do It?" World Economic Forum, December 9, 2022, accessed May 23, 2023, https://www.weforum.org/agenda/2022/12/aviation-net-zero-emissions/.
[16] Paige Kendrick, "The Environmental Injustice in Aviation Emissions," The Georgetown Environmental Law Review, February 6, 2023, accessed May 23, 2023, https://www.law.georgetown.edu/environmental-law-review/blog/872/.
[17] Sungjoo Ahn, "EPA's New Aviation Emissions Standard: Why It's Already Obsolete," Harvard Law School Environmental and Energy Law Program, February 25, 2021, accessed May 23, 2023, https://eelp.law.harvard.edu/2021/02/epas-aviation-emissions-standard/.
[18] "Our Commitment to Fly Net Zero by 2050," International Air Transport Association, accessed May 22, 2023, https://www.iata.org/en/programs/environment/flynetzero/.
[19] Ellerbeck, "The Aviation Sector Wants to Reach Net Zero by 2050. How Will It Do It?"
[20] "Our Commitment to Fly Net Zero by 2050," International Air Transport Association.
[21] "Our Commitment to Fly Net Zero by 2050," International Air Transport Association.

The complexity and high costs of SAFs have limited their use in the aviation industry, although this has been changing in recent years. In 2015, the quantity of SAF purchased by U.S. airlines was near zero, but had increased to approximately 4.5 million gallons in 2020.[22] Over the next several decades, the production and use of SAFs is expected to increase substantially and make the fuel more accessible to the aviation industry.[23] In 2021, the U.S. Department of Energy, Department of Transportation, and Department of Agriculture, along with other government agencies, launched the Sustainable Aviation Fuel Grand Challenge seeking to accelerate SAF production and meet 100 percent of aviation fuel demand by 2050.[24] The challenge includes goals of producing 3 billion gallons annually by 2030, and expanding to 35 billion gallons annually by 2050.[25]

According to the U.S. Department of Energy, an estimated 1 billion tons of biomass can be sustainably collected annually in the U.S.[26] These biomass products—such as corn grain, oil seeds, agricultural residues, and wood mill waste—could produce an estimated 50 to 60 billion gallons of low-carbon SAFs each year. This would be sufficient to not only meet projected aviation fuel demand, but also support other modes of transportation and produce bioproducts and renewable chemicals.[27] One example of renewable jet fuel production can be found outside Houston, Texas, where Neste U.S. and Texmark Chemicals are producing fuel made from used cooking oil and waste from animal and vegetable processing plants.[28] Although production is currently modest, Neste is the largest producer of renewable jet fuels in the world and expects that their production will grow from 1 million tons annually to 1.5 million tons by the start of 2024.[29] In Maryland, Baltimore/Washington International (BWI) Thurgood Marshall Airport has launched an initiative to collect used cooking oil from its 50 hospitality partners and use it as SAF inputs.[30] The initiative is part of the Solution Zero project that aims to achieve zero-waste and zero-cost operations at BWI.

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[22] Bijay P. Sharma, et al., "Economic Analysis of Developing a Sustainable Aviation Fuel Supply Chain Incorporating with Carbon Credits: A Case Study of the Memphis International Airport," *Frontiers in Energy Research* Volume 9, (December 2021): 2, accessed June 5, 2023, https://www.frontiersin.org/articles/10.3389/fenrg.2021.775389/full.
[23] Axel Esqué, Robin Riedel, and Daniel Riefer, "Reducing Aviation Emissions Over the Long and Short Run," McKinsey & Company, June 22, 2021, accessed May 15, 2023, https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/future-air-mobility-blog/reducing-aviation-emissions-over-the-long-and-short-haul.
[24] "Sustainable Aviation Fuel Grand Challenge," U.S. Department of Energy, accessed June 13, 2023, https://www.energy.gov/eere/bioenergy/sustainable-aviation-fuel-grand-challenge.
[25] "Sustainable Aviation Fuel Grand Challenge," U.S. Department of Energy.
[26] "Sustainable Aviation Fuels," U.S. Department of Energy, accessed May 22, 2023, https://www.energy.gov/eere/bioenergy/sustainable-aviation-fuels.
[27] "Sustainable Aviation Fuels," U.S. Department of Energy.
[28] Niraj Chokshi and Clifford Krauss, "A Big Climate Problem with Few Easy Solutions: Planes," *New York Times*, June 2, 2021, accessed June 5, 2023, https://www.nytimes.com/2021/05/28/business/energy-environment/airlines-climate-planes-emissions.html.
[29] "Neste MY Sustainable Aviation Fuel," Neste, accessed June 5, 2023, https://www.neste.com/products/all-products/saf.
[30] Elizabeth Baker, "BWI Thurgood Marshall Airport to Recycle Cooking Oil into Sustainable Aviation Fuel," Passenger Terminal Today, March 10, 2023, accessed June 5, 2023, https://www.passengerterminaltoday.com/news/sustainability/bwi-thurgood-marshall-airport-to-recycle-cooking-oil-into-sustainable-aviation-fuel.html.

In addition to the emission reductions from using SAFs, there is potential to gain additional economic and environmental benefits. Farmers have the opportunity to increase their revenue by producing biomass crops, while also mitigating erosion and improving soil quality.[31] Research is being conducted on agricultural byproducts—such as leftover biomass from corn harvesting and poplar wood from tree farms—to evaluate potential production of large quantities of SAF that yield additional economic benefits for farmers and rural communities.[32] The use of wet wastes—such as animal manure and wastewater sludge—can alleviate pollution to watershed areas while simultaneously reducing methane emissions.[33]

The impact that State regulations will have on commercial aviation will depend on how much they differ from federal and international regulations. However, due to the interconnected nature of both domestic and international air travel, it is more likely that national and global standards will be the drivers of industry change, rather than any one individual state. Notably, state-level regulations that impact ground activities at airports have the potential to affect operations more quickly. Emission-mitigating efforts could include the conversion of ground fleets to electric vehicles, on-site clean energy generation, building electrification, and improving water and energy efficiency.[34]

Ability to Attract, Expand, and Retain Industries: Agriculture

Farmers have an important role in the reduction of GHG emissions and adapting to climate change. Maryland's 2020 GHG inventory showed that the agricultural industry was responsible for 4 percent of all GHG emissions across the state, including 16 percent of methane and 74 percent of nitrous oxide emissions released.[35] As climate change advances, farmers are also experiencing effects of new weather patterns that include increasing temperatures, later frosts, and extreme storms producing heavy rainfalls that damage crops and wash away soil and fertilizers.[36] Additionally, rising sea levels are impacting coastal farmers through saltwater intrusion and making thousands of acres unsuitable for farming.[37]

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[31] "Sustainable Aviation Fuels," U.S. Department of Energy.
[32] "Sustainable Aviation Fuels: A Pathway to Economic Opportunity and a Low Carbon Future," University of Washington, College of the Environment, September 28, 2021, accessed June 5, 2023, https://environment.uw.edu/news/2021/09/sustainable-aviation-fuels-a-pathway-to-economic-opportunity-and-a-low-carbon-future/.
[33] "Sustainable Aviation Fuels," U.S. Department of Energy.
[34] Kevin DeGood, "Reducing Airport Greenhouse Gas Emissions Through Renewable Energy Generation and Demand Reduction," Center for American Progress, June 21, 2022, accessed May 30, 2023, https://www.americanprogress.org/article/reducing-airport-greenhouse-gas-emissions-through-renewable-energy-generation-and-demand-reduction/.
[35] "Greenhouse Gas Inventory," Maryland Department of the Environment, accessed June 5, 2023, https://mde.maryland.gov/programs/air/climatechange/pages/greenhousegasinventory.aspx.
[36] "Maryland Climate-Smart Ag," University of Maryland, College of Agriculture and Natural Resources, accessed June 5, 2023, https://agnr.umd.edu/research/research-and-education-centers-locations/harry-r-hughes-center-agro-ecology/maryland.
[37] Bill Lambrecht and Gracie Todd, "Coastal Farmers in Maryland and Across Mid-Atlantic Being Driven Off Their Land as Salt Poisons the Soil," *The Baltimore Sun*, December 15, 2020, accessed June 5, 2023, https://www.baltimoresun.com/news/environment/bs-md-coastal-farmers-salt-poisons-soil-20201215-jdzgwdv72nd6zbtnr74majvpui-story.html.

In Maryland, approximately 32 percent of all land is used for agricultural purposes. The industry produced $8.3 billion in the state's economy in 2021, with a roughly even split between field crops and animal agriculture.[38] According to the U.S. Department of Agriculture, the top revenue generating crops in the state were broiler chickens, corn, and soybeans.[39] Cultivation of these crops brings new challenges as climate change progresses. For example, poultry farming is expected to become increasingly difficult as farmers pay for increased cooling costs during summer months and contend with increased mortality and salmonella rates as temperatures rise.[40] Although research on soybeans has attempted to breed salt-resistant strains, efforts have not yet been successful. This is a particular concern for farmers in Maryland's lower Eastern Shore region, where approximately 85,000 acres were planted in 2019.[41]

As part of the State's Greenhouse Gas Reduction Act (GGRA) Plan, several programs are aimed at modifying agricultural practices to reduce emissions and increase GHG sequestration in soil. The Maryland Healthy Soils Initiative seeks to "improve the health, yield, and profitability of Maryland's soils and promote the further adoption of conservation practices that foster soil health while increasing sequestration capacity."[42] Soils have the ability to store three times more carbon than the atmosphere, which means that even a modest increase in soil carbon can represent a substantial tool to reduce atmospheric carbon dioxide levels.[43] Not only do these practices generate environmental benefits, but they can also increase agricultural yields and soil nutrient retention.[44]

The recent Climate Solutions Now Act includes a provision that at least $0.5 million be included in the annual budget between fiscal year (FY) 2024 through FY 2028 for the Maryland Healthy Soils Program.[45] Current law also requires that the Maryland Department of Agriculture provides "incentives, including research, education, technical assistance, and, subject to available funding, financial assistance to farmers to implement farm management practices that contribute to healthy soils."[46] Financial assistance is available through the Healthy Soils

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[38] Adam Bednar, "Future of Md. Agriculture Linked to Climate Change, Reducing Pollution," *The Daily Record*, December 29, 2022, accessed June 5, 2023, https://thedailyrecord.com/2022/12/29/future-of-md-agriculture-linked-to-climate-change-reducing-pollution/.
[39] "Agriculture," Maryland.gov, accessed June 5, 2023, https://msa.maryland.gov/msa/mdmanual/01glance/html/agri.html.
[40] Maryland Department of the Environment, "The Greenhouse Gas Emissions Reduction Act 2030 GGRA Plan," 13, accessed June 5, 2023, https://mde.maryland.gov/programs/air/ClimateChange/Documents/2030%20GGRA%20Plan/THE%202030%20GGRA%20PLAN.pdf.
[41] Lambrecht and Todd, "Coastal Farmers in Maryland and Across Mid-Atlantic Being Driven Off Their Land as Salt Poisons the Soil."
[42] Maryland Department of the Environment, "The Greenhouse Gas Emissions Reduction Act 2030 GGRA Plan," 49.
[43] Tom Croghan, "America's Farmers Can Fight Climate Change," *Baltimore Sun*, May 24, 2019, accessed May 16, 2023, https://www.baltimoresun.com/opinion/op-ed/bs-ed-op-0527-farmers-20190524-story.html.
[44] Croghan, "America's Farmers Can Fight Climate Change."
[45] "Maryland SB528, Climate Solutions Now Act of 2022," TrackBill, 16, accessed June 5, 2023, https://trackbill.com/bill/maryland-senate-bill-528-climate-solutions-now-act-of-2022/2210814/.
[46] "Maryland SB528, Climate Solutions Now Act of 2022," TrackBill, 17.

Competitive Fund for agricultural practices that include (but are not limited to) use of cover crops, conservation tillage, conservation cover, conservation crop rotation, nutrient management, and integrated pest management.[47] This program provides up to $50,000 for qualifying farmers to adopt these types of soil health or agroforestry practices.[48]

While there are both economic and environmental benefits of these state regulations, implementation and adherence to these standards are not without their own challenges. It can be difficult to persuade farmers to modify long-running practices and undertake additional risks, particularly if these efforts incur new costs. Customization of soil enhancement and sequestration methods can be very specific to locations and crops, necessitating adaptations that require additional resources.[49] Education and research are crucial to making these changes not only economically feasible, but also financially beneficial to farmers. Research efforts in Maryland and across the country aim to provide farmers with new information and technologies that help to reach environmental goals while helping farmers mitigate negative impacts from climate change on their crops and bottom-line finances.

For example, the Maryland Climate-Smart Ag Project is focused on research that simultaneously predicts impacts of climate change on agricultural production systems while developing tools and strategies to keep the state's agricultural industry viable.[50] Researchers from Maryland, Delaware, and Virginia are evaluating crops for their salt tolerance as saltwater intrusion moves further inland and becomes more problematic for coastal farmers.[51] As well as creating difficult conditions for crops, the salt and wet conditions can prompt release of stored phosphorus and nitrogen from the soil and pollute both surface and groundwaters.[52] Additionally, researchers at the University of Maryland are working on gene editing that increases the resiliency of crops against drought, infestations, and disease.[53]

Efforts made by researchers and farmers thus far have produced positive results. In 2021, a four-year project funded by the National Fish and Wildlife Foundation concluded that aimed to increase and accelerate the use of improved fertilizer application practices in the Chesapeake Bay region.[54] Through the project efforts—which involved approximately 1,477 farmers and more than 1,300 agribusiness and partners—nitrogen and phosphorus use was decreased by an

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[47] "Soil Health Information," Maryland Department of Agriculture, accessed June 6, 2023, https://mda.maryland.gov/resource_conservation/Pages/Soil-Health.aspx.
[48] "Soil Health Information," Maryland Department of Agriculture.
[49] Croghan, "America's Farmers Can Fight Climate Change."
[50] "Maryland Climate-Smart Ag," University of Maryland, College of Agriculture and Natural Resources.
[51] Lambrecht and Todd, "Coastal Farmers in Maryland and Across Mid-Atlantic Being Driven Off Their Land as Salt Poisons the Soil."
[52] Lambrecht and Todd, "Coastal Farmers in Maryland and Across Mid-Atlantic Being Driven Off Their Land as Salt Poisons the Soil."
[53] Bednar, "Future of Md. Agriculture Linked to Climate Change, Reducing Pollution."
[54] "Regenerative Agriculture in Maryland," The Nature Conservancy, last updated May 17, 2023, accessed June 5, 2023, https://www.nature.org/en-us/about-us/where-we-work/united-states/maryland-dc/stories-in-maryland-dc/mddc-how-we-work-agriculture/.

estimated 913,000 pounds and 23,000 pounds, respectively, across 46,000 acres.[55] Case studies of farms that implemented soil conservation practices such as reduced or no-till, nutrient management, and cover crop use gained an average of $37 per acre annually in revenue.[56] As research continues to provide new information and tools, the aim is to make implementation of best practices more widespread for those in the agricultural industry. This would not only yield environmental benefits, but also provide farmers with buffers against climate change shocks and additional financial gains.

Impacts on Rural, Low- and Moderate-Income, or Minority Electricity Ratepayers

When setting climate goals and regulations to lower GHG emissions, it is important to recognize that all households are not impacted equally by these changes. In Maryland, approximately 20 percent of all households are considered low income, based on 200 percent of the Federal Poverty Level.[57] Low-income Marylanders spend an average of 12 percent of their income on energy costs, compared to approximately 2 percent for all state residents.[58] Given these income disparities, it can be very difficult for low- and moderate-income households across the state to implement energy-saving opportunities such as weatherization, rooftop solar, and building electrification.[59] Therefore, it is increasingly important to provide equitable assistance to these households as Maryland pushes towards GHG reductions and climate goals to ensure no Marylanders are left behind in these efforts and their associated benefits.

Maryland has several existing programs that aim to help low-income households with energy costs, including the Maryland Energy Assistance Program, the Electric Universal Service Program, and Arrearage Retirement Assistance.[60] These programs assist residents with paying home heating and energy bills, and can also help to alleviate burdens from past-due energy accounts. The EmPOWER Maryland Limited Income Energy Efficiency Program provides energy efficiency upgrades to qualifying household that reduce their energy costs.[61] Examples of efficiency improvements include insulation for attics, floors, and walls; hot water system improvements; lighting retrofits; and furnace cleaning, tuning, and safety repairs.[62]

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[55] "Regenerative Agriculture in Maryland," The Nature Conservancy.
[56] Chesapeake Bay Foundation, "Farm Forward," 2-3, accessed May 16, 2023, https://www.cbf.org/document-library/cbf-reports/farm-forward-report.pdf.
[57] Earth Justice, "Electrification and Building Upgrades for Low-Income Residences," 2, accessed May 16, 2023, https://earthjustice.org/wp-content/uploads/20230123_marylandreport.pdf.
[58] Earth Justice, "Electrification and Building Upgrades for Low-Income Residences," 3.
[59] Earth Justice, "Electrification and Building Upgrades for Low-Income Residences," 2.
[60] "OHEP Programs," BGE, accessed June 6, 2023, https://www.bge.com/MyAccount/CustomerSupport/Pages/OHEP-Programs.aspx.
[61] "EmPOWER Maryland Limited Income Energy Efficiency Program," Maryland Department of Housing and Community Development, accessed June 6, 2023, https://dhcd.maryland.gov/Residents/Pages/lieep/default.aspx.
[62] "EmPOWER Maryland Limited Income Energy Efficiency Program," Maryland Department of Housing and Community Development.

Additionally, several programs are available for multifamily housing developments based on income, building type, and location requirements.[63]

Despite the programs designed to reduce energy transition burdens on low- and moderate-income residents, challenges and barriers remain in efforts to reach eligible households. According to an analysis conducted by the Department of Housing and Community Development, roughly 30 percent of potential weatherization customers were deferred from the State's EmPOWER Program between January 2018 and March 2020.[64] The dominant reason for these deferrals was that other repairs were required before weatherization could be completed. One potential remedy for this issue may be the creation of a single platform to address any pre-service repairs and have a "one-stop shop" or "whole-home approach" to better serve Marylanders.[65] There are also issues with awareness of the EmPOWER program, with approximately 75 percent of single-family applicants being repeat candidates.[66] Additionally, differing incentives between property owners and renters can limit the willingness of owners to make investments in energy efficiency, as the primary beneficiaries are the renters paying utility bills. To better reach these renters—who represent approximately 60 percent of low-income households in the state—incentives may need to be reconfigured to increase participation from property owners.[67]

In their Energy Plan for 2022, the Maryland Energy Administration (MEA) emphasized the importance of equitable and reliable access to clean energy for all Marylanders.[68] While this report details the State's commitment to assist low- to moderate-income households with energy costs and access to energy efficiency, there are opportunities to expand their reach and effectiveness.[69] One of the action items detailed in the 2022 report calls out the need to improve energy equity across the state. The report specifically notes the recent establishment of a diversity, equity, and inclusion (DEI) Committee to "promote and expand DEI goals and initiatives in its incentive programs, and in its day-to-day operations, which will be core to FY23 program planning and beyond."[70]

Both state and federal funds are available to support Maryland's GHG-reduction policies and improve energy efficiency. Maryland funding includes EmPOWER ratepayer surcharges, auction proceeds from the Regional Greenhouse Gas Initiative, and budget appropriations from the

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[63] "Multifamily Energy Efficiency and Housing Affordability Program," Maryland Department of Housing and Community Development, accessed June 6, 2023, https://dhcd.maryland.gov/HousingDevelopment/Pages/EnergyEfficiencyWeatherization.aspx.
[64] Earth Justice, "Electrification and Building Upgrades for Low-Income Residences," 4-5.
[65] Earth Justice, "Electrification and Building Upgrades for Low-Income Residences," 6.
[66] Earth Justice, "Electrification and Building Upgrades for Low-Income Residences," 5.
[67] Earth Justice, "Electrification and Building Upgrades for Low-Income Residences," 5.
[68] Maryland Energy Administration, "Energy Plan for 2022," 14-15, accessed June 13, 2023, https://energy.maryland.gov/Reports/MEA%20Energy%20Plan%202022.pdf.
[69] Maryland Energy Administration, "Energy Plan for 2022," 64-65.
[70] Maryland Energy Administration, "Energy Plan for 2022," 119.

Maryland Climate Solutions Now Act.[71] Approximately $250 million in federal funding and incentives is available to Maryland from the Infrastructure Investment and Jobs Act, and the Inflation Reduction Act (IRA) for residential energy efficiency upgrades and electrification.[72] Individual homeowners, home builders, and commercial building owners can also take advantage of federal tax credits and deductions for energy efficiency through the IRA.[73] While additional funds may become available over time, these federal and state funds can be used to bolster near-term accessibility of energy efficiency improvements to low- and moderate-income households.

Health and Mortality Benefits Resulting from Maryland GHG-Reduction Policies

The social costs of GHG emissions can be challenging to quantify, as they include a broad array of factors such as health and mortality, property damages, environmental migration, and risk of conflict.[74] However, during policy-making processes, it is important to consider how a change in GHGs impacts many aspects of life. This subsection will summarize how Maryland's GHG reduction policies have the potential to improve health and mortality and provide current estimates on the quantification of these benefits.

Several negative health effects are associated with rising temperatures and extreme weather events including cardiovascular and respiratory issues, food and waterborne illnesses, infectious diseases, and motor vehicle accidents.[75] While no groups are immune from exposure impacts, certain populations are more at risk of adverse effects including those living in poverty; residents of coastal or floodplain areas; children, older adults, pregnant and breastfeeding women; and those with chronic medical conditions.[76] A 2016 report released by the Maryland Department of Health and Mental Hygiene and the Maryland School of Public Health outlined the health burden imposed by climate change predictions for the state.[77] According to the report, extreme heat and precipitation events in the state are expected to increase the risk of Salmonella and Campylobacter infections, increased risk of hospitalizations for heart attacks and asthma, and cause a greater risk of motor vehicle accidents.[78]

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[71] Earth Justice, "Electrification and Building Upgrades for Low-Income Residences," 11.

[72] Earth Justice, "Electrification and Building Upgrades for Low-Income Residences," 8.

[73] "Federal Income Tax Credits and Incentives for Energy Efficiency," Energy Star, December 30, 2023, accessed December 11, 2023, https://www.energystar.gov/about/federal_tax_credits.

[74] Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide: Interim Estimates Under Executive Order 13990," 2, accessed June 12, 2023, https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

[75] Maryland Department of the Environment, "The Greenhouse Gas Emissions Reduction Act 2030 GGRA Plan," 5-6.

[76] "Climate Change and Health: Who's Most at Risk," U.S. Environmental Protection Agency, accessed June 12, 2023, https://www.epa.gov/climateimpacts/climate-change-and-human-health-whos-most-risk.

[77] Maryland Institute for Applied Environmental Health, University of Maryland School of Public Health College Park, "Maryland Climate and Health Profile Report," accessed June 12, 2023, https://mde.maryland.gov/programs/Marylander/Documents/MCCC/Publications/Reports/MarylandClimateandHealthProfileReport.pdf.

[78] Maryland Institute for Applied Environmental Health, "Maryland Climate and Health Profile Report," 8.

Despite global health issues being recognized as one of the greatest threats from climate change, quantification of both negative effects and benefits of mitigation are still somewhat limited and often concentrate on specific factors.[79] For example, one study completed by the Maryland Department of the Environment—focused on air quality improvements from State policies—estimated health benefits at approximately $40 million annually.[80] These estimates are primarily comprised of reductions in the number of lost workdays associated with respiratory and cardiovascular illnesses. In addition to combating climate change through GHG-reduction policies, the Maryland Commission on Climate Change has suggested that the State implement a "Ready-Set-Go framework" for public health needs.[81] This framework would facilitate early warnings systems for seasonal changes when possible (Ready phase), adjust resources and personnel needs for sub-seasonal changes (Set phase), and prompt any needed evacuation, provisions of aid, or open shelters for short-range changes (Go phase).[82]

[79] R. Daniel Bressler, "The Mortality Cost of Carbon," *Nature Communications* Volume 12, 4667 (2021): 2, accessed June 5, 2023, https://www.nature.com/articles/s41467-021-24487-w.
[80] Bryan P. Sears, "Poll: About 60% of Marylanders Oppose Plan to Mandate Electric Car Sales by 2035," *Maryland Matters*, June 12, 2023, accessed June 12, 2023, https://www.marylandmatters.org/2023/06/12/poll-about-60-of-marylanders-oppose-plan-to-mandate-electric-car-sales-by-2035/.
[81] Maryland Commission on Climate Change, "2022 Annual Report," 24, accessed June 12, 2023, https://mde.maryland.gov/programs/air/ClimateChange/MCCC/Documents/2022%20Annual%20Report%20-%20Final%20%284%29.pdf.
[82] Maryland Commission on Climate Change, "2022 Annual Report," 24.

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Appendix A—Detailed Data Tables

Figure 12: Detailed Economic Impacts for Current + Planned Policies Relative to the Reference Scenario

Year	Employment	Personal Income, Millions of Fixed 2023 Dollars	Gross State Product, Millions of Fixed 2023 Dollars
2020	-796	-$90	-$181
2021	4,921	$323	$485
2022	7,215	$502	$765
2023	7,760	$591	$863
2024	8,031	$650	$929
2025	8,329	$707	$998
2026	5,822	$550	$856
2027	2,976	$340	$632
2028	1,374	$163	$507
2029	-313	$10	$368
2030	-700	-$49	$363
2031	1,860	$174	$674
2032	5,209	$488	$1,101
2033	7,203	$791	$1,396
2034	11,420	$1,232	$1,973
2035	14,850	$1,636	$2,457
2036	16,706	$1,877	$2,743
2037	17,953	$2,063	$2,957
2038	18,859	$2,215	$3,131
2039	19,611	$2,349	$3,292
2040	20,322	$2,478	$3,453
2041	18,072	$2,339	$3,245
2042	15,635	$2,150	$2,971
2043	13,318	$1,946	$2,683
2044	11,310	$1,752	$2,416
2045	9,650	$1,577	$2,179
2046	8,963	$1,478	$1,976
2047	8,742	$1,429	$1,848
2048	8,829	$1,419	$1,770
2049	9,103	$1,436	$1,726
2050	8,170	$1,320	$1,454
Average 2020 - 2035	**5,323**	**$501**	**$887**
Average 2020 - 2050	**9,368**	**$1,156**	**$1,678**

Sources: CGS, MDE, REMI PI+, RESI

Figure 13: Detailed Health Impacts for Current + Planned Policies Relative to the Reference Scenario

Year	Employment	Personal Income, Millions of Fixed 2023 Dollars	Gross State Product, Millions of Fixed 2023 Dollars
2020	0	$0	$0
2021	0	$0	$0
2022	0	$0	$0
2023	0	$0	$0
2024	0	$0	$0
2025	0	$0	$0
2026	0	$0	$0
2027	0	$0	$0
2028	0	$0	$0
2029	1	$0	$0
2030	3	$1	$0
2031	6	$1	$1
2032	9	$2	$1
2033	12	$3	$2
2034	15	$3	$2
2035	18	$4	$2
2036	21	$5	$3
2037	23	$6	$3
2038	26	$7	$3
2039	29	$8	$4
2040	32	$9	$4
2041	34	$10	$4
2042	37	$11	$5
2043	40	$12	$5
2044	43	$13	$6
2045	46	$15	$6
2046	49	$16	$7
2047	52	$18	$7
2048	54	$19	$8
2049	57	$21	$8
2050	60	$22	$8
Average 2020 - 2035	**64**	**$1**	**$1**
Average 2020 - 2050	**22**	**$7**	**$3**

Sources: CGS, MDE, COBRA, RESI

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