CADMUS

Rhode Island Carbon Pricing Study

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Rhode Island Office of Energy Resources

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Cadmus

Mike Walsh, Farrah Andersen, Jesse Way, Megan Lynch

Synapse

Asa Hopkins, Pat Knight, Jason Frost

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Executive Summary

Overview and Project Background

In 2014, the Rhode Island General Assembly enacted the Resilient Rhode Island Act, which created the Executive Climate Change Coordinating Council (EC4). The EC4 was required to develop a plan to meet a set of ambitious greenhouse gas emissions reduction targets, including an 80 percent reduction below 1990 levels by 2050. Later, in 2017, the Rhode Island General Assembly enacted an amendment to the Act, requiring the EC4 to study the effectiveness of a state and/or multi-state carbon pricing program to incentivize institutions and industry to reduce emissions.

To meet this charge, the Rhode Island Office of Energy Resources (OER) and the Rhode Island Department of Environmental Management (DEM), in consultation with the Rhode Island Department of Transportation (DOT), contracted with the Cadmus Group and Synapse Energy Economics (collectively referred to as "the Project Team" in this document) to investigate potential state and regional carbon pricing policy options to support Rhode Island in achieving the requirements laid out in the Resilient Rhode Island Act. This report outlines the process and results of the study. It provides an impartial assessment of the implementation considerations and potential impacts of illustrative carbon pricing policies. The study will inform, not set, potential future policy design.

It should be noted that a carbon price is just one potential tool within a broader suite of decarbonization strategies that could support Rhode Island's decarbonization objectives. As such, this analysis aims to evaluate the potential contribution of a carbon price to support a portfolio of carbon reduction strategies, rather than design a price that would independently achieve the state's goals.

Summary of Approach

The Project Team's process for assessing potential carbon pricing policies for Rhode Island included several key steps, including:

- **Literature Review and Policy Selection**: The Project Team reviewed and summarized critical state-level policies, regional climate initiatives, and international examples of carbon pricing to better understand the impact of these initiatives on emissions, as well as their advantages, disadvantages, and feasibility of implementation. The learnings from the literature review informed which carbon pricing policies were appropriate to study in Rhode Island, particularly focused on price level, sectors covered, and use of revenue.
- **Policy Analysis:** Next, the Project Team analyzed the defining elements of a typical carbon pricing policy against assessment criteria identified in collaboration with the Rhode Island Team. Policy elements analyzed include price level, applicable sector, and use of revenue. The purpose of this analysis was to identify key tradeoffs in the implementation and impact of a carbon pricing policy as it relates to each policy element identified above.
- **Carbon Pricing and Economic Modeling:** The Project Team also modeled policy cases to quantify the potential impacts of a carbon price and associated investments or rebates on Rhode Island's energy use, emissions, economy, and public health. Each policy case has a specified carbon price level (e.g., \$25 per metric ton of CO_2) and associated use of revenue (e.g., a heat pump subsidy).

The price levels studied include a low price that started at $6 per metric ton in 2021 and increases to about $25 in 2050 and a high price that starts at $15 in 2021 and increases to about $100 in 2050. These policy cases were compared to a hypothetical future case with no carbon pricing policy, referred to as the sustained policy case.

- **Stakeholder Engagement and Public Comment:** To ensure the findings of this report reflected feedback from Rhode Island residents and businesses that would be potentially impacted by a carbon pricing policy, the Project Team conducted stakeholder outreach at key points throughout the study. These efforts included interviews with frontline community members and organizations serving frontline communities, and sector-specific focus groups with key representatives of the Rhode Island building thermal and transportation sectors. Additionally, the Project Team held three webinar updates that were open to the public, each of which was followed by a two-week comment period.

Key Findings

The Project Team synthesized the findings from the policy analysis and modeling to identify key takeaways. These key takeaways are briefly summarized below:

A carbon price at the levels analyzed in this study would not achieve Rhode Island's 2050 greenhouse gas (GHG) reduction targets alone. For Rhode Island to achieve its long-term decarbonization goals, additional actions will be needed to complement carbon pricing. While a carbon price may not achieve Rhode Island's GHG emissions reduction target on its own, policymakers should note that a higher price results in more GHG reductions than a lower price.

Determining how to use revenue generated by the carbon price is a chief policy design step. The use of revenue generated by the carbon price has significant implications for Rhode Island's statewide GHG and social equity objectives, as well as for the outcomes at the household level. The policy cases examined in this study showed that the use of revenue could drive greater GHG impacts than the carbon price did as a market signal. Revenue use decisions also greatly impact the social equity outcomes and impacts at the household level.

Equity needs to be a conscious choice in both process and ultimate policy design. Some communities disproportionately experience the burdens of climate change and have least access to the benefits of clean energy technology. For instance, low-income households spend a higher portion of income on energy than other households and thus would be disproportionately impacted by a carbon price, unless revenue generated by the carbon price is intentionally targeted to support them. To ensure a carbon price is designed and implemented equitably, Rhode Island should engage frontline communities early and often in the process of policy development, and then integrate feedback into final policy design.

A carbon price has a small impact on electric vehicle (EV) adoption. The results of this study need to be considered in the broader context of the EV market. More favorable vehicle and fuel prices are only two components of increasing EV adoption. To significantly increase the adoption of EVs, other barriers need to be overcome, such as reducing range anxiety, increasing awareness of EVs, and improving the availability and diversity of EV models in Rhode Island.

A carbon price contributes, in a limited fashion, to increasing the adoption of air source heat pumps (ASHPs). A carbon price does not significantly impact the dynamics already seen in the heating industry. The high cost of heating oil promotes a transition to ASHPs, which is amplified by a carbon price. The low cost of natural gas hinders widespread transition from gas heating system to ASHPs, a dynamic which is not sufficiently changed by a carbon price to make ASHPs more cost-effective.

A carbon price will create shifts in Rhode Island's economy, but aggregate economic impacts are expected to be negligible. The study showed that aggregate impacts on jobs is expected to be slightly positive, while the impact on state GDP is slightly negative. However, both impacts are close to zero in the context of Rhode Island's entire economy, accounting for changes of 0.1 percent or less of total jobs and state GDP.

A carbon price would generally have a limited aggregate impact on households. The aggregate near-term cost impacts of a carbon price on households are small. Households that see the highest cost increase are those who spend the most on fossil fuels. Households can mitigate added costs or achieve cost savings by adopting clean energy technologies and weatherizing their homes. The study also showed that health impacts are small but positive.

Wider geographic scope would lead to greater success. Developing a carbon price in coordination with other states has several advantages and would likely lead to greater success of the program. Specifically, wider geographic participation can lower administrative costs and increase social acceptability of the program. The Regional Greenhouse Gas Initiative (RGGI) has shown that a program with a wide geographic scope can be successful. However, regional participation may involve making tradeoffs on important parts of policy design based on the needs and preferences of other states, including price.

Section 1: Introduction

Project Background and Purpose

In 2014, the Rhode Island General Assembly enacted the Resilient Rhode Island Act.[1] The Act created an Executive Climate Change Coordinating Council (EC4) comprised of state agency directors. That body was charged to assess, integrate, and coordinate climate change efforts throughout state agencies to reduce emissions, strengthen the resilience of communities, and prepare for the effects of climate change. The Act required the EC4 to develop a plan to meet the following greenhouse gas (GHG) emissions reduction targets:

- 10 percent below 1990 levels by 2020
- 45 percent below 1990 levels by 2035
- 80 percent below 1990 levels by 2050

In 2017, the Rhode Island General Assembly enacted an amendment to the Resilient Rhode Island Act that required the EC4 to study the effectiveness of a state and/or multi-state carbon pricing program to incentivize institutions and industry to reduce emissions.

To meet this charge, the Rhode Island Office of Energy Resources (OER) and the Rhode Island Department of Environmental Management (DEM), in consultation with the Rhode Island Department of Transportation (DOT) (collectively referred to in this report as "the Rhode Island Team"), contracted with the Cadmus Group and Synapse Energy Economics (referred to as "the Project Team") to investigate potential state and regional carbon pricing policy options. The Project Team was asked to provide an impartial assessment of the implementation considerations and expected impacts of those options to inform potential future policy design. This study is intended to inform, not set, potential carbon pricing policy design in Rhode Island.

Furthermore, it should be noted that a carbon price is just one potential tool within a broader suite of decarbonization strategies that could support Rhode Island's decarbonization objectives. As such, this analysis aims to evaluate the potential contribution of a carbon price to support a portfolio of carbon reduction strategies, rather than design a price that would independently achieve the state's goals. Other state initiatives, such as accelerating the growth of renewable energy resources, aggressive deployment of cost-effective energy efficiency resources, Heating Sector Transformation (HST)[2], and the Transportation Climate Initiative Program (TCI-P)[3], will remain vital even in a world with carbon pricing. More information on the suite of decarbonization initiatives underway in Rhode Island can be found in Section 2: Rhode Island's Decarbonization Landscape.

[1] Climate Change Coordinating Council. 2014. *Chapter 42-6.2: Resilient Rhode Island Act of 2014.* http://webserver.rilin.state.ri.us/Statutes/TITLE42/42-6.2/INDEX.HTM

[2] For more information on Rhode Island's efforts to transform the heating sector, please visit: http://www.energy.ri.gov/HST/.

[3] For more information on the Transportation Climate Initiative Program (TCI-P), please visit: https://www.transportationandclimate.org/final-mou-122020.

The Role of a Carbon Price

Anthropogenic[4] GHGs are well-documented as the primary cause of global climate change. As the climate changes, society has experienced increasingly severe impacts, such as flooding, drought, wildfires, and ocean acidification. These negative consequences impose a cost on society. Since these costs are not realized when greenhouse gases are released into the atmosphere, costs are borne by those impacted instead of those responsible for emitting GHGs. This is an example of an *externality* – an impact of an action that is not reflected in the transactional cost of the good or the service involved. A carbon price seeks to correct this externality by attributing a monetary value to GHG emissions, which reflects their harm to society. This price places the cost of GHGs on those emitting them instead of those bearing the impact. A carbon price can a be applied to any sectors in the economy where GHGs are emitted. It is often applied in the three major sectors of the energy economy: electricity generation, building thermal (heating), and transportation.

Carbon prices sends a long-term price signal to the market, which disincentivizes the use of fossil fuels and improves the economics of cleaner technologies. Carbon pricing programs also typically generate revenue for the regulating entity, which can then be invested into clean energy and efficiency programs, further reducing GHG emissions, or distributed to residents as a rebate, offsetting some of the increased cost of goods and services. This study explores both the direct impact of the carbon price and the impact of revenue use. [5]

[4] Merriam-Webster defines anthropogenic as “of, relating to, or resulting from the influence of human beings on nature.”

[5] Union of Concerned Scientists. 2017. *Carbon Pricing 101.* https://www.ucsusa.org/resources/carbon-pricing-101

Summary of Approach

The Project Team's process for assessing potential carbon pricing policies for Rhode Island is summarized in Figure 1 below:

Figure 1. Summary of approach

1. Literature Review and Policy Selection	2. Policy Analysis	3. Carbon Pricing and Economic Modeling
• Reviewed state, regional, and international carbon pricing initiatives. • Leveraged findings to select and define illustrative policy cases.	• Analyzed the defining elements of a typical carbon pricing policy against assessment criteria. • Summarized and organized findings for each assessment criteria.	• Modeled policy cases and compared them to a sustained policy or baseline case. • Assessed and quantified the GHG, health, and economic impacts of various policy cases.

4. Stakeholder and EC4 Engagement
• Conducted stakeholder engagement throughout the study, including equity interviews, sector-specific focus groups, and webinar updates to the public and EC4 followed by public comment sessions.

1. **Literature Review and Policy Selection**: To better understand how carbon pricing programs could be implemented in Rhode Island, the Project Team reviewed and summarized critical state-level policies and regional climate initiatives (e.g., RGGI and TCI-P). The Project Team also evaluated international examples of carbon pricing. The selected international and domestic policies were examined for how they reduced emissions in the electricity, thermal, and transportation sectors, including their advantages, disadvantages, and feasibility of implementation.

2. **Policy Analysis:** To help inform the design of a potential carbon pricing policy in Rhode Island, the Project Team analyzed the defining elements of a typical carbon pricing policy against assessment criteria identified in collaboration with the Rhode Island Team. Policy elements analyzed include price level, applicable sector, and investment options. The purpose of this analysis was to identify key tradeoffs in the implementation and impact of a carbon pricing policy as it relates to each policy element identified above.

3. **Carbon Pricing and Economic Modeling**: To quantify the potential impacts of a carbon price and associated investments or rebates on Rhode Island's energy use, emissions, economy, and public health, the Project Team modeled policy scenarios, each of which has a specified carbon price level (e.g., \$25 per metric ton of CO_2) and associated use of revenue (e.g., a heat pump subsidy). Referred to as policy cases. These policy cases were compared to a hypothetical future scenario with no carbon pricing policy, referred to as the sustained policy case. Carbon pricing policies and the associated use

of revenue change the total cost of owning and using heating and transportation equipment. These changes impact the adoption rates of low-carbon alternatives such as electric vehicles, heat pumps, and energy efficiency measures (e.g., weatherization). The Project Team's modeling suite quantifies the changes in adoption rates of low-carbon alternatives and the resulting reductions in emissions and changes in the state's economy.

4. **Stakeholder and EC4 Engagement:** To ensure that the findings of this report reflected feedback from Rhode Island residents and businesses that would be potentially impacted by a carbon pricing policy, the Project Team conducted stakeholder outreach at key points throughout the study. These efforts included interviews with frontline community members and organizations serving frontline communities, sector-specific focus groups with key representatives of the Rhode Island building thermal and transportation sectors, and three webinar updates to the public and the state's Executive Climate Change Coordinating Council (EC4). Each webinar update was followed by a two-week public comment period where stakeholders could submit additional feedback via email. Feedback was consolidated by the Project Team, incorporated into the report where possible, and resulted in a high-level response posted on the public project website.[6] For more information on stakeholder engagement efforts, please see Appendix B: Stakeholder Engagement Summary.

Organization of this Report

The remainder of this report is organized into the following sections:

- **Section 2: Rhode Island's Decarbonization Landscape:** Provides a summary of current decarbonization initiatives underway in Rhode Island's electricity, building thermal, and transportation sectors, and describes how a carbon pricing policy may interact with these initiatives.

- **Section 3: Carbon Pricing Policy Cases Examined:** Introduces and provides details on the six illustrative policy cases examined in this study (e.g., sectors covered, price level, and revenue use).

- **Section 4: Modeling the Policy Cases:** Discusses the modeling methodology and results from the GHG, economic, and health impacts modeling. Modeling results were later combined with the findings from the qualitative policy analysis to inform the synthesized findings of this study.

- **Section 5: Near-term Cost Impacts for Households:** Shows estimated near-term cost impacts for four illustrative households in Rhode Island. These near-term impacts were used to inform the synthesized findings of this study.

[6] State of Rhode Island Office of Energy Resources. 2020. *Rhode Island Carbon Pricing Study.* http://www.energy.ri.gov/carbonpricingstudy/

- **Section 6: Qualitative Policy Analysis:** Summarizes findings from the Project Team's policy analysis, which analyzed the defining elements of a carbon pricing policy against key assessment criteria. Policy analysis findings were later combined with the outputs of the qualitative modeling findings to inform the synthesized findings of this study.

- **Section 7: Additional Design Considerations:** While this report focuses specifically on the included sectors, price level, and revenue use of a carbon pricing policy, this section outlines additional design considerations and their impacts that should be considered when designing and implementing a carbon pricing policy.

- **Section 8: Synthesized Findings:** Summarizes the overarching key findings of this study, which should be used to guide thinking on the development of a carbon price for the state of Rhode Island. These key findings synthesize results from the qualitative modeling, qualitative policy assessment, and stakeholder engagement efforts.

- **Section 9: Conclusion & Next Steps:** Summarizes and concludes the report and outlines key next steps for Rhode Island.

In addition, this report includes the following appendices:

- **Appendix A** provides a detailed overview of the methodology for the GHG, economic, and health impact modeling.
- **Appendix B** provides a summary and key findings of stakeholder engagement processes.

Section 2: Rhode Island's Decarbonization Landscape

Existing Policies and Programs

As noted in the previous section, the Resilient Rhode Island Act of 2014 established ambitious GHG emissions reduction targets for Rhode Island. In addition to assessing the effectiveness of a carbon pricing program, Rhode Island has implemented or is participating in a number of policies, programs, and other initiatives to accelerate decarbonization. A summary of current initiatives in the electricity, transportation, and building thermal sectors can be found below. While energy efficiency was not the focus of this report, many of Rhode Island's national-leading efforts are directly captured or linked to below. Please note this list is representative of Rhode Island's efforts, but is not comprehensive.

Electricity Sector

Regional Greenhouse Gas Initiative (RGGI): [7,8]

Along with nine other northeastern states, Rhode Island participates in RGGI, a regional and market-based cap-and-trade program that aims to reduce CO_2 emissions from the power sector. The program places an annually declining cap on emissions from fossil fuel-fired electric generating facilities in the region. It has built a broad coalition of ten states[9] that is continuing to grow, with Virginia planning to participate in 2021 and Pennsylvania considering to participate as well.[10,11] RGGI has been successful in helping to reduce carbon emissions from the electricity sector while the economy in the region has continued to grow.[12] Specifically, emissions have decreased by 47 percent during the duration of the program, which is still ongoing.[13] Participating states are able to invest proceeds from CO_2 allowance auctions into a number of programs that benefit consumers, such as bolstering energy efficiency programs and accelerating renewable energy growth.

Cap-and-trade programs, such as RGGI, are a form of carbon pricing. The difference between a cap-and-trade program and a carbon fee is discussed in Section 7: Additional Design Considerations. Rhode Island

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[7] Rhode Island Department of Environmental Management. *Regional Greenhouse Gas Initiative (RGGI).* http://www.dem.ri.gov/programs/air/rggi.php

[8] State of Rhode Island Office of Energy Resources. *Regional Greenhouse Gas Initiative.* http://www.energy.ri.gov/policies-programs/programs-incentives/rggi.php

[9] States currently participating in RGGI include Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.

[10] Virginia's Legislative Information System. 2020. *HB 981 Clean Energy and Community Flood Preparedness Act; Definitions, Funds, Report.* https://lis.virginia.gov/cgi-bin/legp604.exe?201+sum+HB981

[11] Pennsylvania Department of Environmental Protection. *Regional Greenhouse Gas Initiative.* https://www.dep.pa.gov/Citizens/climate/Pages/RGGI.aspx

[12] Ceres. 2015. *The Regional Greenhouse Gas Initiative: A Fact Sheet*. https://www.ceres.org/sites/default/files/Fact%20Sheets%20or%20misc%20files/RGGI%20Fact%20Sheet.pdf

[13] Jan Ellen Spiegel, Yale Climate Connections. 2020. *Power plant emissions down 47% under the Regional Greenhouse Gas Initiative.* Yale Climate Connections. https://www.yaleclimateconnections.org/2020/01/power-plant-emissions-down-47-percent-under-the-regional-greenhouse-gas-initiative/

could apply an additional carbon price in the electricity sector, as has been done in Massachusetts[14], which would create an additional compliance obligation for electric generators who emit GHGs.

100 Percent Renewable Electricity by 2030 Goal:[15]

In January 2020, Governor Raimondo signed an Executive Order (20-01) committing Rhode Island to achieving 100 percent renewable electricity by 2030. Furthermore, the Order directed OER to conduct an economic and energy market analysis and develop actionable policies and programs to achieve this goal. This analysis is complete and accessible on OER's website.[16].

Least-Cost Procurement:[17]

In 2006, the Rhode Island General Assembly passed legislation that established the Comprehensive Energy Conservation, Efficiency and Affordability Act. This Act created a "Least-Cost Procurement" policy, which requires Rhode Island's electric and natural gas distribution companies to invest in all cost-effective energy efficiency (e.g., higher efficiency lighting, HVAC systems, and appliances; insulation; and air sealing) before acquiring additional supply. This strategy is considered "least-cost" because many of these energy-saving measures cost approximately 4 cents per KWh over their lifetime, while electric supply costs between 8-12 cents per KWh.

Additional Policies, Programs, and Initiatives:

Rhode Island offers a number of additional policies, programs, and initiatives aimed at decarbonizing the electricity sector, including, but not limited to, the Rhode Island Renewable Energy Standard (RES), the Renewable Energy Fund (REF), and the Renewable Energy Growth Program (REG). For more information, please visit OER's website.

Transportation Sector

Transportation & Climate Initiative Program (TCI-P):[18]

In December 2020, Rhode Island, Massachusetts, Connecticut, and the District of Columbia announced the launch of a groundbreaking multi-state program that will reduce transportation-sector pollution while investing $300 million per year in cleaner transportation choices and healthier communities. Known as the Transportation & Climate Initiative Program, or TCI-P, it is a multi-state effort to develop an approach to reduce greenhouse gas emissions from the transportation sector, which is a major contributor to GHG

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[14] ICAP. 2017. *Massachusetts Introduces Additional Cap-and-trade System.* https://icapcarbonaction.com/en/news-archive/483-massachusetts-introduces-additional-cap-and-trade-system

[15] State of Rhode Island Office of Energy Resources. 2020. *100 Percent by 2030 Renewable Electricity Goal.* http://www.energy.ri.gov/100percent/

[16] State of Rhode Island Office of Energy Resources. 2020. *100 Percent by 2030 Renewable Electricity Goal.* http://www.energy.ri.gov/100percent/.

[17] State of Rhode Island Office of Energy Resources. *Least-Cost Procurement (2006).* http://www.energy.ri.gov/policies-programs/ri-energy-laws/least-cost-procurement-2006.php

[18] Transportation and Climate Initiative. 2010. *Massachusetts, Connecticut, Rhode Island, D.C. are First to Launch Groundbreaking Program to Cut Transportation Pollution, Invest in Communities.* https://www.transportationandclimate.org/final-mou-122020

emissions and climate change. Under this new cap-and invest program, the oil companies that distribute gasoline and on-road diesel fuel in the region will need to purchase allowances in an auction for the carbon emitted from their products. The total amount of allowances available for auction would be determined by the states and would decrease gradually over time. This method ensures that greenhouse gas emissions will be reduced through the program.

The proceeds from the auctions will be shared by the participating states and invested in clean transportation improvement. Rhode Island is currently developing an investment plan and will continue to solicit input from a broad range of elected leaders and citizen groups to determine the best use of the funds. Ultimately, the investment plan will focus on developing real choices for Rhode Islanders for better, cleaner, and healthier transportation. Rhode Island will consider clean transportation options such as deploying more electric buses for public transportation, purchasing clean electric school buses for our children, providing incentives to purchase electric vehicles, improving regional rail, installing more charging stations to support electric vehicles, expanding bike path networks, and using more efficient highway design to minimize traffic and congestion. The connections between climate change, public health, equity, and justice are more urgent today than they have ever been, especially for transportation — and equity and environmental justice have been deeply integrated into the program design. Similar to RGGI, TCI-P is a form of carbon pricing.

Mobility Innovation Working Group:[19]

The objective of the Mobility Innovation Working Group is to inform the design of a statewide mobility strategy that will build on Rhode Island's existing portfolio of clean transportation policies and initiatives to further reduce greenhouse gas emissions from the transportation sector, while also enhancing accessible transportation options and promoting economic development. The Working Group consists of state agency leaders and external stakeholders, who have a deep understanding of the mobility, environmental, economic and public health needs of Rhode Islanders. In January of 2021, the Working Group produced a final report outlining a suite of recommended initiatives and policies aimed at enhancing mobility for all Rhode Islanders.[20]

Additional Policies, Programs, and Initiatives:

Rhode Island offers a number of additional policies, programs, and initiatives aimed at decarbonizing the transportation sector, including, but not limited to, the Long Range Transportation Plan, the Transit Master Plan, the Bicycle Mobility Plan, the light duty zero emission vehicle (ZEV) mandate, the light duty ZEV memorandum of understanding (MOU), and the medium- and heavy-duty ZEV MOU. For more information, please visit OER's website and DEM's website.

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[19] State of Rhode Island Climate Change. *Mobility Innovation Working Group*. http://climatechange.ri.gov/state-actions/mobility-innovation.php

[20] AECOM. *Clean Transportation and Mobility Innovation Report.* http://climatechange.ri.gov/documents/mwg-clean-trans-innovation-report.pdf

Building Thermal Sector

Heating Sector Transformation: [21]

In July 2019, Governor Raimondo signed an Executive Order (19-06) initiating a Heating Sector Transformation Initiative led by OER and the Division of Public Utilities and Carriers (DPUC) that is intended to advance the development of clean, affordable, and reliable heating technologies. The study evaluated tradeoffs associated with alternative heating decarbonization strategies such as heat pumps and renewable fuels. This initiative culminated in the development of a report in Spring 2020 that outlined key recommendations that will be used to inform next steps.

Additional Policies, Programs, and Initiatives:

Rhode Island offers a number of additional policies, programs, and initiatives aimed at decarbonizing the building thermal sector, including, but not limited to, the Weatherization Assistance Program (WAP) for income-eligible households, weatherization and efficient thermal measures through utility energy efficiency programs,[22] and the Efficient Buildings Fund which provides low cost financing for state and municipal energy efficiency and renewable energy projects in Rhode Island. For more information, please visit OER's website.

[21] State of Rhode Island Office of Energy Resources. *Heating Sector Transformation.* http://www.energy.ri.gov/HST/

[22] All three Rhode Island utilities offer energy efficiency programs, which support energy savings in building thermal and other areas.

Section 3: Carbon Pricing Policy Cases Examined

Characterizing the Focal Sectors

While Rhode Island has many existing decarbonization initiatives, a carbon price is an additional tool that can help the state achieve its GHG emissions reduction goals. This report analyzes the potential role a carbon price could play to support Rhode Island in reaching its climate goals by further reducing GHG emissions. Specifically, this study was charged with examining the application of a carbon price in the transportation, building thermal, and electric sectors. Given parallel efforts to examine decarbonization of the electric sector in Rhode Island, the Project Team focused resources on gaining insights in the transportation and building thermal sectors. The transportation sector currently accounts for about 36 percent of GHG emissions in Rhode Island, while the residential and commercial building thermal sector accounts for about 24 percent.[23] The study was not tasked with examining a carbon price in the industrial sector.

Pricing Levels

This study primarily examines two price levels based on current and proposed carbon pricing programs in Rhode Island. The two primary price levels are described further in Table 1 below. In addition to the two main prices levels analyzed, the Project Team also examined a third price level during an initial phase of the modeling based on the American Opportunity Carbon Fee Act (AOCFA),[24] a federal bill that was introduced by Rhode Island Senator Sheldon Whitehouse. This price starts at just over $50 in 2021 and increases by 6 percent a year above inflation to just over $300 in 2050. However, beyond the initial pricing-response analysis, which was designed to understand how the market reacted to a higher price, the Project Team did not examine the AOCFA further. It was determined that, as a federal policy, it was less appropriate to analyze at the state-level than the other prices considered. The trajectory of these three price levels can be seen in Figure 2.

Beyond price level, there are several program design elements to consider when implementing a carbon price. Revenue use is a chief design consideration and is discussed further below. Other design elements that influence implementation include whether the carbon price is a cap-and-trade program or a fee, the point of regulation, what gases are regulated, and several others. These other design elements are discussed in Section 7: Additional Design Considerations.

[23] Rhode Island Department of Environmental Management. 2017. *2016 Greenhouse Gas Emissions Inventory.* http://www.dem.ri.gov/programs/air/ghg-emissions-inventory.php

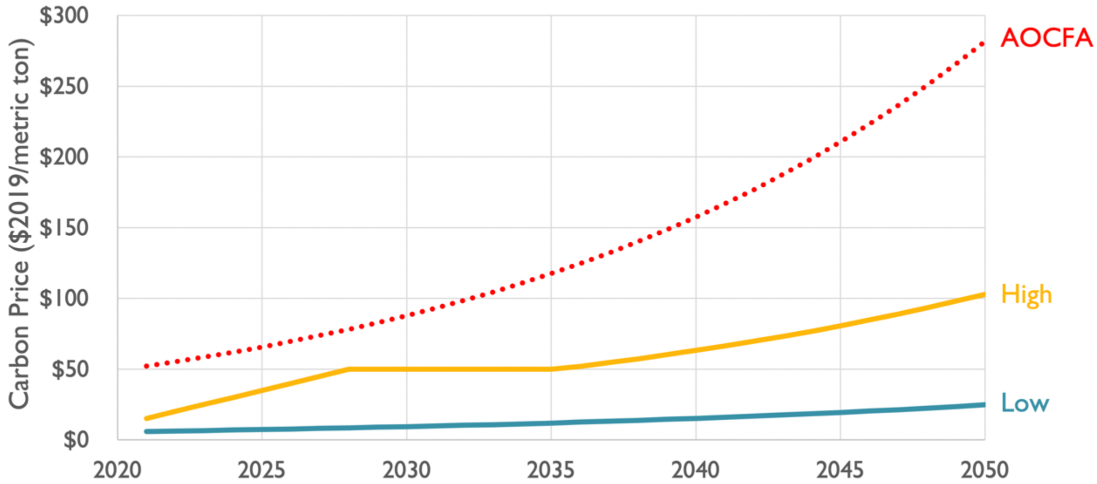
[24] Senator Sheldon Whitehouse, U.S. Senate Finance Committee. 2019. *S.1128 – American Opportunity Carbon Fee Act of 2019.* https://www.congress.gov/bill/116th-congress/senate-bill/1128

Table 1. Description of low and high prices

Price	Low	High
Description	The low price is based on the Regional Greenhouse Gas Initiative's current and expected future pricing levels. It starts at **\$6 per metric ton of CO_2e in 2021 and increases by 5% a year above inflation, reaching just over \$25 in 2050.** This price trajectory also falls within the expected range of prices in the proposed TCI Program.	The high price is based on proposed 2019 legislation that was introduced in the Rhode Island General Assembly, titled the Economic and Climate Resilience Act of 2019.[25] Also known as the "Energize Rhode Island Act", the bill would have implemented a carbon price that **started at \$15 per metric ton of CO_2e,** increasing by \$5 a year until it reaches \$50, at which point it increases with inflation. However, recognizing the likely need for more aggressive action on climate change in the future, the Project Team increased the price by 5% a year above inflation starting in 2034, causing the high price to reach just over \$100 in 2050.
Sectors included	Because RGGI already covers the electricity sector at the levels examined in the low price, the low price is *only* applied to the **transportation and building thermal sectors**.	The high price is applied in the **transportation, building thermal, and electric sectors**.
Rationale for Inclusion	The low price allows the Project Team to evaluate the creation **of a RGGI-like** program to other sectors.	The high price allows the **examination of the Economic and Climate Resilient Act**.

[25] The Economic and Climate Resilience Act of 2019 was proposed legislation in Rhode Island that establishes a carbon price and creates an "economic and climate resilience fund" to disperse revenue. Known as the Energize Rhode Island Act in previous years, this proposed legislation has strong support among environmental advocates in Rhode Island.

Figure 2. Price levels analyzed



Overview of Revenue Uses

There are many ways that carbon pricing revenue could be used. To develop an appropriate study, the Project Team, in consultation with OER, DEM, DOT, and stakeholders, selected specific spending characterizations for analysis and modeling purposes. It is worth noting that other uses of revenue may have different outcomes than those seen in this study.

Beyond administrative costs[26], the Project Team studied two primary uses of revenues from carbon pricing:

- **Investments**: Carbon price revenue that is used to provide direct funding to programs that aim to reduce GHG emissions or accomplish other outcomes in the sector from which the revenue was raised.
- **Rebates (also commonly referred to as dividends)**: Carbon price revenue that is returned to Rhode Island residents or businesses without requirements about how the money is used. Rebates are used to lessen the impact of the price itself, but do not have a direct impact on GHG emissions.

An overview of how the revenue is used in each price scenario can be found in Table 2 below.

Table 2. Use of revenue

Low Price Scenario	High Price Scenario
• Administrative costs • Investment in programs	• Administrative costs • Investment in programs • Rebates

[26] Administrative costs are the costs incurred by the state to implement and manage the policy. This includes staff time, capital costs, and ongoing costs associated with monitoring, verification, and enforcement.

Investment Options

The Project Team examined two illustrative investment options. Please note that these investment options are meant to be illustrative of what investment for a carbon price could be and are not designed to set policy for Rhode Island. These investment options are summarized in Table 3.

- **Incentives**: This option focuses on investing carbon price revenue in programs that prioritize GHG reductions through electrification of end uses, such as vehicles and space heating.[27]
- **Public Services**: This option focuses on investing carbon price revenue in clean energy and transportation-related services that provide support to the public, with an emphasis on ensuring benefits accrue to frontline communities.[28]

Table 3: Summary of investment options

		Incentives	Public Services
Transportation	Majority of Revenue	• Light duty electric vehicle incentives	• Reduced transit fares (about 50% of current fare price)
	Remaining Revenue	• EV charger incentives • Electric transit bus deployment	• Transit bus service expansion • Electric transit bus deployment • Active transportation infrastructure (i.e. bike lanes)
Building Thermal	Majority of Revenue	• Air- and ground-source heat pump incentives	• Free air- and ground-source heat pump installation and free building weatherization for low-income residents and public buildings
	Remaining Revenue	• Building weatherization incentive • Heating/cooling bill pay assistance	• Heating/cooling bill pay assistance

[27] Electrified technologies can use electricity as their fuel. Since electricity can increasingly be supplied through renewable energy such as solar and wind, these technologies have the potential to drive lower GHG emissions than fossil fuel-powered technologies. Additionally, electrified technologies tend to be more energy efficient than their fossil fuel counterparts. As the electric grid decarbonizes, electric technologies will continue to see a decrease in emissions.

Sustainable Solutions Development Network. 2019. *Roadmap to 2050: A Manual for Nations to Decarbonize by Mid-Century*. https://roadmap2050.report/static/files/roadmap-to-2050.pdf

[28] For the purposes of this report, frontline communities are defined as those that are most impacted by the crises of ecology, economy, and democracy, including low-income communities and communities of color. This definition draws upon the definition in the City of Providence's Climate Justice Plan.

Illustrative Cases Studied

There were six illustrative policy cases examined in this study, including five carbon pricing policy cases and a reference baseline, referred to as the sustained policies case. These are summarized in Table 4. Each of the cases is defined by the price level, the types of investments being made with the revenue, and whether there is a rebate being used.

Table 4. Summary of illustrative cases

#	Policy Case	Carbon Price	Investment Focus	Rebates
1	Sustained Policies	None	N/A	No
2	Low Price Alone	Low	N/A	No
3	Low + Incentives	Low	Incentives	No
4	Low + Public Services	Low	Public Services	No
5	High + Incentives	High	Incentives	Yes
6	High + 2x Incentives	High	Double Incentives	Yes[29]

As shown in Table 4, the policy cases examining the low price assume that all revenue not used for administrative costs is invested in programs and, therefore, the policies do not have any surplus revenue to use as a rebate. Because the high price generates more revenue than the low price, there are remaining funds after investments that can be distributed to Rhode Island residents as a rebate. The total amount of the rebate is equivalent to all revenue not used for administrative costs or program investment. For Cases 3 and 5, the investments are exactly the same, with the remaining revenue in Case 5 used in the form of a rebate. Case 6 differs from Case 5 by doubling the total dollar amount invested into the incentives investment option, resulting in a smaller rebate.

There are incremental differences between the illustrative cases, which allowed the Project Team to isolate the impacts of key policy characteristics. Table 5 summarizes what can be learned by comparing the various cases.

Table 5. Key policy characteristics examined

Case A	Case B	Characteristic Examined
Sustained Policies	Low Price Alone	The impact of a price before investments
Low Price Alone	Low + Incentives	The impact of the Incentives investment option
Low Price Alone	Low + Public Services	The impact of the Public Services investment option
Low + Incentives	Low + Public Services	The comparison of the Incentives investment option versus the Public Services investment option
Low + Incentives	High + Incentives	The impact of a higher price and rebate
High + Incentives	High + 2x Incentives	The impact of doubling investment and reducing the amount of the rebate.

[29] The rebate will be smaller in this scenario because investment is higher.

Section 4: Modeling the Policy Cases

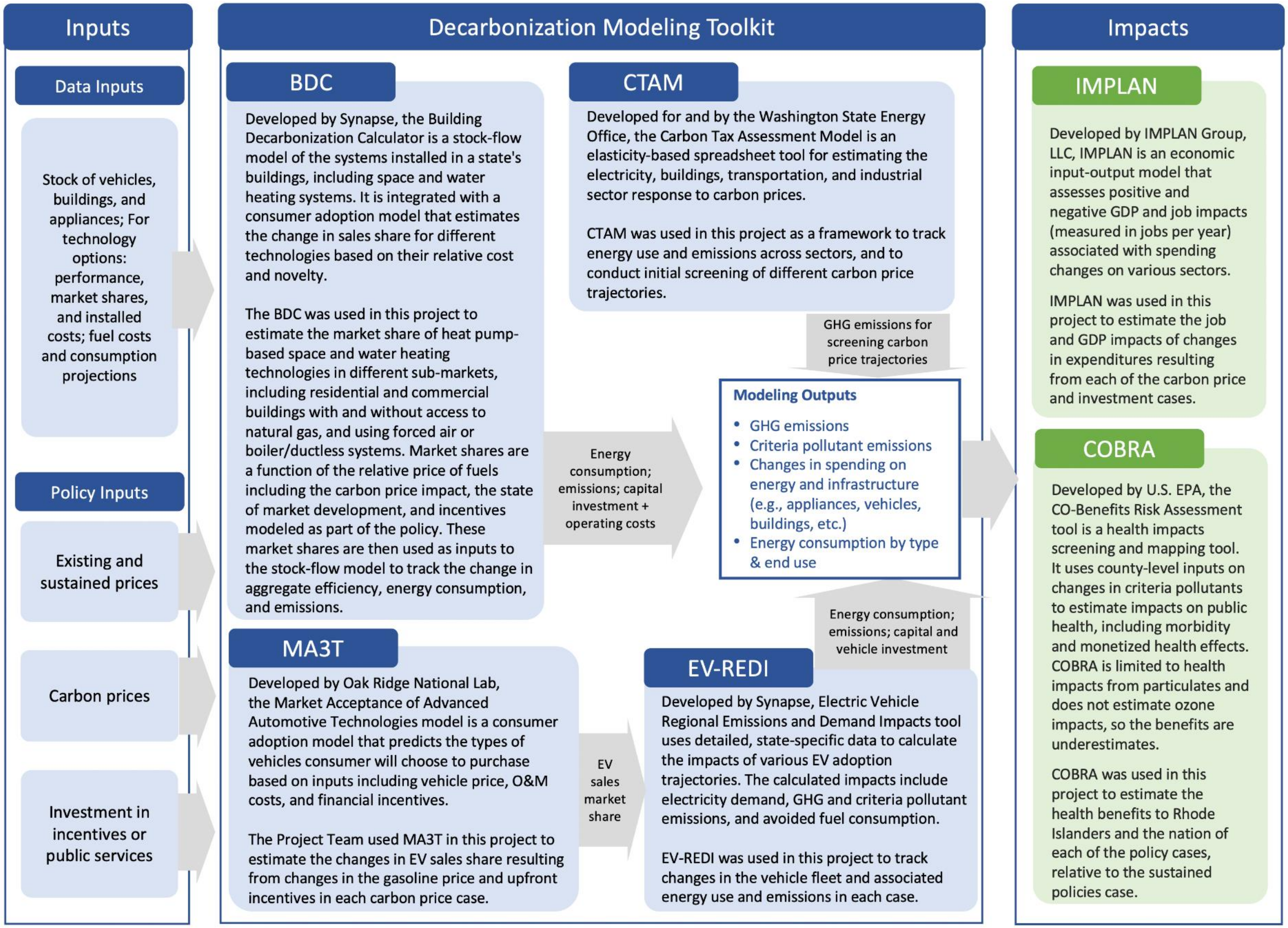
Overview

The Project Team modeled the carbon pricing and investment policy cases using the tool suite detailed in Figure 3. The Project Team used a mix of in-house models (including its Building Decarbonization Calculator and Electric Vehicle Regional Emissions and Demand Impacts tool) and third-party models (including the Carbon Tax Assessment Model, Market Acceptance of Advanced Automotive Technologies model, IMPLAN economic impact model, and CO-Benefits Risk Assessment tool). This suite relates inputs regarding the underlying drivers of energy consumption (e.g., the energy demand and technologies required to meet comfort and mobility needs) with the policy and programmatic context. From there, the suite projects adoption of end use technologies and their resulting energy use, including the resulting changes in fuel and capital expenditures (e.g., spending on heating systems and vehicles) which shape overall economic impacts. Changes in energy consumption drive changes in annual emissions of greenhouse gases (GHG) and other air pollutants which impact human health.

This chapter walks through the inputs and the results of each stage of the analysis, beginning by defining the Sustained Policies case and describing the data and assumptions used. It then presents the energy consumption and capital results in each of the buildings and transportation sectors in the context of each of the policy cases (which compare low versus high carbon prices and incentive versus public service investment strategies). The chapter then presents overall emissions trajectories and results in milestone years for each policy case. The chapter concludes by examining the impact of these policy-driven changes on Rhode Island's economy and the health of its residents.

Throughout, this analysis presents results that reflect the impacts of the carbon pricing and investment policies selected for examination, and not for the full suite of potential policies that may be required to move Rhode Island all the way to its long-term GHG reduction goals. The modeling results presented here assume that other states are taking comparable actions toward comparable targets. Those actions need not take the form of a price on carbon, but, for example, this modeling assumes that electric vehicles are widely available as a result of broad customer demand, and that businesses do not face strong carbon-price-driven incentives to move their operations either to or from Rhode Island.

Figure 3. Modeling toolkit summary



Defining the Sustained Policies Case

The sustained policies for analysis (i.e., the Sustained Policies case) includes the effects of all policies that are currently enacted or are reasonably expected to be enacted. It is not a "business as usual" case because Rhode Island's current policies will drive changes away from "business as usual" or the "status quo." At the same time, the Sustained Policies case does not assume success at achieving state GHG emission reduction targets. This means that this case generally does not reflect broad systemic change in end use energy consumption patterns or technologies of the sort that are likely to be required to meet deep decarbonization targets.

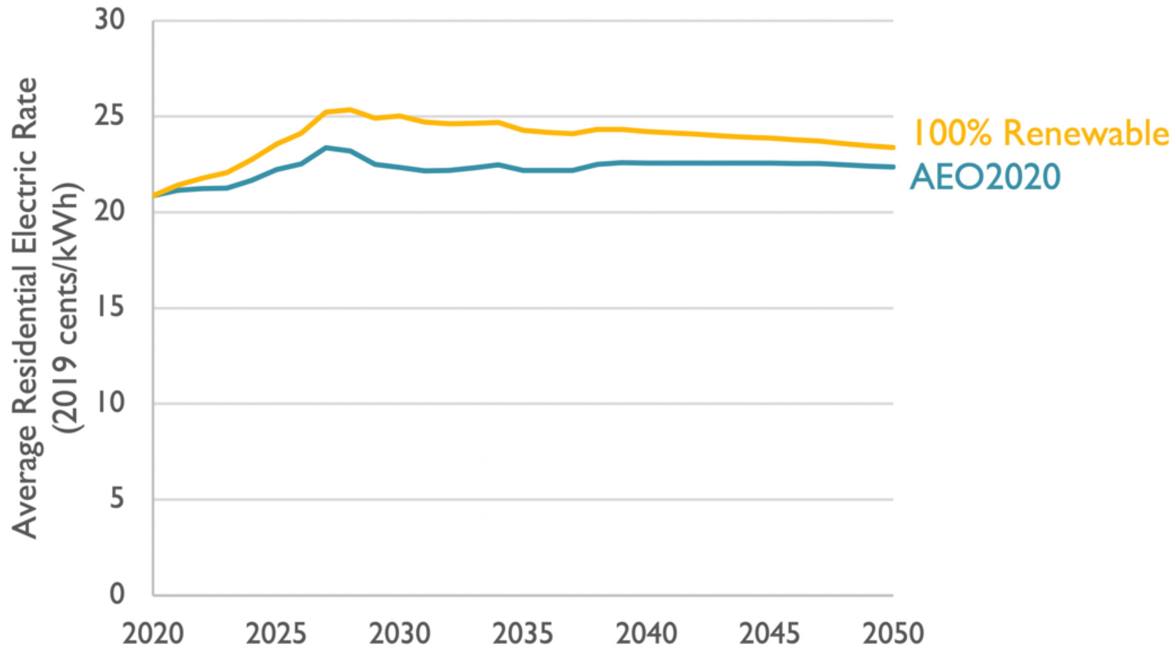
Electricity Supply

The state's current policies will have the greatest impact in the electric sector. In particular, this analysis assumes that the state will successfully meet 100 percent of its electric supply needs with renewable sources by 2030.[30] For the purposes of this analysis, it was not necessary to map out how this goal is achieved—a study conducted by OER has explored this in great detail. Renewable portfolio standards are implemented using renewable energy credits (RECs), each of which corresponds to 1 MWh of renewable electric generation. The fraction of electric supply that is supplied by renewable energy is equal to the ratio of the number of RECs to the state's consumption.

This analysis developed for this carbon pricing report assumed that the RECs required to meet this goal would cost approximately $40 per MWh (in 2019 dollars) each year between 2021 and 2030, and that costs would decrease slowly after 2030 (reflecting technological progress in renewable generating technologies). Figure 4 shows the trajectory of electricity prices developed for this analysis. The underlying trajectory is based on the U.S. Energy Information Administration's (EIA) *Annual Energy Outlook 2020* (AEO2020), as discussed in the Assumptions section below. The value of $40 per MWh is comparable to current prices for renewable energy credits in the region, and is also consistent with the difference between long-term forward energy prices and the price of electricity from recent U.S. offshore wind contracts (which would set a reference point for potential REC prices paid by Rhode Island under long-term contracting approaches to meeting the 100 percent renewable goal).

[30] Pursuant to Executive Order 20-01. For more information, please visit: http://www.energy.ri.gov/100percent/.

Figure 4. Rhode Island residential electric rate projection with assumed impact of 100 percent renewable electricity, as developed for this study, compared with AEO2020 projection



The assumption of success at achieving 100 percent renewable electricity by 2030 is an important assumption, and the overall results would have been noticeably different without it. Analysis of carbon prices with and without this success was not in scope for this work, but intermediate results indicate that without this assumption, market share of electric vehicles and heat pumps systems would be about 10 percent higher over the study period because electrification would be more cost-effective. Actual implementation pathways and technology costs for 100 percent renewable electricity could moderate or exacerbate this effect. As shown by the analysis detailed in the rest of this chapter, rapidly increasing the renewable fraction of Rhode Island's electricity is essential to meeting the state's 2035 emissions target.

Electric and Thermal Demand in Buildings

The Sustained Policies case assumes that the state continues to be a leader in utility energy efficiency programs in both electricity and natural gas. This analysis relies on AEO2020, which includes building shell and heating system improvements that are consistent with continued implementation of efficiency at a rate comparable to historical rates. Importantly, the enabling statute for Rhode Island's least cost procurement and energy efficiency programs sunsets in 2023. If Rhode Island were to cease or curtail the utility efficiency programs, the emission reductions achievable by the carbon pricing policies examined here would be reduced, while energy costs would increase.

Transportation

In the transportation sector, the Sustained Policies case is calibrated to be consistent with contemporaneous analysis of the TCI-P.[31] The primary variables adjusted to calibrate the MA3T consumer adoption model with the TCI-P reference case are the relative costs of internal combustion engine (ICE) vehicles and electric vehicles (EVs). There are a wide range of data sources and projections for EV adoption and the relative cost of EVs and ICE vehicles. The TCI-P reference case projection is among the more optimistic of these cases for the rapid adoption of EVs. This analysis does not assume adoption of or participation in a TCI-P carbon cap and trade program in the Sustained Policies case, but this calibration to the underlying sustained policies enables cross-comparison and avoids unnecessary conflicts between analyses.

The published results of the TCI-P reference case look at the potential TCI-P member states as a single region. When calibrated to Rhode Island's rate of population growth, and after accounting for the impact of electric cost increases resulting from 100 percent renewable electricity, Rhode Island's EV adoption rate in the Sustained Policies case is slightly lower than the average adoption rate across the multi-state TCI-P region. In addition, the Sustained Policies case includes development and installation of EV charging stations in an amount commensurate with its EV adoption.

Other Assumptions and Data Sources

In addition to the assumptions specific to the Sustained Policies case (described above), the analysis required numerous further assumptions, drawing on external resources and models, in order to develop a quantitative assessment of the impact of carbon pricing and investment portfolios. This section provides a summary and citations; further information is available in Appendix A.

The Project Team relied on the *State Energy Data System* (SEDS) from U.S. EIA for historical energy use by fuel in each sector. Before making the adjustments described in the Sustained Policies section, the Project Team used the EIA's AEO2020 Reference case projection to scale the SEDS data to a state-level long-term projection.[32] The AEO2020 trajectory is a reasonable benchmark because it reflects long-standing structures and relationships that are not radically changed by the relatively minor changes in energy consumption reflected in this analysis. If Rhode Island and the broader New England region were to target and succeed at wholesale adoption of heat pumps or electric vehicles (at a scale beyond what the models indicate is likely to result from the adoption of the policies considered here), the shape and amount of demand for electricity and other fuels would change substantially beyond what is modeled in AEO2020. However, such changes are beyond the scope of this analysis.

Fuel prices, including the prices of gasoline, diesel/heating oil, natural gas, and electricity, are based on AEO2020. The COVID-19 pandemic has impacted fuel prices since AEO2020 was published. However, EIA is projecting a return to prices that are comparable to the AEO2020 projections within a few years.

[31] Transportation and Climate Initiative. *Modeling Methods and Results from TCI Regional Policy Design Process*. https://www.transportationandclimate.org/modeling-methods-and-results.

[32] U.S. Energy Information Administration. 2020. *Annual Energy Outlook 2020*. https://www.eia.gov/outlooks/aeo/.

Because this analysis is primarily concerned with (and shaped by) customer adoption of new technologies more than a few years in the future, the Project Team did not made explicit adjustment for the COVID-related fuel price effects. This analysis used internal combustion engine vehicle efficiency trajectories based on historical data for the light duty vehicle fleet from U.S. EPA,[33] scaled into the future based on a projection from AEO2018 that reflects the recent reduction in federal fuel economy standards.[34]

The Project Team used the Electric Vehicle Infrastructure Projection (EVI-Pro) Lite model from the National Renewable Energy Laboratory[35] to estimate the amount of EV charging infrastructure required in each policy case. As mentioned above, the analysis assumed that the Sustained Policies case includes development of the appropriate amount of public EV charging infrastructure to meet drivers' needs in that case. In the carbon price cases, the analysis sets aside investment funds to cover the costs of incremental public charging stations, and incorporates funds to support home EV charging into the EV purchase incentive.

To estimate the cost and impact of electrifying the Rhode Island Public Transit Authority's (RIPTA) bus fleet, the Project Team relied upon the Authority's 2019 *Sustainable Fleet Transition Plan*.[36] This plan estimated the cost of transitioning RIPTA's fleet to different configurations. This analysis used the relative cost of the "mixed en-route and depot charging" case as the primary input. There is substantial uncertainty regarding the future price of electric buses, as well as the supporting charging infrastructure. The *Sustainable Fleet Transition Plan* includes relatively optimistic assumptions for the decline in battery cost and resulting increase in cost-effective range for buses. These assumptions are consistent with the relatively optimistic assumptions inherent in the TCI-P reference case on which the light-duty vehicle analysis relies.

For heat pump market share in residential buildings, the Project Team used regional sales data from D+R International[37] and calibrated to the heat pump saturation and program participation reflected in National Grid energy efficiency programs and associated data collection.[38] The analysis assumed negligible current market share for heat pump water heaters. The Project Team used EIA's *Commercial Building Energy*

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[33] U.S. EPA. 2020. *Explore the Automotive Trends Data*. https://www.epa.gov/automotive-trends/explore-automotive-trends-data.

[34] AEO2020 and AEO2019 did not provide an alternate case reflecting this rule change.

[35] U.S. Department of Energy Alternative Fuels Data Center. *Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite*. https://afdc.energy.gov/evi-pro-lite.

[36] RIPTA. 2019. *Sustainable Fleet Transition Plan*. https://www.ripta.com/wp-content/uploads/2020/07/sustainable_fleet_transition_plan.pdf.

[37] D+R International. 2013 to 2017. *HARDI Data: D+R Unitary HVAC Market Reports*. Linked from https://www.nyserda.ny.gov/About/Publications/Program-Planning-Status-and-Evaluation-Reports/Evaluation-Contractor-Reports/2017-Reports

[38] NMR Group. 2018. *National Grid Rhode Island Residential Appliance Saturation Survey (Study RI2311) Report*. http://rieermc.ri.gov/wp-content/uploads/2019/04/national-grid-ri2311-rass-final-report-11oct2018.pdf; National Grid. 2020. *2019 Energy Efficiency Year-End Report*. http://rieermc.ri.gov/wp-content/uploads/2020/05/ngrid_4888-year-end-report-2019-puc-5-15-20.pdf.

Consumption Survey data to estimate heat pump share in commercial buildings,[39] and developed estimated residential building equipment costs from data collected and evaluations conducted on behalf of the Massachusetts utility energy efficiency programs.[40] For commercial building electrification, the Project Team used estimated costs developed for Washington Gas Light Company, a gas utility located in in Washington, D.C., by ICF International.[41]

Energy Use and Emissions Results

The Project Team used the sector-specific modeling tools described in Figure 3 to estimate the market response to each of the policy cases (i.e., low and high carbon prices with incentive-based or public-service-based investments) in the buildings and transportation sectors. This analysis did not conduct explicit modeling of the regional electric markets and associated emissions because the 100 percent renewable energy requirement for 2030 in the Sustained Policies case quickly eliminates that sector's emissions, and thus any direct effect of the carbon price on Rhode Island's electric sector. The carbon price is not applied in the industrial sector (aside from building space and water heat, which is captured in the buildings analysis), and this analysis assumed that sector would be unchanged as a result of the policy. This section describes the market and energy use changes in the buildings and transportation sectors and then collects the results to present economy-wide emissions impacts.

Buildings

In the Sustained Policies case, Rhode Island's building thermal GHG emissions fall about 20 percent by 2050, due to improving building shells and some shift to heat pumps for space and water heating, especially for buildings that currently heat with heating oil and propane. The carbon pricing and investment cases show greater adoption of heat pumps, along with additional weatherization of existing buildings. Building owners make choices for heating systems based on both upfront and operating costs, and the policy cases make fossil fuel options relatively more expensive on both fronts in ways that differ for each policy.

Carbon price and incentives

Synapse's Building Decarbonization Calculator (BDC) includes a consumer adoption model for building space and water heating systems. It is calibrated to current market share estimates, using the heat pump market share and saturation data described above, along with the current lifecycle cost differential between typical installations of each type of heating system. Both fossil fuel price increases (due to a carbon price) and upfront installation cost decreases (due to incentives) accelerate the market share of

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[39] U.S. EIA. *Commercial Buildings Energy Consumption Survey (CBECS)*. https://www.eia.gov/consumption/commercial/.

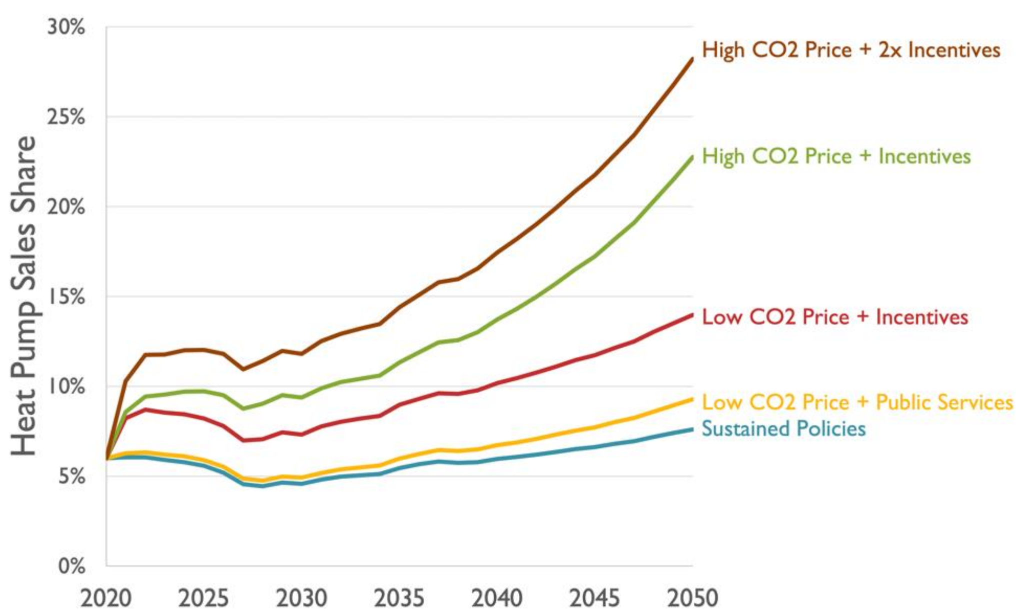
[40] Navigant. 2018. *Water Heating, Boiler, and Furnace Cost Study (RES 19)*. http://ma-eeac.org/wordpress/wp-content/uploads/RES19_Assembled_Report_2018-09-27.pdf; Navigant. 2018. *Ductless Mini-Split Heat Pump Cost Study (RES 28).* http://ma-eeac.org/wordpress/wp-content/uploads/RES28_Assembled_Report_2018-10-05.pdf.

[41] These values were provided to the District of Columbia Department of Energy and Environment in DC Public Service Commission Formal Case 1142 in a file titled "DCAOG Follow Up Questions - 5.07.2020 Responses".

heat pump systems. The BDC models buildings with and without forced air systems, and with and without access to natural gas, as separate markets.

Figure 5 shows the results for space heating heat pump market share under each policy case in one sub-market, residential homes that are currently heated with forced-air natural gas systems. In this sub-market, the heat pump market share remains relatively flat without policy intervention, and the addition of a low carbon price alone has negligible effect. In the Low Carbon Price + Incentive case, where the funded incentive starts at about $1,500 per unit and rises over time and approaches $2,000 per unit, market share increases by about one-third, although it remains below 15 percent even in 2050.[42] Adding a higher carbon price to the same level of incentive funding begins to drive accelerating market share by the 2030s. Note that this case, High Carbon Price + Incentives, has slightly smaller incentives than the Low Carbon Price + Incentives case, on a dollar-per-unit basis, because the same funding is spread over more units. Doubling the incentive creates an additional step up in market share in the early years of the policy and parallels the higher carbon price case in the out-years.

Figure 5. Heat pump sales share in each policy case for gas-heated residential homes with forced air heating systems



The other sub-markets show similar relative effects in the different policy cases, although the markets with delivered fuels (e.g., fuel oil and propane) have much higher market shares throughout because heat pumps are more cost-effective when compared to these fuels. Commercial sub-markets, where heat pumps already have a larger market share so there is a stronger foundation for the market to build on,

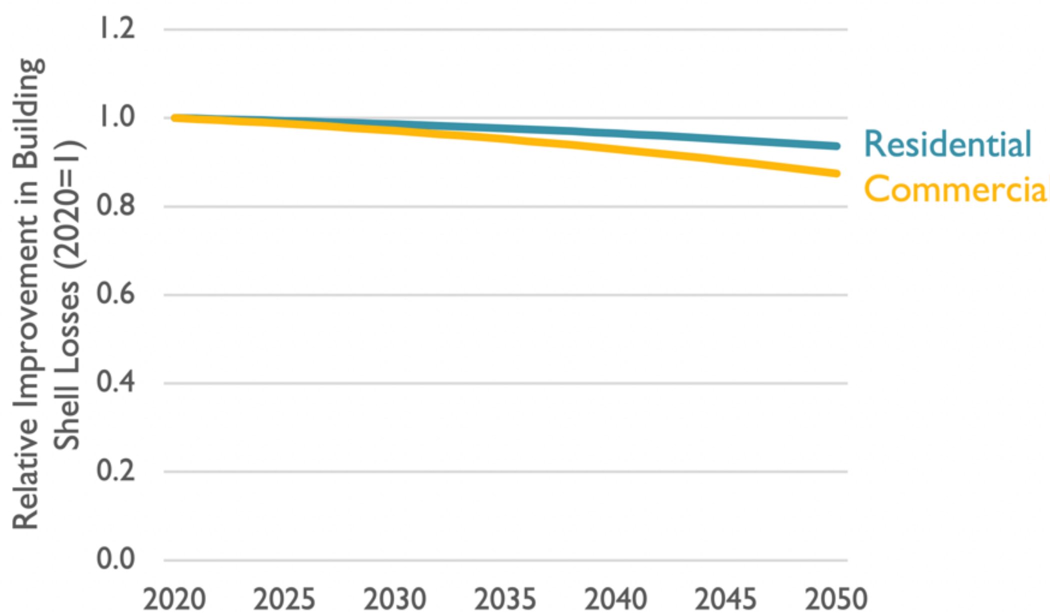
[42] For context, a typical heat pump system has an installed cost of just under $15,000. National Grid currently offers incentives for efficient heat pumps of approximately $1,050 per unit (assuming a roughly 3-ton system capacity) for homes that currently heat with fossil fuels.

are generally more responsive to carbon price and incentive policies than the residential markets. Across all cases, the relatively flat or even downward-trending heat pump adoption through 2030 is related to projected increasing electric rates in this period. Appendix A contains summary tables for sales share of heat pump systems in other sub-markets.

The Project Team investigated the potential impact of biofuel heating oil blends on the model results and found they would have minor effects at the most likely blend ratios. Bioheating oil with 20 percent biofuel content (B20) is the highest blend ratio that has been certified by ASTM International, an organization which sets industry standards for fuels and lubricants, to be used in place of eating oil. If oil dealers switched to B20 blends at the same fuel price as fossil heating oil, and thus reduced the impact of the carbon price by 20 percent, the consumer adoption modeling shows that heat pump market shares versus heating oil would fall by just 4 percent in the high carbon price cases (which show the largest effect). For natural gas customers, the price premium for renewable natural gas (RNG) is higher than the associated reduction in carbon price, so using RNG to avoid these carbon prices would not make economic sense. If the default natural gas supply were to blend RNG, it would tend to make electrification more attractive to customers.

Weatherization incentives funded by a carbon price would build on the existing utility-ratepayer-funded programs to increase building shell performance. Figure 6 shows the resulting reduction in heat losses in building shells, relative to the Sustained Policies case. With the base level of incentives funded by the low carbon price, residential building shells in 2050 are about 6 percent better than they would have been absent the additional funding, and commercial building shells are about 13 percent better. Improvements roughly double in the High Carbon Price + Double Incentives case.

Figure 6. Relative improvement in building shell losses due to additional weatherization incentives (2020=1)

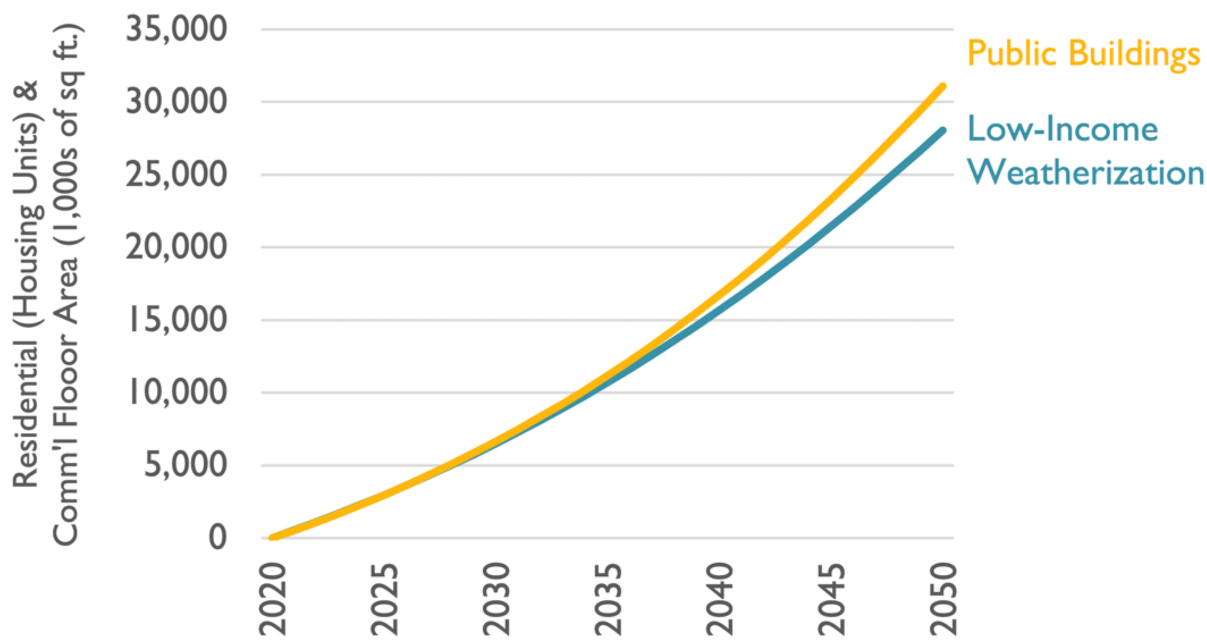


Investments in public services

In the Low Carbon Price + Public Services case, most building owners only see cost increases resulting from the carbon price, rather than benefits resulting from an expansion of public services. This results in only minor changes in heat pump uptake (as illustrated in Figure 5 above). However, public buildings and buildings housing low-income families receive increased funding for no-cost weatherization and electrification. This has the effect of allowing low-income households and frontline communities to directly participate in and benefit from the carbon pricing policy, which may be especially critical to avoid leaving these communities to pay more than their share of the costs of heating system transformation.

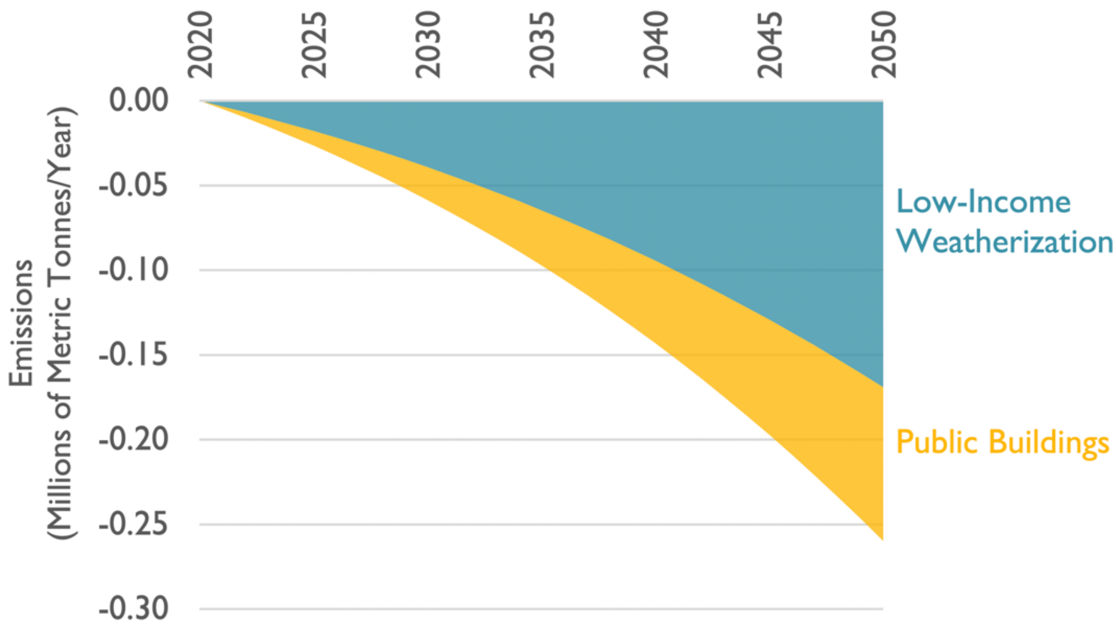
Figure 7 shows the resulting number of units of low-income housing and the square feet of public buildings that are improved with the carbon price funding for investment in public services. Over the study period, about 7 percent of Rhode Island households benefit from the additional weatherization and electrification, and the scale of public buildings served is comparable to the total square footage of all public schools in the state.[43] Figure 8 shows the resulting annual emissions impact.

Figure 7. Cumulative units and floor area served by direct investment of carbon price revenues in weatherization and electrification of low-income and public buildings



[43] Assuming that the state's 317 public schools average about 100,000 square feet (Sources: Public School Review. *Top Rhode Island Public Schools*. https://www.publicschoolreview.com/rhode-island.; and Spaces4Learning, *School Costs: Did You Know...* https://spaces4learning.com/Articles/2015/07/01/School-Costs.aspx.).

Figure 8. GHG emissions reduced from using carbon revenue to directly fund decarbonization in low-income homes and public buildings



Emissions by Case

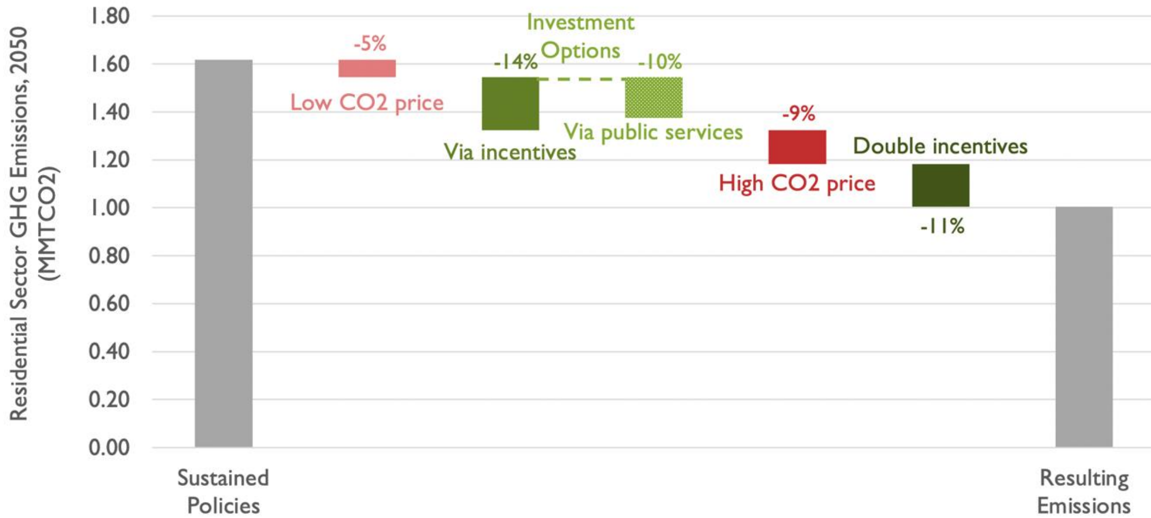
Figure 9 shows the accumulating effects of each component of the carbon price and investment cases in 2050. In the Sustained Policies case, 2050 building sector emissions fall 20 percent from the 2020 estimate of 3.01 $MMTCO_2$ to 2.41 $MMTCO_2$.[44]

Across the combined residential and commercial sectors, the combined emission reduction in 2050 from the Low Carbon Price + Incentive case is 0.5 $MMTCO_2$. Of this reduction, 0.11 $MMTCO_2$ (22 percent) is caused by customer responses to the carbon price, while the remaining 0.39 $MMTCO_2$ (78 percent) is driven by the incentives. The alternative modeled investments in the Public Service case produce 34 percent fewer emission reductions than the modeled incentives: 0.26 $MMTCO_2$ in 2050. As a result, while the Low Carbon Price + Public Services case has the same 2050 price effect of 0.11 $MMTCO_2$, its 2050 total emission reductions are only 0.37 $MMTCO_2$ per year.

In this modeling, the commercial sector is more responsive to the carbon pricing and incentive policies than the residential sector. On average, across the cases considered, the policy-driven emission reductions in the commercial sector are about one quarter to one third larger than the equivalent case for residential buildings. This is because the models use current market share to gauge potential growth from changes in relative cost. The relatively higher current market share for heat pump systems in commercial buildings across the region indicates that the commercial marketplace would be more responsive to policies that encourage greater adoption.

[44] 2020 emissions in each sector are estimated based on the EIA 2020 Annual Energy Outlook. Rhode Island's actual 2020 emissions (in any sector) are unknown as of this writing.

Figure 9. Residential (top) and commercial (bottom) building sector emissions in 2050 under each policy case. Each colored bar shows the reductions from the preceding case that result from the addition of the labeled policy element (e.g., a change in CO2 price or investment strategy). The Public Services case is only examined with the low carbon price.



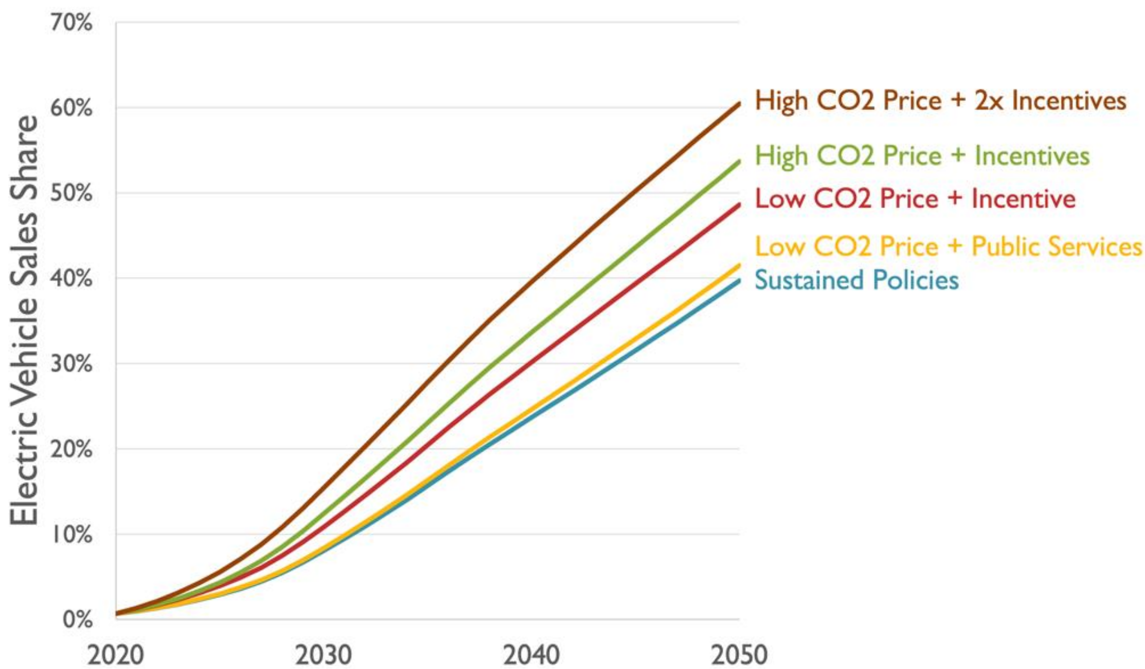
Transportation

Relative to today, transportation emissions fall substantially in the Sustained Policies case due to increasing expected sales of electric vehicles. Carbon prices and investments further reduce emissions by increasing use of EVs and by reducing vehicle miles travelled.

Incentives

Both increasing the cost of gasoline via a carbon price and decreasing the upfront cost of EVs through incentives make EVs more attractive to consumers. Figure 10 shows the increasing market share for EVs projected in each policy case. In general, the fuel price impact is somewhat smaller than the incentive effect.

Figure 10. Electric vehicle sales share in each policy case

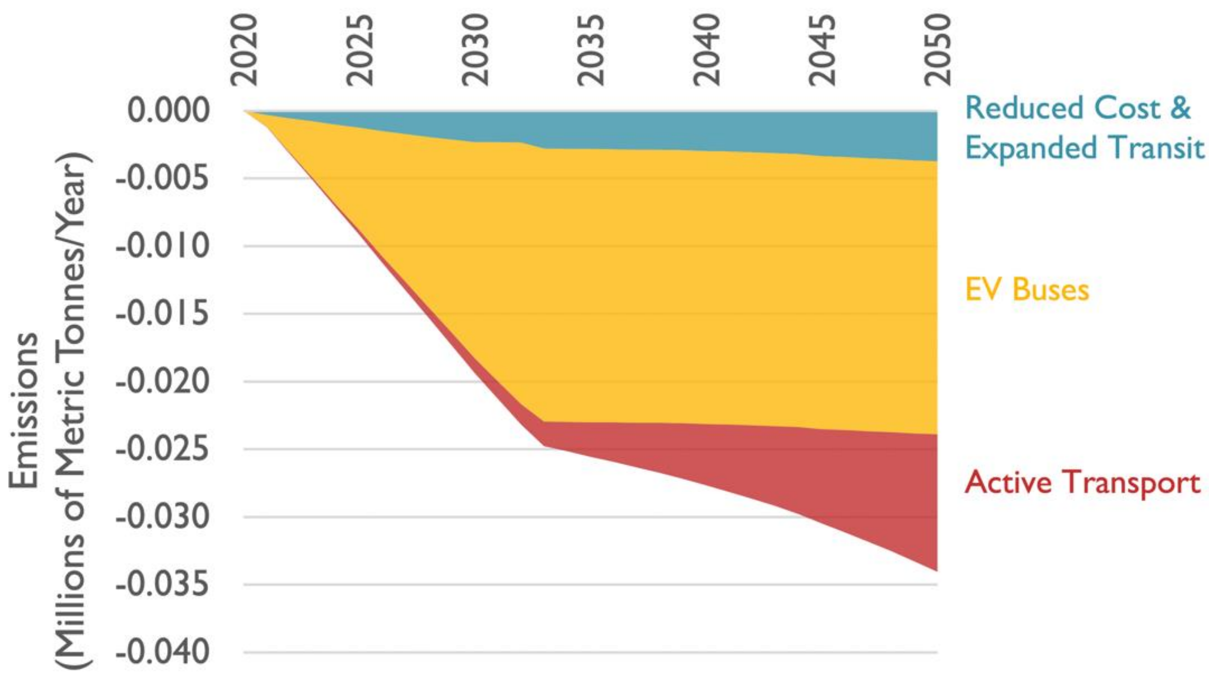


Investments in public services

There are numerous ways that carbon revenue could be invested in the transportation sector to support public services and advance equity, while also reducing GHG emissions. For the purposes of illustrating potential impacts, the analysis dedicated the first tranche of carbon revenue to reducing transit fares, which are approximately halved. In other words, half the carbon revenue from transportation fuel use is rebated to transit riders. The remaining funds were dedicated first to electrifying RIPTA's bus fleet and then split between support for expanding bus service and investing in active transport infrastructure (e.g., sidewalks and bike lanes). In practice, stakeholders, legislators, and transit leaders deciding how to use carbon revenue to support transit might choose a different blend of fare support, expanded service, and electrification to meet broader policy objectives.

Figure 11 shows that the lion's share of emission reductions in this example portfolio come from electrifying the bus fleet. Reduced fares for transit and expanding bus service (at the level funded under this approach) have comparatively little impact on emissions. While they do increase ridership incrementally, the resulting avoided fuel use in personal vehicles is expected to be much smaller than the fuel use of RIPTA's existing bus fleet.

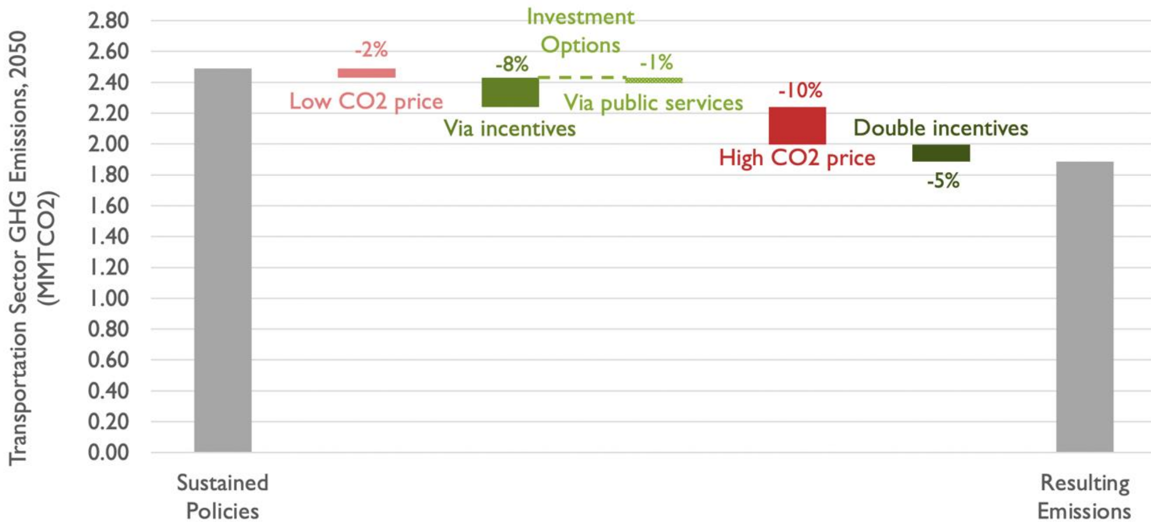
Figure 11. Emissions impact of Public Services investments in transit (i.e., reduced fares and expanded service), electric buses, and support for active transport (e.g., walking and biking) infrastructure



Emissions impacts

Figure 12 shows the accumulating effects of each component of the carbon price and investment cases in 2050. In the Sustained Policies case, 2050 transportation emissions are modeled to fall from the 2020 estimate of 4.21 $MMTCO_2$ to 2.49 $MMTCO_2$. The addition of the low carbon price (equal to approximately $15 per metric ton in 2050) alone would cause 2050 emissions to fall an additional 0.06 $MMTCO_2$. Adding EV incentives would reduce 2050 emissions by an additional 0.19 $MMTCO_2$, while adding public services investments to the low carbon price instead would reduce emissions much less—less than 0.04 $MMTCO_2$ beyond the price impact. The high carbon price (around $100 per ton in 2050) would have a larger effect than the low carbon price, although the emissions impact per dollar of additional carbon price is smaller. The analysis also shows diminishing returns when doubling the incentive level with the high carbon price: where the initial incentive reduces 2050 emissions 0.19 $MMTCO_2$, doubling it reduces 2050 emissions only a further 0.11 $MMTCO_2$.

Figure 12. Transportation sector emissions in 2050 under each policy case. Each colored bar shows the reductions from the preceding case that result from the addition of the labeled policy element (e.g., a change in CO2 price or investment strategy). The Public Services case is only examined with the low carbon price.



Economy-Wide Emissions

Putting policy impacts in the buildings and transportation sectors together shows the combined effects in relation to Rhode Island's statutory GHG reduction targets. Figure 13 shows the annual energy-related emissions pathway under the Low Carbon Price + Incentives policy case, compared with the emissions observed in the Sustained Polices case and RI's statutory targets.[45] The Sustained Polices case achieves the 2035 target primarily as a result of the elimination of emissions from the electric sector, although there are reductions in the building and transportation sectors as well. Each of the policy cases has lower emissions than the Sustained Policies baseline. However, no policy cases meet the 2050 target. In the Low Carbon Price + Incentives case illustrated in Figure 13, the policy case emissions trajectory exceeds the target emissions level beginning in 2038.

Figure 13. Annual energy-related GHG emissions for the Sustained Policies baseline (total) and the Low Carbon Price + Incentives policy case (by sector), along with statutory GHG targets

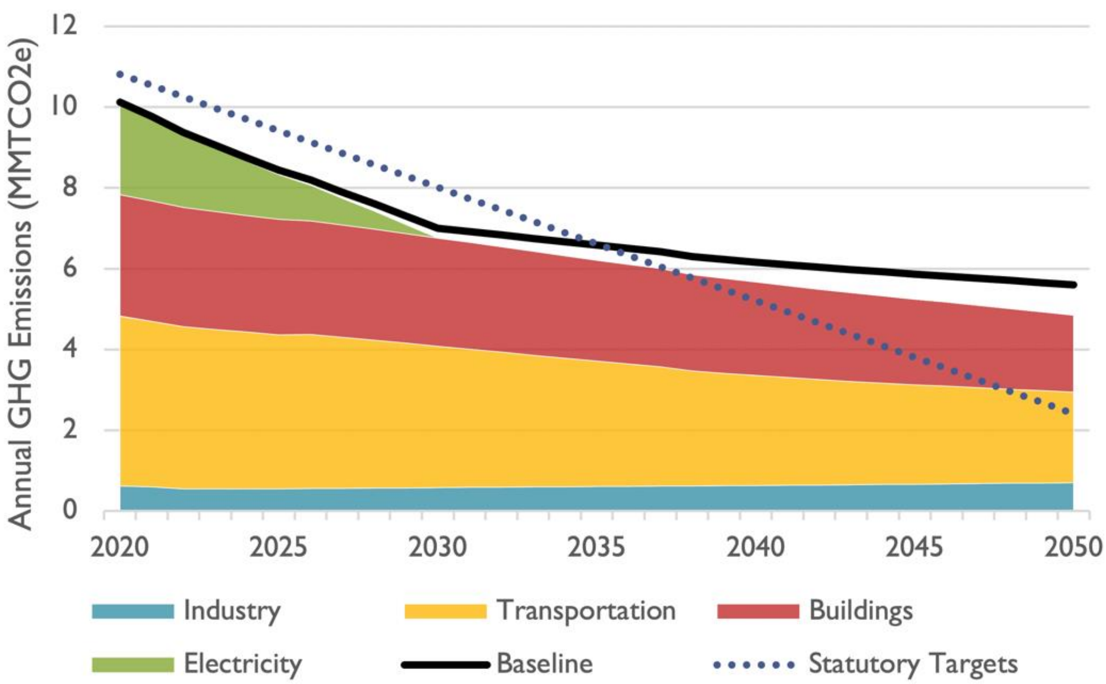
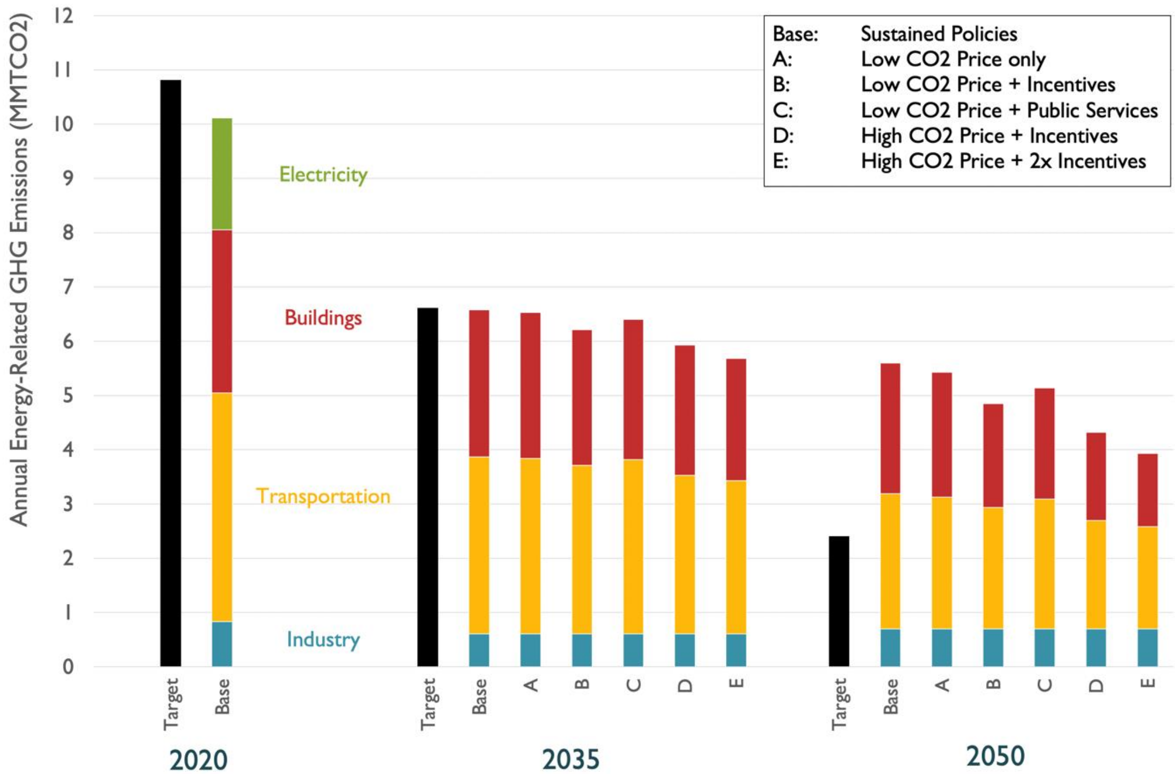


Figure 14 shows the estimated economy-wide energy-related emissions in each of the policy cases in the milestone years of 2020, 2035, and 2050. All cases achieve the 2035 emissions target, and all fail to meet the 2050 target. Additional policies and programs beyond those modeled here would be required to meet or exceed the reductions for the statutory 2050 target. Without 100 percent renewable electricity, it is unlikely that any of the cases would achieve the 2035 target, although there would likely be greater electrification in both transportation and buildings sectors to partly offset the increase in emissions in the electric sector.

[45] Rhode Island does not have annual GHG emission targets. Its targets are statutorily defined for 2020, 2035, and 2050. The statutory targets fall along a straight line, so this analysis uses that interpolated line as a benchmark.

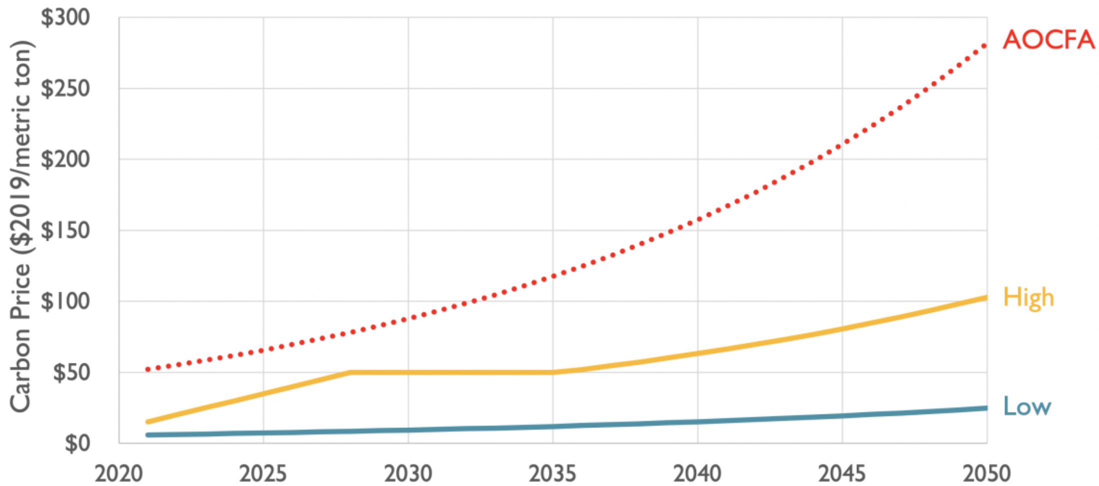
Figure 14. Composition and total of annual energy-related GHG emissions for Sustained Policies and each policy case in 2020, 2035, and 2050.



Evaluation of a Higher Carbon Price

As discussed in Section 3, as part of initial assessment of the scale of potential impact from carbon price scenarios, we evaluated the energy demand changes from three carbon prices using the Carbon Tax Assessment Model (CTAM). The three carbon prices were the two prices evaluated throughout the rest of this report plus the price trajectory in the proposed federal American Opportunity Carbon Fee Act (AOCFA), introduced by Sen. Whitehouse. This trajectory starts at $52 and rises 6 percent above the rate of inflation. This assessment did not include the results from investment of any revenue.

Figure 15. The America Opportunity Carbon Fee Act (AOCFA) carbon price trajectory in context of the high and low carbon prices fully assessed in this report



Unsurprisingly, the higher AOCFA carbon price results in lower emissions than the High case, taking only price-driven effects into account. Emissions in the AOCFA case in 2050 are 1.2 million metric tons (about 26 percent) lower than in the High Price-Only case. This analysis indicates that, even at the AOCFA carbon price, the demand impact of a price signal alone would not be sufficient for the state to meet its emissions targets.

Table 6. 2030 and 2050 price-induced (CTAM-model) emission results for the Low, High, and AOCFA cases

Year	Price trajectory	Price (2019 $/metric ton)	Emissions (MMTCO2)	Emissions reductions below 1990 levels
2030	Low	$9	6.6	45%
	High	$50	6.2	48%
	AOCFA	$88	5.9	51%
2050	Low	$25	5.2	57%
	High	$103	4.7	61%
	AOCFA	$282	3.5	71%

Economic Impacts

Changes in spending on energy and energy-related infrastructure, such as vehicles and HVAC systems, resulting from carbon pricing and investment policies ripple out through the state's economy. Spending shifts from one product (e.g., gasoline) to another (e.g., electricity) for the same purpose (e.g., mobility), cause changes in supply chains. Changes in the aggregate amount of money spent by households and businesses on energy also result in more or less spending on non-energy items (referred to as "respending"). The Project Team modeled these changes using a Rhode Island-specific version of the IMPLAN input-output model, which traces the impacts of spending in one sector on spending in other sectors, and allows us to measure job-year[46] and gross domestic product (GDP) impacts resulting from each component of the response to the carbon pricing and investment policies.

As with the other results presented in this report, these results reflect only the impacts of the policy cases examined in this study above and beyond the Sustained Policies case, and not the economic implications of the broader energy sector transition toward decarbonization.

The Project Team developed economic impact results out to 2035, and not to 2050, because the underlying shape of the economy is unlikely to be closely matched by today's economy past 2035. With respect to today, 2050 is as far in the future as 1990 is in the past, and the components of the Rhode Island and U.S. economies have evolved to be substantially different over that timeframe. Even the results to 2035 should be taken with substantial uncertainty given the potential changes to lifestyles and business that may emerge from the COVID-19 pandemic.

Buildings Sector

In all cases examined in this study, carbon pricing coupled with investment policy results in net job creation from spending changes in the buildings sector. Figure 18 shows the Low Carbon Price + Incentives case. The net increase in spending on HVAC and water heating installation, resulting from the fact that new installations of heat-pump based comfort systems are somewhat more expensive than fossil fuel (FF) combustion systems with separate air conditioners, produces a net increase in jobs. The net increase in building shell improvements (e.g., weatherization) and renewable electricity generation construction, which is linked to increased electrification needs, increases jobs. Reductions in spending on delivered fuels decreases jobs. Reductions in natural gas sales do not have direct job impacts, because natural gas infrastructure spending is unaffected and the regulated gas utility is assumed to pass through the changes in commodity gas purchases without markup or job implications. Customer fuel savings, primarily from delivered fuels, accumulate to counteract the increase in spending on heating systems so that, in years after 2030, respending creates net job increases. Policy impacts from the buildings sector on GDP are similar to their impact on job creation: small and netting out to a small positive effect (see Figure 17). The delivered fuels sector is responsible for somewhat more loss in GDP than loss in jobs, compared to the other drivers.

[46] A job-year is one full time equivalent job for one calendar year.

All other incentives-based cases are qualitatively similar. Equivalent figures for these cases are in Appendix A.

Figure 16. Annual economy-wide job-year increases and decreases resulting from changes in building-related spending patterns in the Low Carbon Price + Incentives case

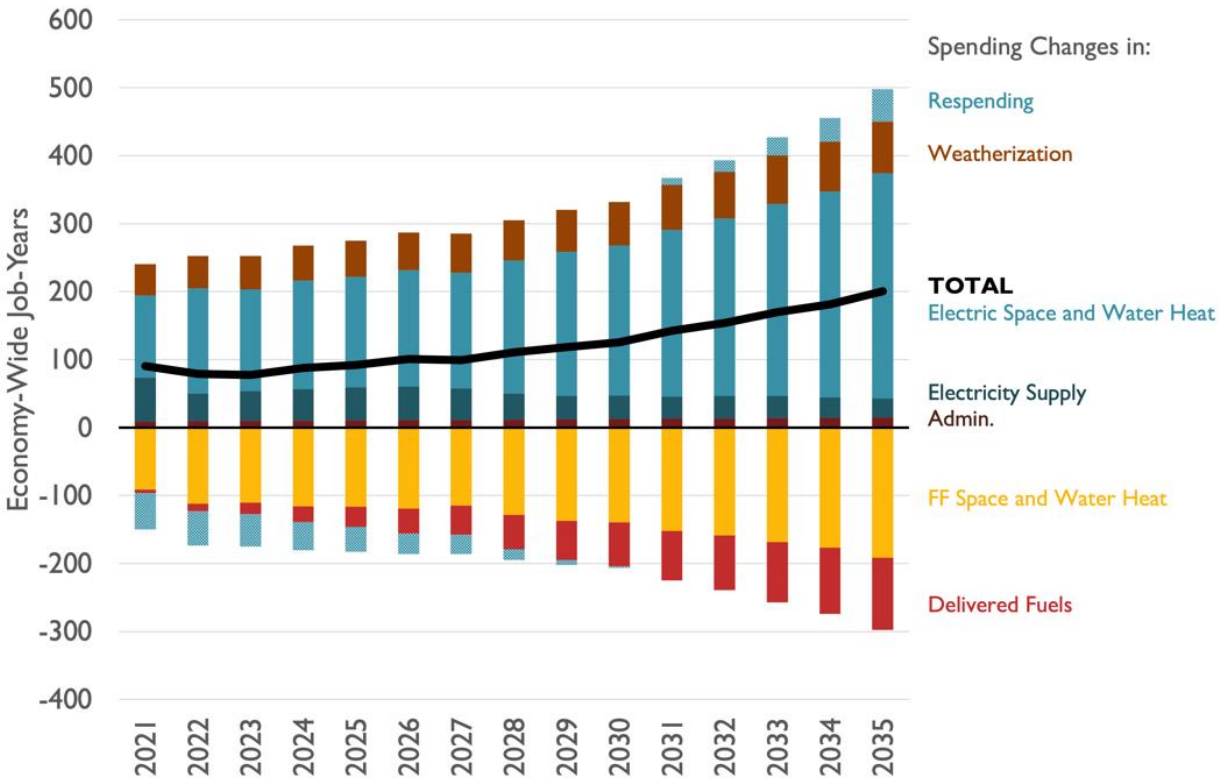
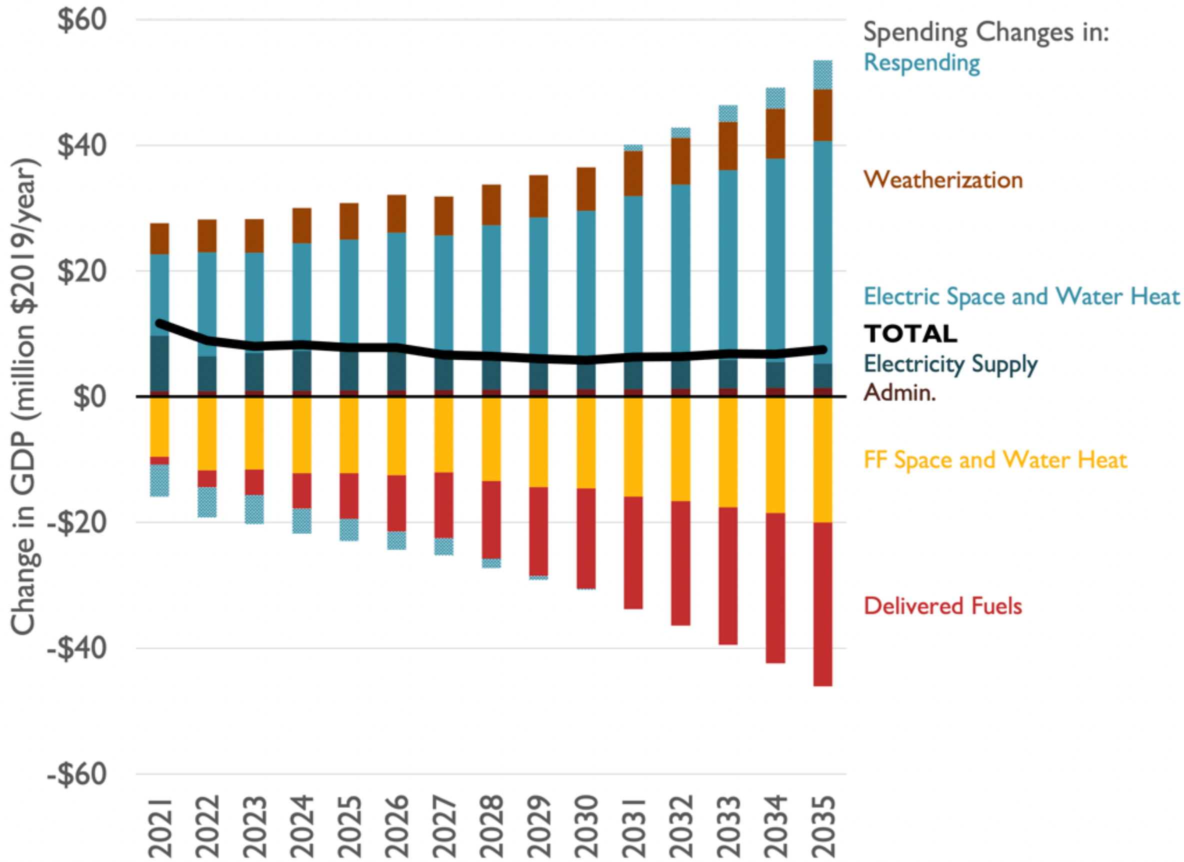


Figure 17. Annual GDP increases and decreases resulting from changes in building-related spending patterns in the Low Carbon Price + Incentives case



In contrast to the incentives-based investment portfolios, the public services case for building investment has a negative impact on jobs and GDP from respending effects. However, the policy as a whole still produces small job gains (see Figure 18.) This difference is largely because this analysis assumed that the low-income and public buildings investments would be evenly spread across the state, split proportionally between gas- and oil-heated homes. As a result, there is less fuel cost savings than in the incentives-based case, where there are more fuel savings because of greater participation by the owners of oil-heated homes. This illustrates the impact of program design choices. The programmatic balance between oil and gas heated homes has downstream effects on customer savings and a further small effect on the broader economy.

Figure 18. Annual economy-wide job year increases and decreases resulting from changes in building-related spending patterns in the Low Carbon Price + Public Services case

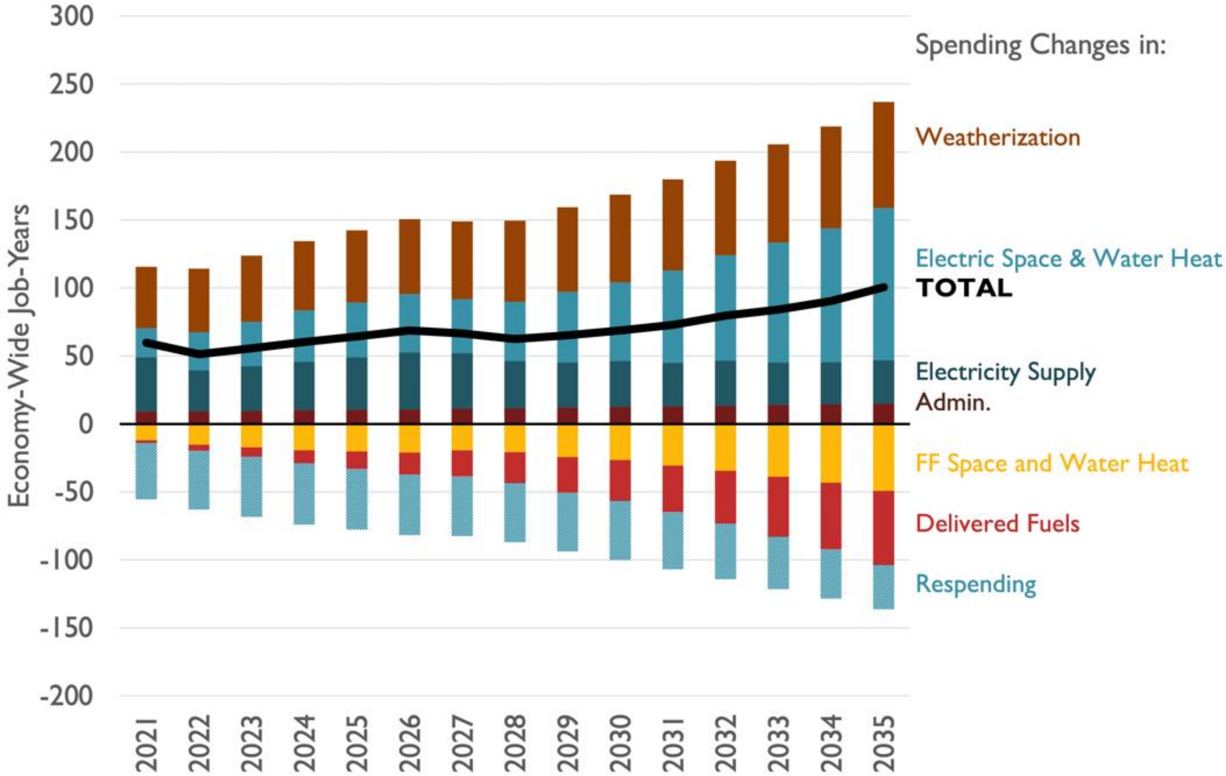
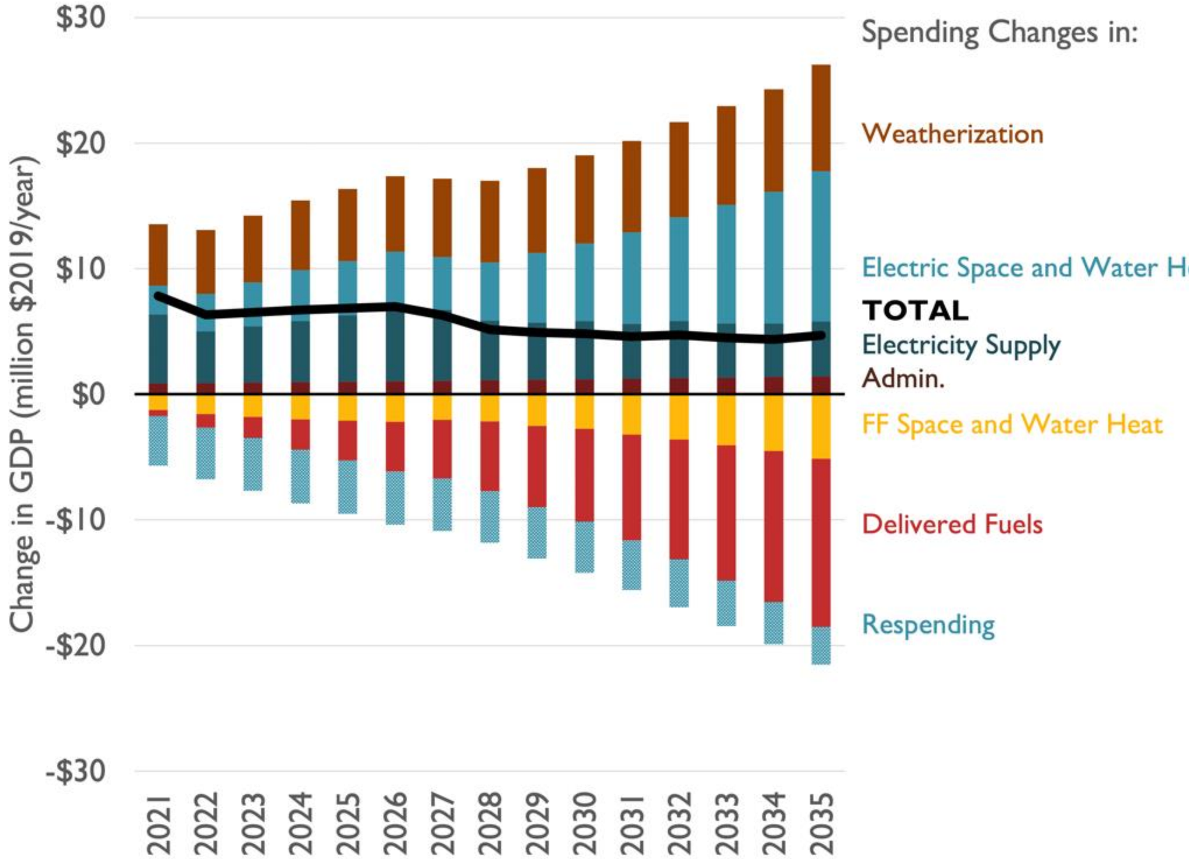


Figure 19. Annual GDP increases and decreases resulting from changes in building-related spending patterns in the Low Carbon Price + Public Services case



Transportation Sector

Policy-driven changes in spending in the transportation sector have an overall slightly negative impact on jobs and GDP in Rhode Island. This is primarily because EVs require substantially less maintenance than traditional ICE vehicles. The resulting reduction in revenue and jobs in repair shops means fewer jobs overall. Meanwhile, drivers benefit from savings on both fuel and maintenance costs, but generic consumer respending is not focused on products and services produced in Rhode Island, so the net effect of this shift is positive for consumers but negative for the state-level economy. Figure 20 shows the overall and spending-driver results for the Low Carbon Price + Incentives case. As was the case with buildings, the overall picture for GDP is similar to job impacts: small and slightly negative. Gas stations contribute more to GDP than to jobs, so they play a larger role here.

Each of the other incentives-based cases is similar, and the equivalent figures can be found in Appendix A.

Figure 20. Annual economy-wide job year increases and decreases resulting from changes in transportation-related spending patterns in the Low Carbon Price + Incentives case

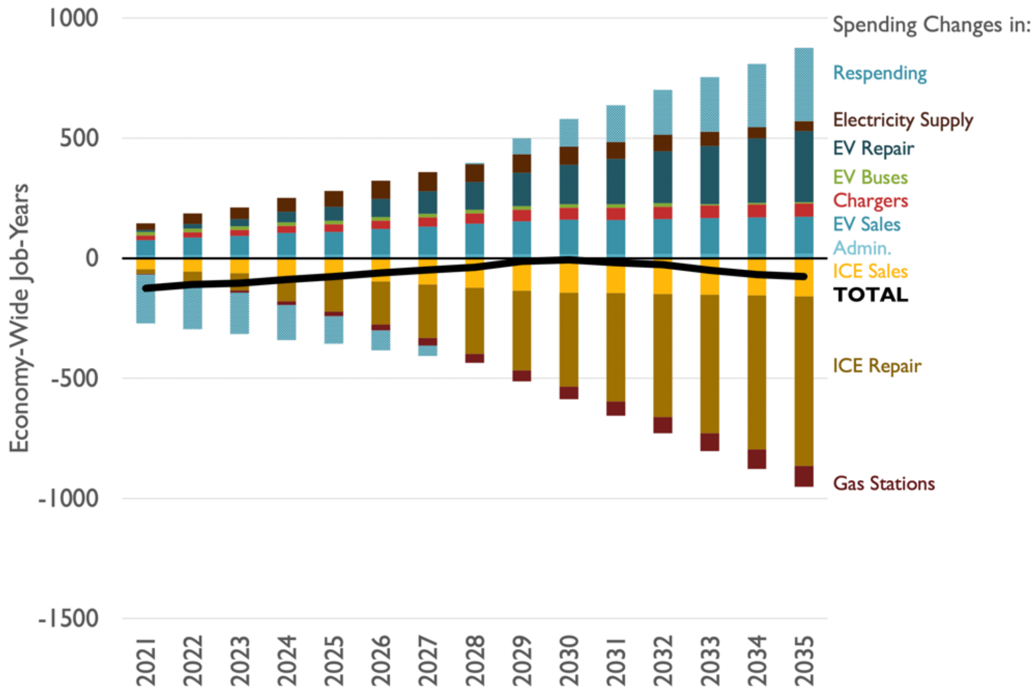
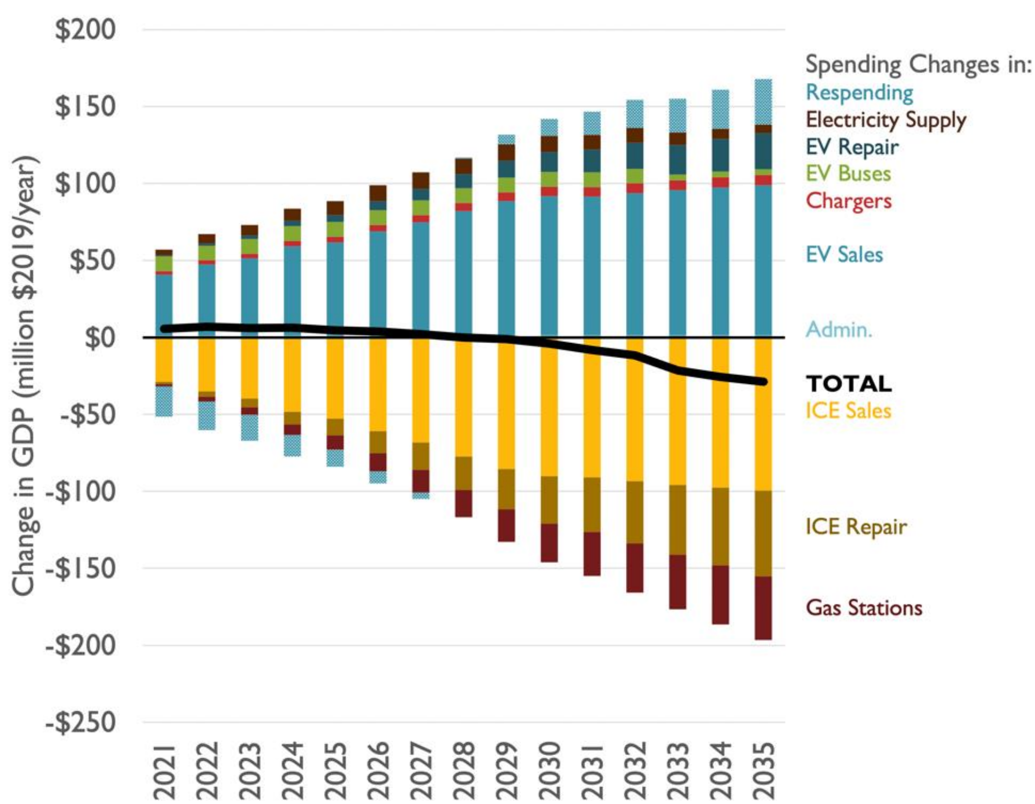


Figure 21. Annual GDP increases and decreases resulting from changes in transportation-related spending patterns in the Low Carbon Price + Incentives case



The economic results of the public services investment case are quite different from the incentives-based approach, because the investments are almost entirely different: reduction in transit fares, bus electrification, expansion of transit service, and support for walking and biking infrastructure. This case has much less EV adoption, which means that it lacks the EV vs. ICE auto repair impact that dominates the net results in the investment cases. (The displacement of vehicle ownership by increased transit ridership is *de minimis*). The transition from diesel to electric buses has very small job impacts, while residents experience a net decrease in disposable income (thus reducing jobs associated with respending). This is because the carbon price increases the cost of fuel but only decreases direct costs in the form of reduced transit fares. Compared to the incentives approach, this investment path spends more funds on annual operational costs, and less on changes in capital spending, so there are fewer accumulating effects over time. When the EV bus transition is complete in 2033, the increased spending on transit service and active transit infrastructure results in a boost in jobs and GDP.

Figure 22. Annual economy-wide job year increases and decreases resulting from changes in transportation-related spending patterns in the Low Carbon Price + Public Services case

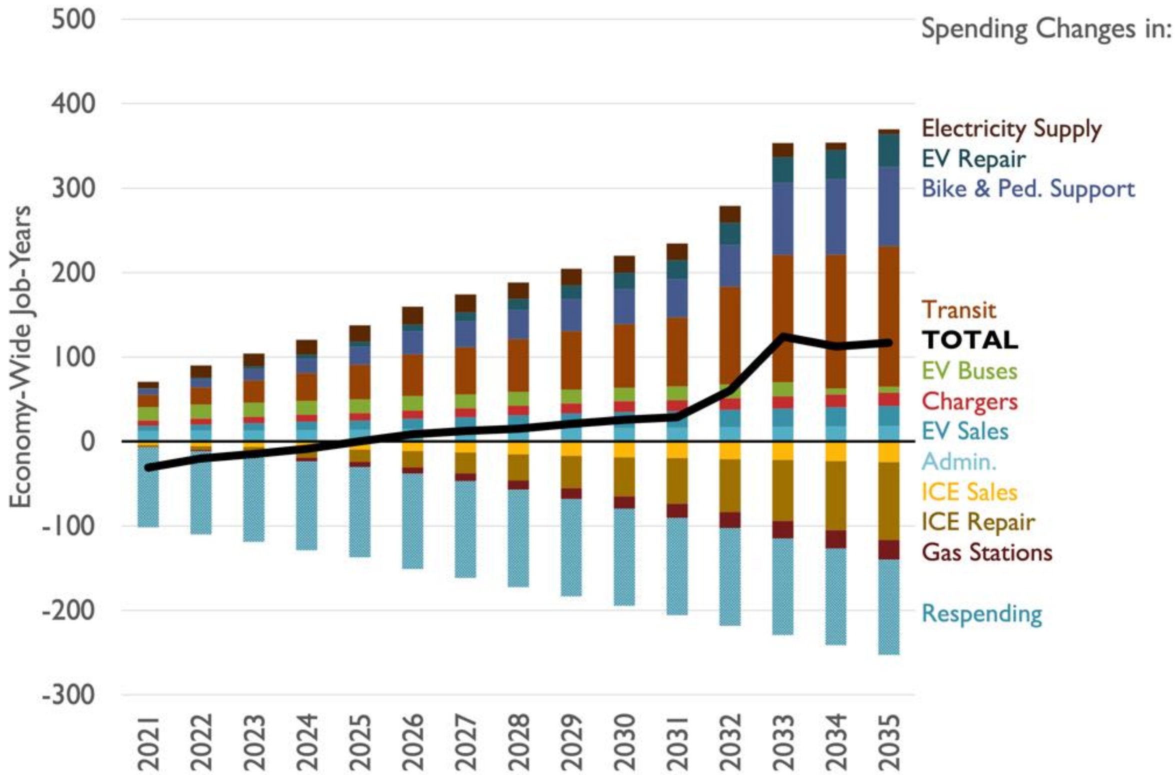
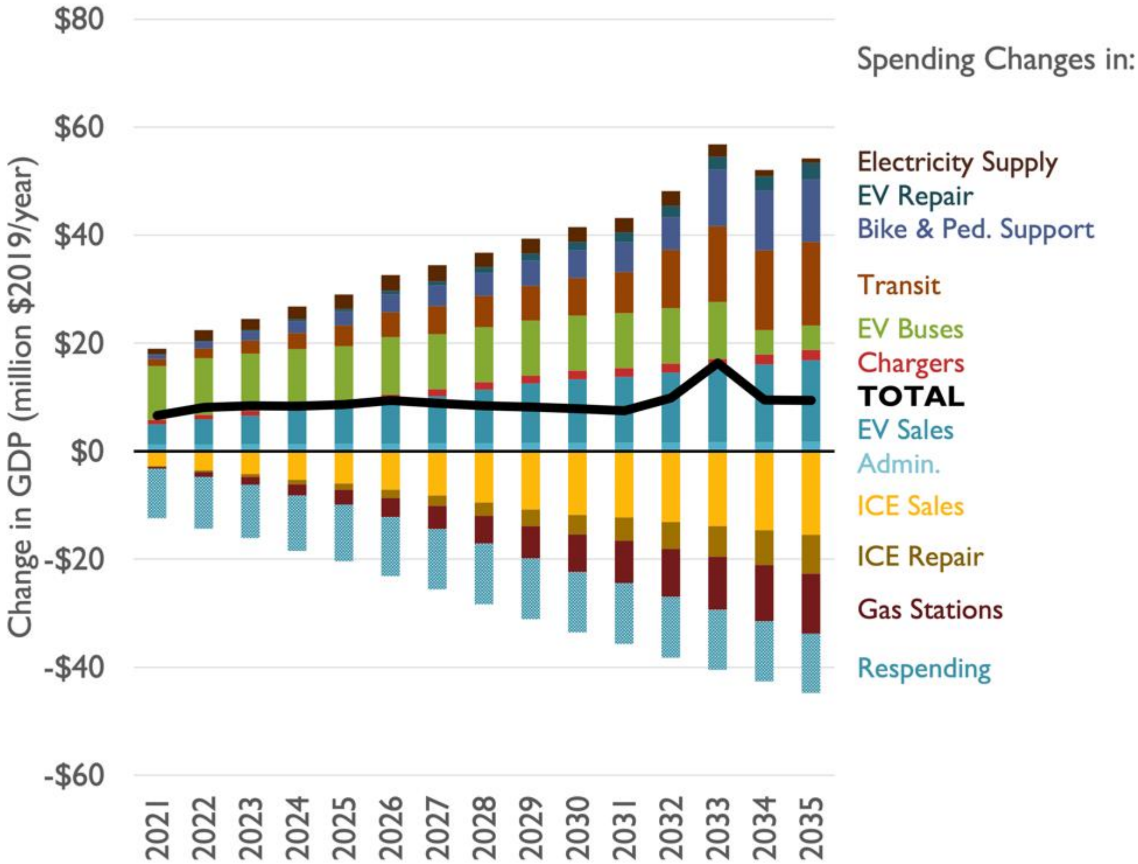


Figure 23. Annual GDP increases and decreases resulting from changes in transportation-related spending patterns in the Low Carbon Price + Public Services case



Comparing Across Policy Cases

The aggregate economic impacts of all four carbon price and investment cases, shown in Figure 24 and Figure 25, are small on the scale of Rhode Island's employment and economy. The largest job impact from any case is an increase of less than 0.07 percent (e.g., less than one job in 1,500). The largest GDP impact from any case is a reduction of 0.1 percent at the end of the projection period in 2035. The differences between cases are even smaller. In general, the more aggressive policy interventions that result in more emission reductions also result in marginally larger impact on the state's economy, both positive and negative. The Public Services investment case is qualitatively different, for the reasons discussed in the preceding sections. It also has the smallest impact on the state's GHG emissions, especially in the transportation sector.

Figure 24. Comparison of the Rhode Island employment impact of the four policy scenarios

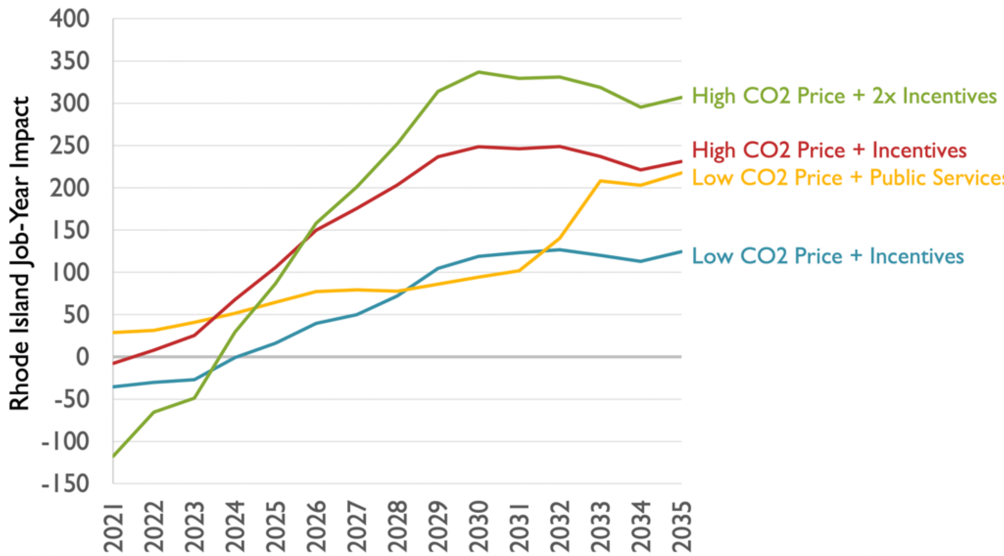
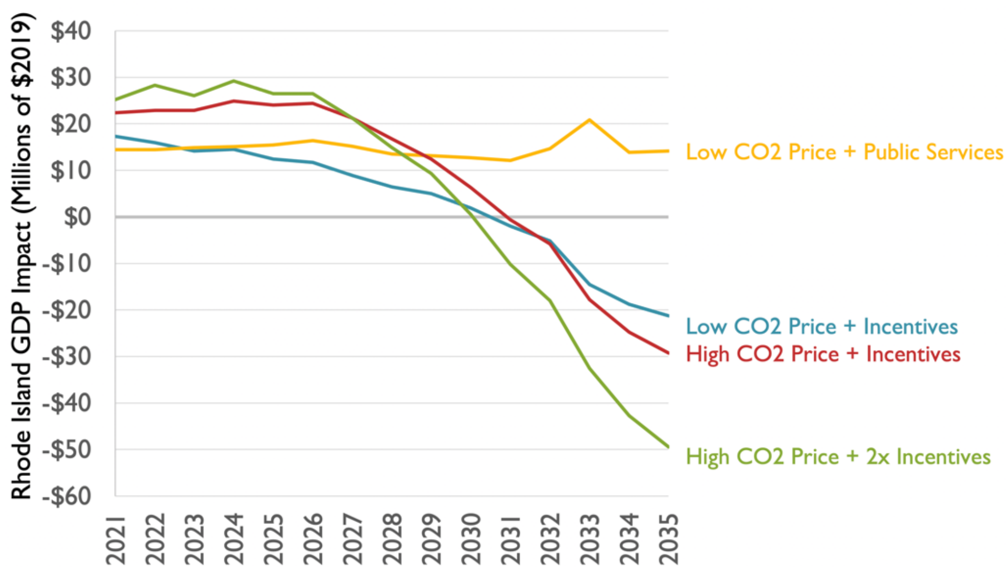


Figure 25. Comparison of the Rhode Island GDP impact of the four policy scenarios

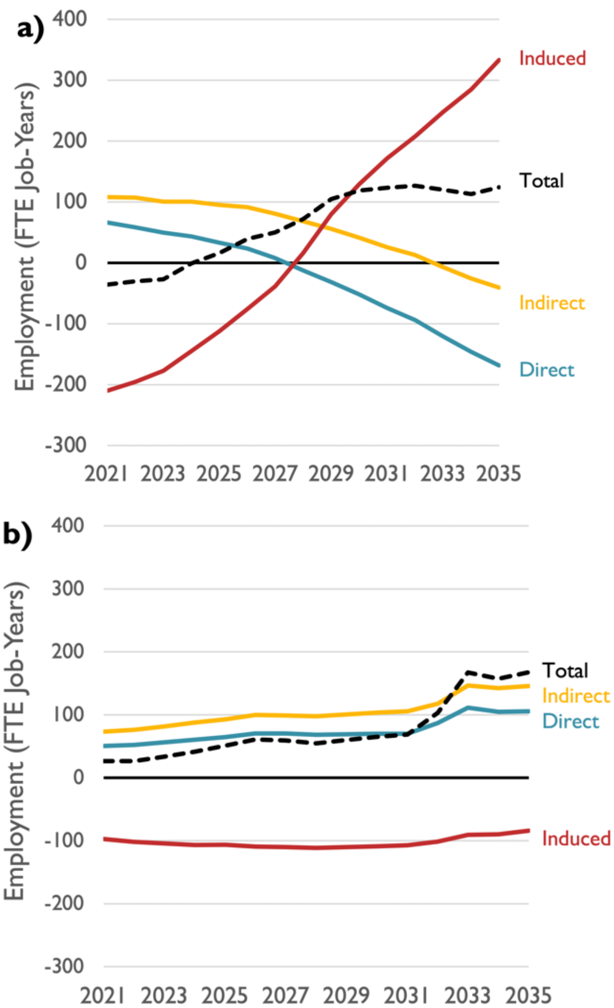


Aggregate changes in state-wide jobs and GDP can be small while the impacts on individual types of firms and jobs are large. In fact, the transition to a fully decarbonized economy would be impossible without fundamental changes in some aspects of the economy (e.g., those related to selling and consuming fossil fuels). In general, the opportunities and growth created in low-carbon industries counteract the losses in fossil-fuel-based industries. In some cases, shifts occur within the same industry (e.g., auto repair shifting from fossil fueled to electric vehicles, or HVAC installers installing heat pumps instead of furnaces and boilers).

The characteristics of net job creation also vary between cases. In the incentives-based cases, there are job losses in the direct areas associated with investment, predominated by auto repair jobs. These spread to indirect jobs. Meanwhile, accumulated customer savings and respending result in increasing induced jobs over time. In the public services case, the direct investment creates jobs in transit operations and construction, and this results in more indirect job creation in supply chains. But the net negative respending results in a loss of induced jobs. Figure 26 shows the two low carbon price cases with the different investment approaches, which have very similar overall employment effects but quite different distributions of those jobs.

Where the aggregate results show GDP declines accompanied by job gains, that implies that wages and profits (i.e., the components of GDP) per job are falling. In the incentives cases that exhibit this behavior, this effect is likely the result of shifts in job composition from higher-skill and higher-wage direct jobs to induced jobs that are in lower-wage sectors such as retail.

Figure 26. Contribution to net job impacts from direct, indirect, and induced jobs in the a) Low Carbon Price + Incentives case (left) and b) Low Carbon Price + Public Services case (right)



Direct *jobs are jobs in the specific industry where the spending changes happen as a result of the policies being examined.*

Indirect *jobs are jobs in the supply chain for the direct sectors.*

Induced *jobs are jobs resulting from household and business spending of net surpluses or deficits that occur as a result of the policies.*

Health Impacts

The Project Team used the COBRA model, published by U.S. Environmental Protection Agency, to estimate the health benefits of each of the modeled carbon price and investment policy options. COBRA estimates health impacts resulting from changes in particulates but does not estimate ozone impacts, for which the atmospheric chemistry is much more complex. Consequently, these results are underestimates of health benefits.

Table 12 shows the cumulative health benefits over the 2021-2050 period from each policy case, in Rhode Island and nationally. Overall, health benefits scale with carbon emission reductions, and are relatively modest. If one were to monetize these benefits using the EPA's default assumptions for the value of health and the value of a statistical life,[47] more than 98.5 percent of the value would come in the form of reduced mortality, at a value of more than $11 million per avoided death.

The national-level benefits are those that result across the country, including in Rhode Island, because of Rhode Island's policy. As such, these include both benefits to Rhode Island residents and benefits to residents of nearby states who breathe pollutants that are produced in Rhode Island. Of the national benefits, 46 percent are in Rhode Island; 43 percent in Massachusetts, Connecticut, or New York; and the remaining 11 percent spread further across the country. The national results do not include any benefits from policies adopted in other states.

These results are also subject to the same caveat as earlier results: they reflect the impact of the carbon pricing and investment policies only, and not the overall transition to a decarbonized economy. In particular, this means that the air quality and health benefits from a relatively optimistic EV adoption trajectory in sustained policies case (based on the TCI-P modeling) are not reflected here.

[47] See https://www.epa.gov/environmental-economics/mortality-risk-valuation and https://www.epa.gov/statelocalenergy/co-benefits-risk-assessment-cobra-health-impacts-screening-and-mapping-tool

Table 7. Cumulative health benefits from each policy case over the 2021-2050 period, in Rhode Island and nationally. Totals may not equal to sum of columns due to rounding.

A) Low Carbon Price + Incentives

	Rhode Island			National
Reductions in…	*Buildings*	*Transport*	*Total*	*Total*
Deaths	11	5	15	27
Non-fatal heart attacks	4	2	6	15
Respiratory hospital admits	2	1	2	6
ER visits for asthma	3	1	4	12
Lost workdays	724	296	1,020	2,472

B) Low Carbon Price + Public Services

	Rhode Island			National
Reductions in…	*Buildings*	*Transport*	*Total*	*Total*
Deaths	9	2	11	27
Non-fatal heart attacks	3	1	4	10
Respiratory hospital admits	1	0	2	4
ER visits for asthma	3	1	3	9
Lost workdays	590	156	746	1,817

C) High Carbon Price + Incentives

	Rhode Island			National
Reductions in…	*Buildings*	*Transport*	*Total*	*Total*
Deaths	18	6	24	55
Non-fatal heart attacks	6	2	9	20
Respiratory hospital admits	3	1	4	9
ER visits for asthma	5	2	7	18
Lost workdays	1,169	385	1,554	3,761

D) High Carbon Price + Double Incentives

	Rhode Island			National
Reductions in…	*Buildings*	*Transport*	*Total*	*Total*
Deaths	25	9	34	79
Non-fatal heart attacks	9	3	12	28
Respiratory hospital admits	4	1	5	12
ER visits for asthma	7	2	10	26
Lost workdays	1,671	557	2,228	5,375

Section 5: Near-term Cost Impacts for Households

Household Characteristics that Drive Policy Impacts

A carbon pricing policy and associated investments would cause changes in the household economics of Rhode Island families. However, the impact would vary depending on the characteristics of the family and their home. A carbon price would increase costs more for families whose energy consumption causes greater GHG emissions, and vice versa. The investment portfolios funded by the carbon revenue would also have different effects, depending on whether a family is able to take advantage of the investment and chooses to do so. For policies that include rebates, the family composition can affect how much rebate they receive. When modeling the illustrative effects, the Project Team characterized households using the following parameters:

- **House size**. Larger floor areas to heat and cool corresponds to larger impacts from changes in the cost of energy. The median home size in Rhode Island is 1400 square feet.[48] For single-family detached homes, the median rises to 1800 square feet.
- **Building shell quality**. Linked with the age of a home, the level of air sealing and insulation in a home's walls and attic impacts heating and cooling energy use. Older or leaky homes can use substantially more energy per square foot than newer or weatherized homes.
- **Heating fuel**. Almost all homes in Rhode Island today are heated with natural gas, heating oil, or propane. Natural gas and propane have substantially lower GHG emissions per unit of energy delivered than does heating oil. As a result, carbon prices have a larger impact in dollar terms on heating oil customers. Heating fuel type is linked to the location of a home: rural homes have much less access to natural gas.
- **Driving patterns**. Vehicles that drive more miles per year use more fuel, and therefore see more financial impact from changes in the price of gasoline. The average vehicle miles travelled per registered vehicle in Rhode Island is about 9,000 miles per year.
- **Vehicle fuel economy**. The cost to operate vehicles that use less fuel per mile driven would increase less as a result of a carbon price.
- **Household size**. While the design of a rebate in the high carbon price case is subject to policy design, in general larger households would receive a larger rebate. For the purposes of the illustrative cases below, this analysis assumes a flat $143 per-capita rebate in 2025 (without differentiation between adults and children, and without any adjustments for income or other factors). The size of a household is also correlated with house size, albeit imperfectly.
- **Building ownership**. While building ownership does not have a direct impact on the household cost of a carbon price, it does shape how a family can take advantage of

[48] U.S. Census. *American Housing Survey*: *Providence metro area*. https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html?s_areas=39300&s_year=2011&s_tablename=TABLE2&s_bygroup1=1&s_bygroup2=1&s_filtergroup1=1&s_filtergroup2=1.

investment supports. In particular, renters are commonly less able to take advantage of incentive programs to upgrade heating and water heating equipment or building shells.

Four Illustrative Households

This section presents the impact of the carbon pricing and investment policies in 2025 for four illustrative households. These households reflect variation across many of the parameters discussed above – urban, rural, and suburban; heating with different fuels; living in newer or older housing; and driving more or less (or taking transit). Given the minor effects of the policies examined here on jobs or GDP, this analysis does not assume that any of the family members gets a different job or experiences some other employment-related impact from the policies. Actual families will experience their own particular circumstances, but these illustrative households provide some insights into the range of potential impacts that households would experience.

Each household summary begins with a short summary of the relevant parameters for the household's energy-relevant situation and a table summarizing the household economic impact of the carbon pricing policies. The "with no actions" section of the table shows the impact of the carbon pricing policies if the household makes no changes in their home, vehicle, or behavior; this represents the highest cost the household might face. The right-hand side of each table presents a summary of the household's economics if they take some action to reduce their emissions, such as replacing an existing vehicle with an EV, replacing their heating system with a heat pump, or weatherizing their home. In the case of Family D, the household sees a difference between the Incentives and Public Services cases. Each table summarizes only the annual energy or operational costs, not the capital cost. Mobility costs include the cost of gasoline and electricity for driving and the cost of transit passes, but do not include vehicle maintenance. Comfort costs include natural gas, heating oil, or electricity used for water heating, winter space heating, and summer air conditioning.

This section examines the impacts on each household during the year 2025 and assumes that they make any change in their home or vehicle at the start of that year. In 2025, the Low Carbon Price cases reflect a cost of $7.30 per metric ton, and the High Carbon Price case has a cost of $35 per ton. As in the earlier analysis, this section assumes that the near-term drop in oil prices from the COVID-19 pandemic has abated by 2025. It is worth noting that EVs have lower fuel costs than average ICE cars even at today's lower gasoline prices.

Family A

- Single parent and child
- Rents a 1,300 sq. ft. apartment with slightly below average building shell
- Heats with gas (80 percent efficient boiler); cools with window AC
- Drives 8,000 miles per year in a relatively efficient (28 mpg) car

Table 8. Illustrative household impacts – Family A

	Base	With no actions Low CO_2 Price	High CO_2 Price	With electrification Low CO_2 Price	High CO_2 Price
Mobility costs	**$1,010**	**$1,030**	**$1,120**	**$550**	**$570**
CO_2 price impact		*+$20*	*+$110*		
Electrification impact				*-$480*	*-$550*
Comfort costs	**$2,130**	**$2,170**	**$2,330**	**$2,130**	**$2,180**
CO_2 price impact		*+$40*	*+$200*		
Electrification impact				*-$40*	*-$150*
Rebate			**-$290**		**-$290**
Total	**$3,140**	**$3,200**	**$3,160**	**$2,680**	**$2,460**

Family A would see a small net cost from the Low Carbon Price policies, and an even smaller net cost from the High Carbon Price policies, absent taking any action to change their home or vehicle.

If the family took actions to reduce their carbon emissions in 2025 through electrification, their net energy cost for transportation would fall, while their cost for comfort (water heat and space conditioning) would rise. In 2025, a new EV to replace their 28 MPG car would have an incremental cost of about $2,000 over an equivalent new gasoline car, assuming a $1750 incentive paid for with carbon revenue. This investment would offer about a four-year payback under either carbon price.

If the family were able to work with their landlord to upgrade space conditioning and water heating to electric options on the normal replacement cycle, the family or landlord would incur an incremental upfront cost of about $1,500 after incentives. Given the further challenges of coordinating building shell improvements in multi-family housing, this analysis does not assume any changes in the building shell. While there are first-year operating cost savings to the heat pump options in the High Carbon Price policy case, they are not enough to offer a simple payback period shorter than the lifetime of equipment. Higher carbon prices in future years, or more favorable electric rates relative to the cost of natural gas, could offer a more attractive payback.

Family B

- Two parents with two children
- Owns a 2,200 sq. ft. suburban home with above average building shell
- Heats with condensing gas (92 percent efficient furnace); cools with central AC
- Two cars:
  - 13,000 miles per year at 28 mpg
  - 7,000 miles per year at 20 mpg

Table 9. Illustrative household impacts – Family B

	Base	With no actions Low CO_2 Price	With no actions High CO_2 Price	With electrification Low CO_2 Price	With electrification High CO_2 Price
Mobility costs	**$2,300**	**$2,350**	**$2,530**	**$1,800**	**$1,900**
CO_2 price impact		*+$50*	*+$230*		
Electrification impact				*-$550*	*-$630*
Comfort costs	**$2,380**	**$2,430**	**$2,610**	**$3,090**	**$3,160**
CO_2 price impact		*+$50*	*+$230*		
Electrification impact				*+$660*	*+$550*
Rebate			**-$570**		**-$570**
Total	**$4,680**	**$4,780**	**$4,570**	**$4,890**	**$4,490**

Family B would see a small net cost from the Low Carbon Price policies, and a small net savings from the High Carbon Price policies, absent taking any action to change their home or vehicle. The net savings from the High Carbon Price policies is critically dependent on the modeled per-capita rebate for the family of four.

In 2025, the family could replace their higher-driving car with an EV at an incremental cost of about $2,000 after the rebate funded by the carbon price (if that is how the revenue is used), and see a simple payback period of less than four years. Heat pumps for space and water heating, estimated to require an incremental cost of $2400 relative to replacement in kind for their existing gas system after incentives, would not offer any payback because fuel costs would increase by more than $500 in any case. This analysis assumes that the family would not weatherize their home, because it is already relatively high performing. This family's case illustrates the challenging customer economics of building electrification when compared with efficient natural gas systems.

The financially optimal choice for this household would be to buy one or two electric vehicles, but not to electrify their home comfort systems.

Family C

- Two retired adults
- Owns an 1,800 sq. ft. rural home with average building shell
- Heats with oil (80 percent efficient boiler); cools with window AC
- Two cars:
  - 11,000 miles/year at 28 mpg
  - 5,000 miles/year at 20 mpg

Table 10. Illustrative household impacts – Family C

	Base	With no actions		With electrification and efficiency	
		Low CO_2 Price	High CO_2 Price	Low CO_2 Price	High CO_2 Price
Mobility costs	**$1,830**	**$1,870**	**$2,010**	**$1,410**	**$1,480**
CO_2 price impact		*+$40*	*+$180*		
Electrification &EE impact				*-$460*	*-$530*
Comfort costs	**$3,720**	**$3,790**	**$4,070**	**$2,300**	**$2,350**
CO_2 price impact		*+$70*	*+$350*		
Electrification & EE impact				*-$1,490*	*-$1,720*
Rebate			**-$290**		**-$290**
Total	**$5,550**	**$5,660**	**$5,790**	**$3,710**	**$3,540**

Because of the relatively higher carbon intensity of heating oil, the carbon price has a larger effect for this couple. In Low Carbon Price cases, their costs rise about $110 per year, while in the High Carbon Price their 2025 costs rise more than $200 per year. As the carbon prices continue to rise in each case, the effects grow.

Electrification of transport and comfort both result in energy cost savings in this case, due to the favorable economics of electrification relative to oil. If the couple were to weatherize their house while converting to ductless heat pumps, they would pay net costs of about $2,000 for space and water heating and cooling systems and $5,000 for weatherization (after incentives). These investments would save about $1,500 or more per year, offering a simple payback of less than five years.

While this couple drives less than average, they would still see about a four-year simple payback when choosing an EV, if they replaced their higher-mileage vehicle in 2025.

Family D

- Two adults, two children
- Qualifies for low-income programs
- Rents a 1,400 sq. ft. home with below average building shell
- Heats with gas (80 percent efficient); cools with central AC
- Drives one car 8,000 miles/year at 20 mpg
- One parent uses the bus (monthly pass)

Table 11. Illustrative household impacts – Family D

	Base	With no actions (and Incentives cases) Low CO_2 Price	With no actions (and Incentives cases) High CO_2 Price	With Public Services investments Low CO_2 Price
Mobility costs	**$2,050**	**$2,080**	**$2,180**	**$1,660**
CO_2 price impact		*+$30*	*+$130*	
Public Services impact				*-$420*
Comfort costs	**$2,530**	**$2,580**	**$2,780**	**$2,270**
CO_2 price impact		*+$50*	*+$250*	
Public Services impact				*-$310*
Rebate			**-$570**	
Total	**$4,580**	**$4,660**	**$4,390**	**$3,930**

In the incentive-based investment cases, this analysis does not assume this low-income family can afford to take decarbonization actions. As a result, this family in 2025 experiences an $80 net cost at the low carbon price and net savings of $190 at the high carbon price (as a result of the per capita rebate).

In the Public Services investment case, this family would save $420 per year from reduced cost for transit and would qualify for home weatherization and heat pumps at no upfront cost (provided they either own their home or could coordinate with their landlord for these improvements). With heat pumps and a 25 percent improvement in the building shell, home comfort costs would decrease in the low carbon price case by about $310/year (about 12 percent of the family's comfort costs).

Combined with the transit pass savings and the increase in gasoline costs, the family's annual mobility and comfort spending would fall by $650 relative to the Sustained Policies base case, and $730 relative to the Low Carbon Price + Incentives case.

Section 6: Qualitative Policy Analysis

Overview

To help inform the design of a potential carbon pricing policy in the state of Rhode Island, the Project Team analyzed the defining elements of a carbon pricing policy against key assessment criteria identified in collaboration with the Rhode Island Team (see **Table 12** below). The defining elements of a carbon pricing policy include price level, applicable sector(s), and investment options. This analysis was informed by desk research and stakeholder engagement, which is described in more detail in Appendix B.

The purpose of this analysis was to identify key tradeoffs related to the implementation or impact of a carbon pricing policy related to elements that could be considered by Rhode Island to inform the design of a holistic carbon pricing policy.

Table 12: Assessment Criteria

Assessment Criteria	Description
Technical Implementation Feasibility	Extent to which a policy is feasible to implement given Rhode Island's current resources, including electronic systems and procedural frameworks for administering such a policy. The analysis considers the extent to which the Rhode Island state government is expected to incur staff time and other costs to implement the policy.
Administrative Feasibility	Extent to which a policy is feasible to manage over its duration. The analysis considers the extent to which the Rhode Island state government is expected to incur staff time and other costs to administer a given policy over time.
Alignment with Existing Initiatives	Extent to which a policy is expected to align with existing decarbonization initiatives in Rhode Island.
Potential for Successful Regional Implementation	Extent to which a policy could successfully be broadened to include regional participation.
Social Equity	Extent to which net benefits associated with the policy are expected to be distributed equitably across Rhode Island residents, particularly the degree to which net benefits are expected to accrue to households in frontline communities. Benefits may include cost savings, local public health improvements, and workforce development opportunities.
Social Acceptability	Feedback regarding how carbon pricing policy is expected to be received among stakeholders (based on the limited desk research and interactions with stakeholders conducted within the study; this is not designed to capture the overall sentiment in Rhode Island).

Findings

Based on the qualitative policy assessment, the Project Team organized identified findings into the below categories for each of the assessment criteria. These findings were later combined with the outputs of the qualitative modeling to inform the key takeaways of the study.

Price Level Findings	• How the criteria are impacted by the price level of the carbon price
Sector Findings	• How the criteria are impacted by the sector in which the carbon price is implemented
Transportation Investment Options Findings	• How the criteria are impacted by the investment of revenue within the transportation sector
Building Thermal Investment Option Findings	• How the criteria are impacted by the investment of revenue within the building thermal sector

Technical Implementation Feasibility

Overall, implementing a carbon price is expected to be highly technically feasible. Rhode Island already has years of experience implementing RGGI, and the lessons learned from this experience could be applied to a carbon pricing program to help minimize technical implementation burdens. Additionally, several other jurisdictions have implemented carbon pricing programs spanning multiple sectors, including California and British Columbia, that could serve as models for Rhode Island.[49,50]

Category	Findings
Price Level	Price level is not expected to impact the technical implementation feasibility of a carbon price, as the updates to electronic systems and procedures needed to implement such a policy will not vary greatly by price level.
Sector	There are no major anticipated differences in the technical implementation feasibility of a carbon price in the either sector, as the updates to electronic systems and procedures for implementing such a policy will not vary greatly by sector.
Transportation Investment Options	Both the Incentives and Public Services investment options are expected to have high technical feasibility. In regards to the Public Services option, eliminating transit fares is technically simple and there are already several cities offering this option, including Boston.[51] In regard to the Incentives option, Rhode Island staff have indicated that restarting their EV incentive program would require minimal up-front administrative burden.[52]
Building Thermal Investment Options	The technical feasibility of either investment option would ultimately depend on program design. A major program design decision that could influence the technical implementation feasibility of a carbon pricing policy is the extent to which Rhode Island leverages existing programmatic infrastructure to implement these investment options (i.e., provide more funding to expand existing programs).

[49] Government of British Columbia. *British Columbia's Carbon Tax*. https://www2.gov.bc.ca/gov/content/environment/climate-change/planning-and-action/carbon-tax

[50] California Air Resources Board. *Cap-and-Trade Program.* https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program

[51] Fare Free Public Transport. *Boston, USA*. https://freepublictransport.info/city/boston/

[52] Feedback from the RI Carbon Pricing Study Team.

Administrative Feasibility

Rhode Island can potentially leverage its experience with RGGI to reduce administrative challenges and associated costs. Rhode Island can also leverage existing programs and institutions to further reduce the administrative burden of collecting and distributing revenue. For example, the Rhode Island Infrastructure Bank, National Grid's energy efficiency programs, or other similar institutions that focus on green investments could be leveraged. However, it should be noted that administrative feasibility of a carbon pricing program will depend on whether it is designed as a carbon tax or cap-and-trade program.

Category	Findings
Price Level	Price level is not expected to impact the administrative feasibility of carbon pricing policy, as the processes for administering such a policy will not vary greatly by price level.
Sector Level	There are no major anticipated differences in the administrative feasibility of a carbon price in either the transportation or building thermal sector as the same reporting requirements, administrative oversight, and enforcement activities will be needed, regardless of sector.
Transportation Investment Options	Overall, the Public Services investment option is expected to face slightly lower administrative costs than the Incentive investment option. This is largely because incentive programs require internal or external staff time to administer, while reducing transit fares requires minimal staff time over the lifetime of the reduced fare.
Building Thermal Investment Options	The administrative feasibility of either investment option would ultimately depend on program design. Potential program design decisions that could influence administrative feasibility include the extent to which Rhode Island leverages existing programmatic infrastructure to implement these investment options, as well as the overall number of incentives distributed.

Alignment with Existing Initiatives

Overall, a carbon price would align well with existing decarbonization efforts in Rhode Island, including existing policies, programs, and initiatives across key sectors that seek to reduce GHG emissions or study decarbonization. Furthermore, a carbon price would contribute to Rhode Island's goal to achieve an 80 percent reduction in GHG emissions by 2050, expand upon the success of RGGI, and generate revenue for programs that can benefit Rhode Island residents and businesses.

Category	Findings
Price Level	A lower price is more in line with Rhode Island's existing initiatives and action on carbon pricing, including aligning with the price of RGGI. However, a higher price is more in-line with Rhode Island's ambitious GHG reduction targets.
Sector Level	A carbon price in the transportation sector appears more aligned with existing initiatives than a price in the building thermal sector. To date, the transportation sector will adopt carbon pricing through TCI-P, as well as other initiatives aimed at promoting electric vehicles. However, within the building sector, most initiatives to-date have focused on energy efficiency as opposed to robust electrification.
Transportation Investment Options	Both the Incentives and Public Services investment options align with current transportation decarbonization initiatives in Rhode Island. Related to the Incentives investment option, Rhode Island has implemented the zero-emission vehicle (ZEV) mandate, signed onto both the light-duty and medium- and heavy-duty ZEV memorandum of understandings (MOUs), and is considering adopting California's Advanced Clean Trucks rule. Related to the Public Services option, Rhode Island currently offers limited forms of free/reduced fare transit, such as free bus fares for low-income seniors and people with disabilities.
Building Thermal Investment Options	Current building sector initiatives within Rhode Island primarily focus on energy efficiency and building weatherization, which are more aligned with the Public Services investment option. However, the state recently completed a Heating Sector Transformation Study that explored future options for the transition to low-carbon heating options and was more aligned with the Incentives investment option.

Potential for Successful Regional Implementation

It appears there is some potential for the successful regional implementation of a carbon pricing policy. The RGGI program has a wide geographic scope and has demonstrated that regional carbon pricing programs can be successful. Additionally, TCI-P shows continued interest in carbon pricing among a broad set of states. Lastly, Massachusetts has adopted an additional carbon pricing program in the electricity sector, demonstrating some, but limited, carbon pricing activity outside of RGGI.

Category	Findings
Price Level	While some states in the region are exploring ambitious decarbonization efforts and may support a higher price, a lower price is more likely to garner a broader coalition. To date, RGGI is in line with this study's low price and TCI-P has focused on a similarly low range of pricing levels.
Sector Level	The transportation sector is expected to have somewhat greater potential for successful regional implementation than in the building thermal sector. The transportation sector currently has some momentum through TCI-P. Additionally, to-date, there are more impactful initiatives within the region to decarbonize the transportation sector than in the building thermal sector.
Transportation Investment Options	In the event of a regional carbon pricing program, it is assumed that the investment of revenue would still be determined at the state-level. As such, the transportation investment options are not analyzed for this criterion.
Building Thermal Investment Options	In the event of a regional carbon pricing program, it is assumed that the investment of revenue would still be determined at the state-level. As such, the building thermal investment options are not analyzed for this criterion.

Social Equity

Carbon prices have the potential to be regressive given that low-income households typically spend a greater portion of their income on energy and would thus be more greatly impacted by a carbon price. However, intentional policy design choices, such as targeted revenue reinvestment, can offset the regressive nature of a carbon price. Ultimately, the equitability of a program will depend on how the revenue is targeted (e.g., by income, geographic location, etc.).

Category	Findings
Price Level	In the absence of revenue spending, a higher price is expected to place a higher burden on households in frontline communities than a lower price. However, a higher price will generate more revenue that can be targeted towards programs that promote equity.
Sector Level	Excluding use of revenue, there are no major net-differences in the overall social equity impacts of a carbon price in the transportation sector as compared to the building thermal sector. The degree of impact will depend on several factors, including a person's location, their home heating fuel, status as a renter or homeowner, and the extent to which they rely on a car for transportation.
Transportation Investment Options	Public Services investments are more likely to have greater social equity outcomes than incentive investments. In the case of the Incentives investment option, many low-income residents may still not able to afford EVs, even with incentives, given their high upfront cost. In the case of the Public Services option, providing reduced fare and expanded public transit will be a boon for those who live close to it. However, it should be noted that rural residents who do not live near public transit would likely be excluded from experiencing the benefits of this option.
Building Thermal Investment Options	Public Service investments are more likely to have greater social equity outcomes than Incentive investments. In the case of the Incentives investment option, many low-income residents may still not be able to afford a heat pump, even with incentives, given their high upfront cost. In the case of the Public Services option, providing free weatherization and heat pump installation for low-income residents can help reduce the cost barrier to participating in heating sector decarbonization. However, cost is only one of multiple barriers, particularly for renters.

Social Acceptability

A carbon pricing policy would align with existing initiatives the state of Rhode Island is supporting related to decarbonization (see Section 2: Rhode Island's Decarbonization Landscape), and some stakeholder groups have expressed support for carbon pricing. However, some stakeholders have been opposed to carbon pricing legislation in Rhode Island for various reasons, including concerns that it is not as effective as more prescriptive policies and may result in costs being passed on to consumers.

Category	Findings
Price Level	Based on stakeholder feedback, a lower price is generally seen as more socially acceptable, however there are specific groups (e.g. environmental advocates) who prefer a higher price.
Sector Level	There are no major anticipated differences in the social acceptability of a carbon price in the transportation sector as compared to the building thermal sector.
Transportation Investment Options	Public service investments are expected to be slightly more socially acceptable than incentive investments given that technology-neutral advocates (e.g. biofuel industries) may oppose EV incentives, and EV incentives are sometimes seen as subsidies for affluent households. However, while free transit ridership may garner popular support, the modest associated emissions reductions may limit support among environmental advocates.
Building Thermal Investment Options	There is no major difference in the overall expected social acceptability of either investment option. Both investment scenarios are in line with current initiatives, but technology-specific interventions (e.g. heat pumps) may face push back from certain groups that prefer a technology-agnostic approach. Furthermore, some stakeholders may be supportive of targeting resources towards low-income households, while others may prefer a greater emphasis on maximizing decarbonization.

Section 7: Additional Design Considerations

While this report specifically focuses on the price level, included sectors, and revenue use of a carbon pricing policy, there are several other important design features to consider in the design of a policy that have important implications for the implementation and overall impact of a carbon price. This section provides a list of these key features and an explanation of their overall implications.

Approach: Cap-and-Trade vs Fee

There are two common approaches of applying a price on carbon, including cap-and-trade programs and carbon fees (commonly referred to as taxes).

- **Cap-and-Trade**: Under a cap-and-trade program, there is an upper limit, or cap, on total emissions from regulated entities and a corresponding amount of emission allowances. Under such a program, regulated entities need to attain allowances that correspond to their level of emissions. These emissions allowances are either freely allocated or sold at an auction. After being distributed, they can be bought and sold by regulated entities in a carbon market, where the price of the allowances is set by market factors (i.e., the supply and demand of the allowances). Given that these allowances are scarce and therefore valuable, emitters will be incentivized to reduce their emissions in order to limit the number of allowances they need to purchase. Cap-and-trade also sometimes provides flexibility for regulated entities, in that excess allowances from one year can be used for compliance in future years and in some circumstances, allowances can be borrowed from future years to meet compliance in the current year.[53]
- **Fee**: Conversely, a carbon fee sets a fee per ton of carbon emissions from regulated entities. Emitters who are covered by the policy would be required to pay a per-ton fee for their total emissions. As a result, emitters are incentivized to reduce their emissions in order to reduce their overall payment. While the fee schedule is set by the regulator, there is no cap on total emissions.[54]

In summary, cap-and-trade programs provide certainty in the volume of emissions without certainty on price. Conversely, carbon fees provide certainty on price without certainty on GHG emissions volume. However, in practice, the distinction between these two methods is often blurred, resulting in hybrid approaches that limit emissions while setting bounds on the extent to which the price can vary. For example, cap-and-trade programs often will institute a price floor on the cost of allowances and a cost containment reserve that releases additional allowances if the allowance price reaches an established ceiling. In doing so, the cap-and-trade program can only operate within a range of carbon prices, and the cap may be flexible as a result. Similarly, a carbon fee scheme will sometimes have a mechanism by which

[53] Union of Concerned Scientists. 2017. *Carbon Pricing 101: When carbon emissions cost money, we produce less of them*. https://www.ucsusa.org/resources/carbon-pricing-101

[54] Ibid.

price increases are triggered based on whether the program is achieving a target GHG emissions reduction trajectory.[55]

Point of Regulation

The point of regulation is the stage in the fossil fuel supply chain at which the tax is assessed, which in turn impacts the number of regulated entities. There are multiple points in the supply where a carbon price can be applied, including upstream, midstream, or downstream. An upstream point of regulation is one that is early in the supply chain, at the point of extraction (e.g. a coal mine or wellhead) or the port of entry. A midstream point of regulation would apply to the first purchaser of fossil fuels within the supply chain, such as a refinery. Lastly, a downstream point of regulation is one that is late in the supply chain where the end-user combusts the fuel, such as households or businesses that use natural gas to heat their home or a power plant that uses natural gas to produce electricity. Based on this structure, carbon pricing schemes with upstream points of regulation tend to have fewer regulated entities than downstream regulated systems.

Overall, the point of regulation can have large impacts on administrative costs. Costs associated with measurement, reporting, and verification are lower in carbon tax schemes with an upstream point of regulation and fewer regulated entities.[56] These costs take two forms. The first is administrative costs for the regulating entity, in this case Rhode Island. The second is costs borne by the regulated entity to comply with the regulation. Higher administrative costs for the regulating entity result in less funding remaining for investments and rebates. Administrative costs borne by the regulated entity tend to be at least partially passed through to consumers, resulting in higher prices for goods and services. RGGI uses a downstream point of regulation, with electric power plants being the regulated entity,[57] while the California cap-and-trade program uses a mix of upstream and downstream. The California scheme takes a similar approach to RGGI in the electricity sector but regulates fuel distributors in the transportation and building thermal sectors.[58]

Gases Covered

There are several gases that can be regulated in a carbon pricing system, and different carbon pricing systems regulate different subset of these gases. While many of these gases do not contain carbon, they still contribute to the GHG effect that causes climate change. The Global Warming Potential (GWP) is a standard measure that was developed to compare the relative potency of which the various gases warm

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55 Sheldon Whitehouse, U.S. Senator for Rhode Island. 2019. *American Opportunity Carbon Fee Act.* https://www.whitehouse.senate.gov/imo/media/doc/American%20Opportunity%20Carbon%20Fee%20Act%20Fact%20Sheet%20EMBARGOED.PDF

56 Jessica Coria and Juurate Jaraite. 2018. *Transaction Costs of Upstream Versus Downstream Pricing of CO_2 Emissions.* Environmental and Resource Economics 72:965–1001 (2019). SprinkerLink. https://link.springer.com/article/10.1007/s10640-018-0235-y

57 International Carbon Action Partnership. 2021. *USA – Regional Greenhouse Gas Initative.* https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=50

58 Center for Climate and Energy Solutions. *California Cap and Trade.* https://www.c2es.org/content/california-cap-and-trade/

the atmosphere.[59] RGGI only regulates carbon dioxide (CO_2),[60] while the California cap-and-trade program covers several gases, including: carbon dioxide (CO_2), methane (CH4), nitrous oxide (N20), sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), perfluorinated compounds (PFCs), nitrogen trifluoride (NF3), and other fluorinated GHGs.[61] The number of gases included under a carbon pricing scheme will impact reporting requirements and administrative costs, with more gases being more complicated to monitor. However, it will also impact the overall effectiveness of the scheme in mitigating the consequences of climate change, with more gases being monitored being more likely to have a greater influence.

Offsets

Offsets are alternative methods of reducing a regulated entity's effective greenhouse gas emissions, and work to decrease the carbon price burden on a regulated entity. Offsetting techniques often include extracting greenhouse gases from the air or preventing the release of future greenhouse gases. A few examples of offsets include managing methane from agriculture, capturing and destroying landfill methane, carbon sequestration through reforestation, avoiding forest destruction, or better forest management.

Offsets can be a contentious topic in carbon pricing program design. To ensure the integrity of the avoided or sequestered greenhouse gases, programs often have rigorous standards, only allow specific project types, and limit the portion of emissions that can be offset. For instance, the California program allows regulated entities to meet 6 percent of their compliance obligation with offsets, half of which need to create direct environmental benefits in California.[62] The RGGI program allows regulated entities to meet 3.3 percent of their compliance obligation with offsets.

Exemptions

Exemptions include program elements that excuse certain industries from being subject to the carbon price. Exemptions are typically enacted to maintain the competitiveness of industries that would otherwise face a disadvantage as the result of a carbon tax in one jurisdiction without one in another jurisdiction. For example, Sweden, which at the time of this writing has the highest carbon tax in the world,

[59] Piers Forster and Venkatachalam Ramaswamy, contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.. 2007. *Changes in Atmospheric Constituents and in Radiative Forcing.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf

[60] International Carbon Action Partnership. 2020. *USA – Regional Greenhouse Gas Initiative (RGGI).* https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=50

[61] International Carbon Action Partnership. 2020. *USA – California Cap-and-Trade Program.* https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=45

[62] Ibid.

exempts some energy-intensive industries, such as steel production, from paying the carbon tax.[63] This study does not cover the industrial sector, which is typically where exemptions would occur.

Emitter Threshold

The emitter threshold refers to the minimum threshold at which entities are included within the pricing scheme. Beyond the point of regulation, the emitter threshold will further specify what size entities are included within the carbon pricing scheme. In turn, this will impact the number of regulated entities, which can have consequences on administrative costs and the scope of emissions covered. In the U.S., RGGI covers fossil fuel electric generating units with a capacity greater than or equal to 25 MW,[64] while the California cap-and-trade program applies to electric power plants, industrial plants, and fuel distributors emitting greater than or equal to 25,000 metric tons of CO_2 per year.[65,66]

Penalties

Penalties involve setting and enforcing policies for failure to pay the carbon tax at a level equivalent with regulated emissions output. Penalties are designed to discourage noncompliance among regulated entities in properly reporting and paying for emissions. Both RGGI and California have multiplicative penalties for failure to comply with the carbon price. In RGGI, entities need to submit three times as many emissions allowances for each allowance they fail to submit.[67] In California, the penalty is four times as many emissions allowances.[68]

Rebate Design

As discussed in the Analysis Scope & Approach section of this report, rebates refer to revenue that is returned directly to residents and businesses, without any conditions about how the those who receive the rebates spend the funds. By returning revenue directly to residents and businesses, rebates offset some of the higher cost of using fossil fuels. In some cases, the rebate can more than offset the increase in energy costs for residents. Rebates also provide a tangible benefit for residents and businesses, while the other benefits of a carbon price are often less concrete (e.g., reducing the severity of climate change).

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[63] The Tax Foundation. 2020. *Looking Back on 30 Years of Carbon Taxes in Sweden*. https://taxfoundation.org/sweden-carbon-tax-revenue-greenhouse-gas-emissions/

[64] International Carbon Action Partnership. 2020. *USA – Regional Greenhouse Gas Initiative (RGGI).* https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=50

[65] International Carbon Action Partnership. 2020. *USA – California Cap-and-Trade Program.* https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=45

[66] Center for Climate and Energy Solutions. *California Cap and Trade.* https://www.c2es.org/content/california-cap-and-trade/

[67] International Carbon Action Partnership. 2020. *USA – Regional Greenhouse Gas Initiative (RGGI).* https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=50

[68] International Carbon Action Partnership. 2020. *USA – California Cap-and-Trade Program.* https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=45

A rebate could be designed and implemented in several different ways. A few illustrative methods of designing a rebate include a per-capita dividend, a progressive dividend, and an income tax offset. These three methods are described further below.

Per-Capita Dividend

A per-capita dividend returns revenue to every Rhode Island household and business on a per-capita basis and is the rebate option that was modeled in this analysis. Every year, each resident would receive a payment of the same value as everyone else and each business would receive a payment proportional to their number of employees each year. The advantage of a per-capita dividend is that because each resident is receiving the same amount in their payment, meaning that per capita dividends are more likely to garner widespread support for the carbon price. Per-capita dividends are often criticized because even though all residents receive the same amount, some people do not think it is right that the government would be giving money to higher-income households.

A version of the per-capita dividend was the method proposed in Rhode Island's Economic and Climate Resilience Act of 2019, which called for 30 percent of revenue to be distributed to Rhode Island businesses. Of the revenue distributed to businesses, 70 percent would be distributed to employers in an amount proportional to the employer's share of total employment in the state. The additional 30 percent would be distributed to any business who are expected to be particularly impacted by a carbon price, including energy intensive or trade exposed industries.[69]

Progressive Dividend

A progressive dividend is similar to a per-capita dividend except that the dividend would scale inversely with income for residents, so that low-income residents receive a higher payment than high-income residents. The advantage of a progressive dividend is that those who are most likely to struggle with the affordability of energy as a result of the carbon tax would receive the highest compensation. Progressive dividends are seen by some as not being fair. The view of opponents is that everyone is paying higher prices as the result of carbon tax and therefore everyone should receive an equal share in a dividend.

A version of the progressive dividend is the method employed in the Economic and Climate Resilience Act of 2019. In the act, 40 percent of revenue is used to provide direct dividends to residents. Of the revenue being distributed as dividends to residents, 50 percent would be divided evenly among residents in the bottom third of income in Rhode Island, 35 percent would be divided evenly among residents in the middle third of income in Rhode Island, and 15 percent would be divided evenly among residents in the top third of income in Rhode Island.[70]

Income Tax Offset

An income tax offset would use the revenue from the carbon tax to reduce the income tax rate in Rhode Island. The advantage of this method is that in shifting the tax from income to GHG emissions, Rhode

[69] State of Rhode Island in General Assembly, Senate Environment and Agriculture. 2019. *Economic and Climate Resilience Act of 2019 (S 0662).* http://webserver.rilin.state.ri.us/BillText19/SenateText19/S0662.pdf

[70] Ibid.

Island would be promoting economic activity while disincentivizing the emission of GHGs, creating a more efficient economic system. The disadvantage of income tax offsets is that they are regressive. Because income taxes are proportional to income, a reduction in income tax provides a larger direct benefit to higher-income households than lower-income households. Furthermore, they may not provide benefit for a significant proportion of the population in Rhode Island because many people do not pay income tax. Estimates have shown that that over half of Rhode Island residents do not pay income tax,[71] which is in-line with more recent nationwide estimates, which indicate that about 44 percent of Americans do not pay income tax.[72] Typically households not paying income tax is a result of not crossing a minimum income threshold, including households with very low incomes, those who are unemployed, low-income retirees on social security, and dependent children.

[71] GoLocalProv. 2012. *Half of Rhode Islanders Don't Owe Income Taxes.* https://www.golocalprov.com/news/half-of-rhode-islanders-dont-owe-income-taxes

[72] Tax Policy Center: Urban Institute & Brookings Institution. 2018. *TaxVox: Federal Budget and Economy.* https://www.taxpolicycenter.org/taxvox/tcja-increasing-share-households-paying-no-federal-income-tax

Section 8: Synthesized Findings

Overview

As Rhode Island considers the development of a carbon price, there are several key findings that were gained from this study. These key takeaways synthesize findings from the GHG impact modeling, economic and health impacts modeling, and qualitative policy assessment described in previous sections of this document.

The key findings can inform the design of a carbon price for Rhode Island and should be considered in parallel with existing and future complementary efforts to decarbonize Rhode Island's economy. Unless otherwise noted, these findings hold true across all price levels and cases examined in this study.

Key Findings

A carbon price at the levels analyzed would not achieve Rhode Island's 2050 GHG emissions reduction target alone

For Rhode Island to achieve its long-term decarbonization goals, additional actions will be needed to complement carbon pricing. The emissions for policy cases range from 3.9 to 5.1 $MMTCO_2$ in 2050, which falls short of Rhode Island's target of 2.4 $MMTCO_2$. These figures demonstrate that the necessary technological transitions that would need to occur are not fully achieved through the carbon pricing scenarios examined in this study. It is important to note that this is true even assuming Rhode Island achieves the Executive Order committing to 100 percent renewable electricity by 2030.

While a carbon price may not achieve Rhode Island's GHG emissions reduction target on its own, there are two important takeaways that policymakers should consider when designing a carbon price in Rhode Island. First, a higher price results in more GHG reductions than a lower price. Second, investment in decarbonization programs results in more GHG reductions than the market signal resulting from the price. While the price drives modest emissions reductions through disincentivizing fossil fuels, investments were more impactful in changing consumer preferences from fossil fuel-based technologies to cleaner technologies, such as heat pumps and electric vehicles.

Finally, during the study, many stakeholders noted that a carbon price that enables Rhode Island to achieve its 2050 GHG emissions reduction targets should be considered. This study did not include a direct scenario aligned with that objective, as the goal of the study was not to model what carbon price would be needed to reach a specific reduction target, but rather to explore the impact of potential state and regional carbon pricing policies.

Determining how to use revenue generated by the carbon price is a chief policy design step

There are numerous ways that revenue from a carbon price could be used. However, due to practical constraints, this study examined a limited set of options for revenue use. Even through the limited illustrative examples, it was clear that the use of revenue could drive greater GHG impacts than the than the market signal resulting from the price. The revenue can also be used to achieve other societal goals beyond GHG reduction. For example, the Incentives investment option had larger impacts on GHG emissions than the Public Services investment option but did not necessarily benefit low-income and frontline communities. The use of revenue generated by a carbon tax thus represents an important and consequential policy choice in the state's GHG reduction efforts.

The program design for investment of revenue can further impact outcomes. Particularly, design choices can be made to increase the access to cleaner technologies to low-income residents. For example, incentives programs for clean technologies could provide additional funding to households below a certain income level, increasing affordability for low-income households and the equitability of the incentives.

Equity needs to be a conscious choice in both process and ultimate policy design

Some communities disproportionately experience the burdens of climate change and have less access to the benefits of clean energy technology than others. For instance, low-income households spend a higher portion of their income on energy and thus would be disproportionately impacted by a carbon price in the absence of revenue use. As a result, carbon prices are potentially regressive, unless revenue generated by the carbon price is intentionally targeted to support them. Therefore, the equitability of a carbon pricing program depends on the use of the revenue. For example, low-income households could see a net gain in income with a rebate, particularly if it is designed such that low-income residents see a higher portion of the revenue than high-income residents.

If Rhode Island moves forward with developing a carbon price, it should engage residents early in the process and frequently throughout. The state should also consider ways it can center frontline communities within this participation. Resulting feedback should be utilized appropriately to ensure the experiences and needs of frontline communities and households are reflected in program design. Doing so can ensure the carbon price is implemented equitably and help strengthen relationships with communities and build trust.

A carbon price has a small impact on electric vehicle (EV) adoption

The study shows that a carbon price has a limited positive impact on increasing EV adoption. Moreover, the study finds that incentives drive more adoption than the market signal resulting from the price. The assumptions in the transportation sector within this study were based on the Transportation and Climate Initiative's modeling. These assumptions indicate that EVs are expected to achieve upfront cost parity with gasoline-powered vehicles in 2030 and assume a higher rate of EV adoption than some other studies. Partially as a result of this baseline of high EV adoption, this study finds that a carbon price does not sufficiently change the economics to drive significant additional adoption of EVs. However, the carbon price-funded incentive does induce some consumers to purchase an EV who would otherwise not have done so.

The results of this study need to be considered in the broader context of the EV market. Improving favorability of vehicle and fuel price are only two components of increasing EV adoption. To significantly increase the adoption of EVs, other barriers need to be overcome, such as reducing range anxiety, increasing awareness of EVs, and improving the availability and diversity of EV models in Rhode Island. Furthermore, as electric prices rise as a result of the renewable energy standard, the cost savings from EVs are not quite as significant as they would be otherwise. Revenue generated from a carbon price could be used to address some of these barriers by supporting charging deployment and educational programs.

A carbon price contributes, in a limited fashion, to increasing the adoption of air source heat pumps (ASHPs)

Without a carbon price, the lifetime costs of oil heating systems are typically more expensive than ASHPs, while natural gas heating systems are less expensive than ASHPs. A carbon price does not significantly impact these dynamics already seen in the heating industry, even within the high price examined in this study. The high cost of heating oil promotes transition to ASHPs, which is slightly amplified by a carbon price. The low cost of natural gas hinders widespread transition from gas heating system to ASHPs, a dynamic which is not sufficiently changed by a carbon price to make ASHPs are more cost-effective. Furthermore, as electric prices rise as a result of the Renewable Energy Standard, ASHP economics are not as favorable as they would be otherwise.

The results of this study need to be considered within the broader context of the heat pump market. In addition to cost barriers, there are a wide range of other market barriers that will need to be addressed in order to achieve widespread deployment of heat pumps in Rhode Island. Some key challenges include a lack of consumer awareness, limited confidence in the benefits of heat pumps, consumer preferences for traditional heating sources, gaps in the supply chain, and a limited workforce of qualified installers. Revenue generated from a carbon price could be used to address some of these barriers by supporting consumer education and workforce development programs.

A carbon price will create shifts in Rhode Island's economy, but aggregate economic impacts are expected to be negligible

The study showed that aggregate impacts on jobs is expected to be slightly positive, while the impact on state GDP is slightly negative. However, both impacts are close to zero in the context of Rhode Island's entire economy, accounting for changes of 0.1 percent or less of total jobs and GDP. While the aggregate changes are small, there are important shifts that will occur in Rhode Island's economy. These changes are to be expected of any action that seeks to reduce GHG emissions, as jobs shift from industries that rely on fossil fuels to those that support renewable, electric, and other cleaner technologies. The magnitude of these shifts scales with the degree of decarbonization driven by such actions.

In the transportation sector, jobs shift from gas-powered cars to electric vehicles as consumers make the same switch. For example, car salespeople will transition from selling gasoline-powered vehicles to electric vehicles; auto repair jobs will see a similar transition; and there will be fewer jobs available at gas stations. However, there will be an increase in jobs associated with the installation of electric vehicle charging equipment. Additionally, the reduced maintenance and fuels costs of electric vehicles will create savings for electric vehicle drivers, which will then be spent in other sectors of the economy.

The building thermal sector sees a similar transition. Jobs will shift from fossil fuel heating to electric heating and weatherization. For example, HVAC technicians will start to transition from installing oil and gas heating systems to more heat pump installations. Delivered fuel suppliers will see a decrease in jobs, while jobs associated with electricity transmission and distribution could see an increase as more heat pumps are installed. There is also an increase in jobs associated with weatherizing homes as a result of the spending in such programs.

A carbon price would generally have a limited aggregate impact on households

The aggregate near-term cost impacts of a carbon price on households are small. Households that see the highest cost increase are those who spend the most on fossil fuels. Typically, this would include households who heat with oil, have large homes, have poor insulation, or drive more than average. As such, households can mitigate added costs, or achieve cost savings, by adopting clean energy technologies and weatherizing their homes. Although the aggregate changes are relatively small, as indicated above, it is worth noting that those whose jobs are impacted by shifts in economic activity would see large impacts. This includes both households that lose jobs and those that gain jobs as a result of the shifts in the economy.

Policy design can dictate how revenue use is targeted, which determines how different households are impacted. For example, the Public Services investment option resulted in greater benefit for low-income households and those who use public transit than it did for other households. The presence of a rebate can also result in some households achieving a net gain in income. This is more likely to occur for large families or those who have low expenses associated with fossil fuels. The rebate could also be designed such that it provides greater benefit for low-income households than high-income households, by changing the amount distributed to households inverse to income level.

It is also important to acknowledge the health benefits that would accrue to households as the result of a carbon price. This study showed that health impacts are small but positive.

Wider geographic scope would lead to greater success

Developing a carbon price in coordination with other states has several advantages and would likely lead to greater success of the program. First, operating at a regional scale can improve socially acceptability. It is easier to justify a carbon price to those who view it unfavorably if several states are moving towards implementation than if Rhode Island were to develop one on its own. Additionally, emissions reductions can also occur at a lower cost to businesses and residents. Particularly in a cap-and-trade program, where emissions allowances are tradeable, entities who can decarbonize more cheaply will do so, reducing the cost of allowances. It will also reduce costs to the Rhode Island government because administrative costs can be shared among the participating states, creating economies of scale.

The Regional Greenhouse Gas Initiative has shown that a program with a wide geographic scope can be successful. In fact, new states are still participating, with Virginia set to participate in January 2021 and Pennsylvania considering participating as well. However, regional participation may involve making tradeoffs on important policy design decisions (e.g., price) based on the needs and preferences of other states. While there may be appetite for a higher carbon price among progressive states in the region who are currently studying deep decarbonization, such as Massachusetts and New York, a lower price may be more likely to garner a broader coalition of states.

Section 9: Conclusion & Next Steps

The results of this study show that there is a diversity of perspectives on carbon pricing and numerous ways in which it could be implemented. Furthermore, it highlights that carbon pricing is one of many tools available to the state of Rhode Island in an effort to achieve its ambitious decarbonization goals. As this report describes, Rhode Island already has a multi-faceted, robust, and expanding set of decarbonization policies and programs. As the findings of the several decarbonization-related studies (including this one) and initiatives become available, Rhode Island can align these elements into its broader decarbonization strategy. Rhode Island can utilize the findings of this decarbonization study to inform whether it pursues a carbon pricing scheme, and if it does, what its goals would be for implementing a carbon pricing scheme within the context of the state's broader decarbonization efforts. Specifically, these goals may include what price level or GHG reductions it wants to achieve through adoption of a carbon price. Higher prices and more stringent emissions caps will result in greater GHG emissions reductions.

If Rhode Island decides to move forward with a carbon price, there are several key decisions that would need to be made regarding program design. Chief among them, Rhode Island would need to determine whether a carbon fee, a cap-and-trade, or hybrid program would best fit with achieving its goals.

Another key decision for Rhode Island is whether to pursue a carbon price independently or in cooperation with regional partners. The success of RGGI and the ongoing effort on TCI-P has shown that there is an appetite for regional coordination on carbon pricing. However, these initiatives have occurred around relatively low-price levels. If Rhode Island seeks to pursue a higher carbon price, it may choose to move forward independently or work with a smaller coalition of states than has been seen in RGGI and the development of TCI-P.

Perhaps even more important than the price itself are the decisions about how to use the revenue. Revenue use will be critical in determining the success of the carbon price. The use of revenue should be aligned with Rhode Island's objectives and broader decarbonization efforts. While there were some illustrative examples examined in this study, the revenue can be used however policymakers see fit. However, it is important to remember that there will likely be key tradeoffs between various uses of the revenue, and stakeholder input on decision making will be vital.

Through the process of program development, Rhode Island should work closely with stakeholders in determining the structure of the program and the use of revenue. This includes government entities, such as Rhode Island's Office of Energy Resources, Department of Environmental Management, Department of Transportation, Public Transit Authority, and Division of Taxation, among others. In addition, Rhode Island should work closely with community members and organizations, particularly those in low-income and frontline communities. Community engagement should begin prior to program development and should continue regularly throughout.

In summary, while the impacts of a carbon price alone would not be sufficient to achieve the state's decarbonization goals, the price can be an important supplemental tool. The specific design of a potential policy would generate different outcomes against key indicators, such as emissions reductions, economic impacts, and health outcomes. Policymakers can use the quantitative and qualitative findings of this study, as well as ongoing stakeholder engagement, to design a carbon pricing structure that best achieves statewide energy, economic, and environmental goals, and appropriately complements its robust portfolio of decarbonization initiatives.

Appendix A: Detailed Modeling Methodology & Assumptions

Assumptions

Building sector

Residential

Space heating and cooling

Our source for shipment-weighted average efficiency for HVAC equipment is a 2017 HVAC Market Report, prepared for New York State Energy Research and Development Authority by D+R International.[73] Table 13 shows the cost and efficiency assumed for each heating and cooling technology.

Table 13. Assumed cost and efficiency of residential space heating and cooling equipment

Equipment Type	Cost	Efficiency	Cost Source(s)
Gas furnace	$5,640	92% (AFUE)	Navigant (2018a) *Water Heating, Boiler, and Furnace Cost Study*[74]
Gas boiler	$8,890	93% (AFUE)	Navigant 2018a
Oil furnace	$5,505	85% (AFUE)	Navigant 2018a
Oil boiler	$7,535	86% (AFUE)	Navigant 2018a
Ducted HP	$14,496	Heating: 8.85 (HSPF)	Navigant (2018b) *Ductless Mini-Split Heat Pump Cost Study*[75]
		Cooling: 15.54 (SEER)	
Ductless HP	$14,496	Heating: 10.43 (HSPF)	Navigant 2018b
		Cooling: 21.02 (SEER)	
Central AC	$4,124	14.57 (SEER)	Navigant (2011). *Incremental Cost Study Final Report*, prepared for NEEP's EMV Forum. Assumes a 2-ton system with SEER 14.5.
Room AC	$1,000	10.00 (SEER)	Project Team estimate (cost of 2-3 large window ACs)

We estimated average demand for heating service as 70 MMBTU/per year, based on a range of heating loads 60 (furnace) to 80 (boiler) MMBTU in Cadmus's 2015 High Efficiency Heating Equipment Impact

[73] D+R International. 2013 to 2017. *HARDI Data: D+R Unitary HVAC Market Reports*. Linked from https://www.nyserda.ny.gov/About/Publications/Program-Planning-Status-and-Evaluation-Reports/Evaluation-Contractor-Reports/2017-Reports in particular the 2017 report at https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2017ContractorReports/2017-DRUnitaryHVACMarket.pdf

[74] Navigant, prepared for the Electric and Gas Program Administrators of Massachusetts. 2018a. *Water Heating, Boiler, and Furnace Cost Study (RES 19) Final Report*. Prepared for the Electric and Gas Program Administrators of Massachusetts. https://ma-eeac.org/wp-content/uploads/RES19_Task5_FinalReport_v3.0_clean.pdf.

[75] Navigant, prepared for the Electric and Gas Program Administrators of Massachusetts. 2018b. *Ductless Mini-Split Heat Pump Cost Study (RES 28) Final Report*.. https://ma-eeac.org/wp-content/uploads/RES28_Task4_FinalReport_v2_clean.pdf.

Evaluation[76] (Figure 20). This analysis was conducted for Massachusetts, but heating degrees are similar to Rhode Island so we used the data from this study without any modification.

We estimated average demand for cooling service as 13 MMBTU/per year, based on a 3 ton system and 360 effective full load hours per year, based on National Grid's Rhode Island Technical Reference Manual.[77]

We assumed that both heating and cooling demand per unit would fall at the rate described in the EIA AEO2020. Incremental weatherization funding for incentives was assumed to deliver energy savings of 0.00825 MMBTU per year per dollar in residential buildings, based on the average performance of building envelope measures in the MassSave program.[78]

Water heating

Table 14 shows the assumed cost and efficiency of residential water heating equipment.

Table 14. Assumed cost and efficiency of residential water heating equipment

Equipment Type	Cost	Efficiency	Cost Source(s)
Combustion storage (natural gas, oil, or propane)	$2,234	63% (gas and propane); 58% (oil)	Navigant 2018a
Heat pump water heater	$2,327	292%	Navigant 2018a

We assumed a hot water service demand of 12 MMBTU per year, based on Project Team analysis of EIA Residential Energy Consumption Survey data.

Commercial

Space heating and cooling

Table 15 shows the assumed cost and performance of commercial space heating and cooling equipment. These values were derived from information provided by Washington Gas Light, the gas utility for Washington, DC, to the District of Columbia Department of Energy and Environment in the context of cost analysis of electrification of commercial buildings in the District. The represent an average across different building types, including institutional, large commercial, and small commercial construction.

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[76] Cadmus, prepared for the Electric and Gas Program Administrators of Massachusetts. 2015. *High Efficiency Heating Equipment Impact Evaluation Final Report*. Prepared for the Electric and Gas Program Administrators of Massachusetts. https://neep.org/sites/default/files/resources/High-Efficiency-Heating-Equipment-Impact-Evaluation-Final-Report.pdf.

[77] National Grid. *Rhode Island Technical Reference Manual For Estimating Savings from Energy Efficiency Measures 2020 Program Year*. http://rieermc.ri.gov/wp-content/uploads/2019/11/ngrid-ri-2020-trm.pdf.

[78] Derived from data provided by MassSave at https://www.masssavedata.com/Public/MeasuresDetails.

Table 15. Assumed cost and efficiency of commercial space heating and cooling equipment

Equipment Type	Cost per 1,000 sq ft.	Efficiency
Gas furnace or boiler, with chiller	$1,663	Heating: 93% Cooling: 500%
Oil furnace or boiler, with chiller	$1,663	Heating: 88% Cooling: 500%
Ducted HP	$3,033	Heating: 259% Cooling: 500%
Ductless HP	$3,033	Heating: 306% Cooling: 500%

We assumed a heating service demand of 39.9 MMBTU per year per 1,000 square feet, based on Project Team analysis of EIA Commercial Building Energy Consumption Survey data, and a cooling demand of 13 MMBTU/year per 1,000 sq ft., assuming that commercial cooling loads are somewhat higher than residential loads on a per square foot basis, due to internal loads and daytime occupancy.

We assumed that both heating and cooling demand per unit would fall at the rate described in the EIA AEO2020. Incremental weatherization funding for incentives was assumed to deliver energy savings of 0.0180 MMBTU per year per dollar in residential buildings, based on the average performance of building envelope measures in the MassSave program.[79]

Water heating

Table 16 shows the assumed cost and performance of commercial water heating equipment. The low average costs per 1,000 square feet, relative to residential costs, reflect the relatively low demand for hot water in most commercial space. Only about two thirds of commercial building square feet require any hot water service at all. We assume a demand of only 6 MMBTU per year of hot water per 1,000 square feet, based on analysis of EIA Commercial Building Energy Survey data, for buildings that do have hot water demand. Costs are based on the same Washington, DC, data source described above for space heating. Efficiency is based on boiler efficiency.

Table 16. Assumed cost and efficiency of commercial space heating and cooling equipment

Equipment Type	Cost per 1,000 sq ft.	Efficiency
Gas storage water heater	$130	93%
Oil storage water heater	$130	88%
Heat pump water heater	$330	300%

Transportation sector

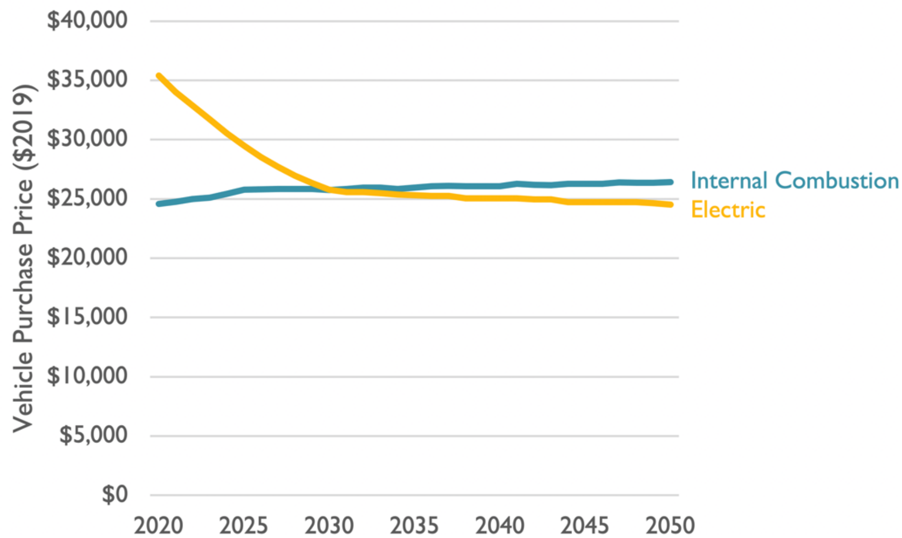
Electric light duty vehicles

Figure 27 shows the average purchase price we assumed for new internal combustion and electric vehicles, before tax credits or incentives. EVs become less expensive to purchase than traditional

[79] Derived from data provided by MassSave at https://www.masssavedata.com/Public/MeasuresDetails.

vehicles in 2031. We assumed that vehicle miles traveled per vehicle remains fixed at the current level of about 9,200 miles per year.

Figure 27. Average purchase price of new internal combustion and electric vehicles



Source: Project Team analysis, calibrated to Transportation Climate Initiative baseline modeling

Public transit

Bus electrification

We modeled the cost and savings of bus fleet electrification on RIPTA's 2019 *Sustainable Fleet Transition Plan*.[80] Specifically, we used the relative cost of the plan's "mixed en-route and depot charging" case as our primary input, and spread the costs evenly within each time period reported in that plan. Those costs are $10 million per year for the first 12 years and then $3.9 million per year for the next 12 years, and $2.6 million per year for the remaining period until 2050. These costs include both bus costs and charging infrastructure costs.

Increased service

We assumed that ridership would grow in proportion to increases in RIPTA's annual budget, reflecting increased service that could be offered with those funds. This is a relatively optimistic assumption in that RIPTA likely already serves its highest-value routes. Additional routes or frequency would provide diminishing returns. Estimates provided by RIPTA during consultations without team confirmed this effect, with a near doubling of RIPTA's budget assumed to lead to only a 40-70 percent increase in ridership.

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[80] RIPTA. 2019. *Sustainable Fleet Transition Plan*. https://www.ripta.com/wp-content/uploads/2020/07/sustainable_fleet_transition_plan.pdf.

Increased ridership reduces vehicle miles traveled in personal vehicles, although we assumed that only 80 percent of transit miles displace personal vehicle miles (because some may displace walking or cycling, or reflect trips that otherwise would not have happened).

Active transport

We modeled the effect of investments in active transportation promotion based on the results of a study in New Zealand which measured the effect of a combination of infrastructure investment and marketing to encourage active transport.[81] We scaled the New Zealand results down by 50 percent to reflect Rhode Island's less hospitable weather. This results in an estimate of a cost of $6.60 per mile of reduction in annual miles traveled.

Detailed Results

Heat pump adoption

Residential

Space heating

Heat pump adoption for space heating increases steadily in all cases, although more robustly with policy drivers and in homes without access to natural gas (e.g., those dependent on oil, propane, or electric resistance heat) where customer economics is more favorable.

[81] Chapman et al. 2018. *A Cost Benefit Analysis of an Active Travel Intervention with Health and Carbon Emission Reduction Benefits*. Int J Environ Res Public Health. 2018 May; 15(5): 962. doi: 10.3390/ijerph15050962. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5982001/.

Figure 28. Heat pump space heating market share in each policy case, for homes with access to natural gas

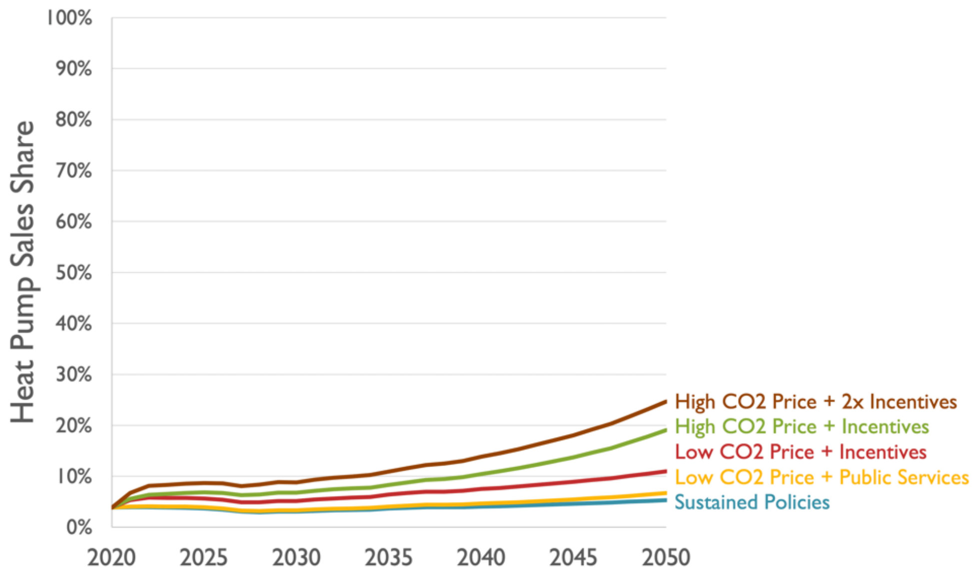
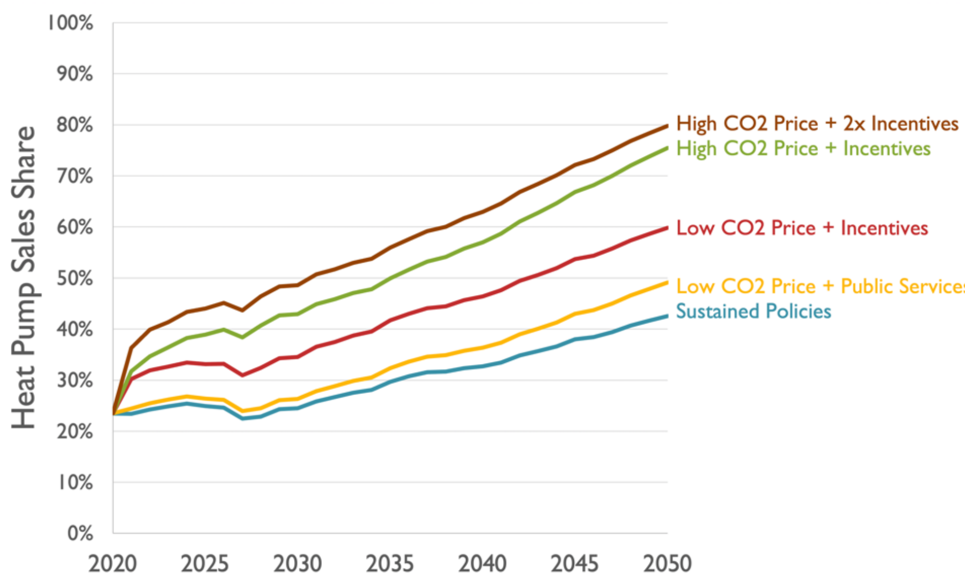


Figure 29. Heat pump space heating market share in each policy case, for homes without access to natural gas



Water heating

Heat pump water heater adoption is much faster in homes without access to natural gas, due to favorable customer economics. High carbon prices or incentives drive rapid shifts in homes with gas after 2040.

Figure 30. Heat pump water heating market share in each policy case, for homes with access to natural gas

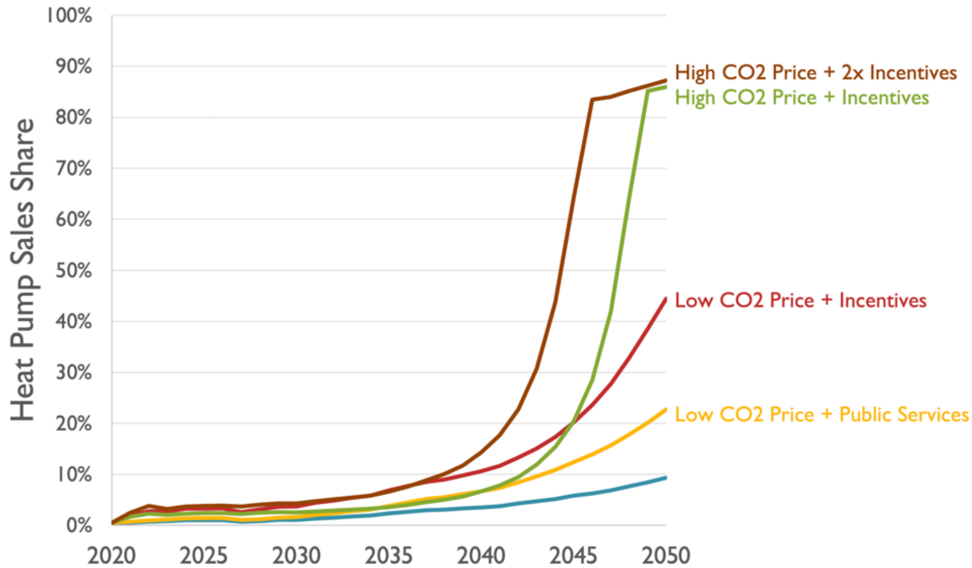
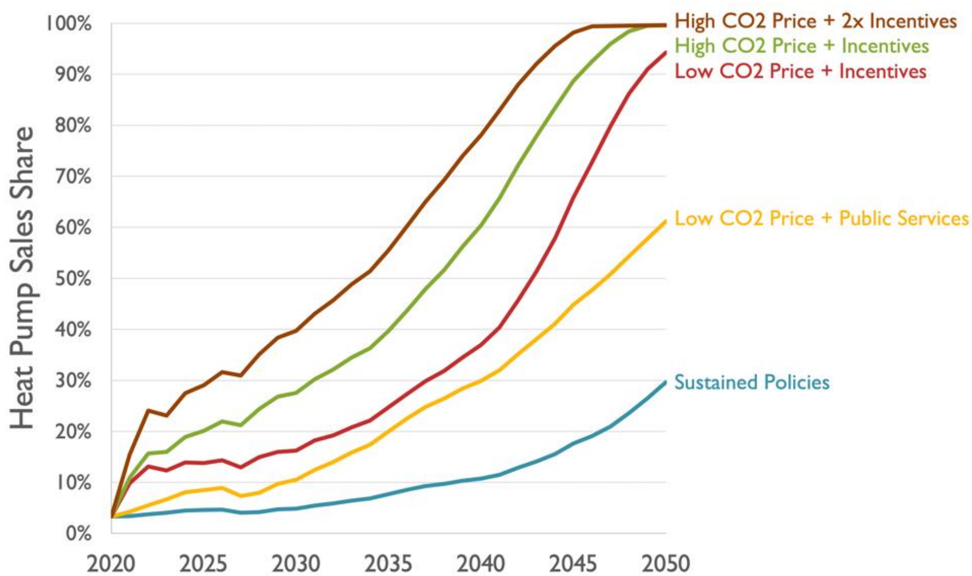


Figure 31. Heat pump water heating market share in each policy case, for homes without access to natural gas



Commercial

Space heating

The commercial buildings space heating sector shows a stronger response to policy than in residential buildings. As in residential, heat pump adoption is much faster in all policy cases among those without access to natural gas.

Figure 32. Heat pump space heating market share (on a square footage basis) in each policy case, for commercial buildings with access to natural gas

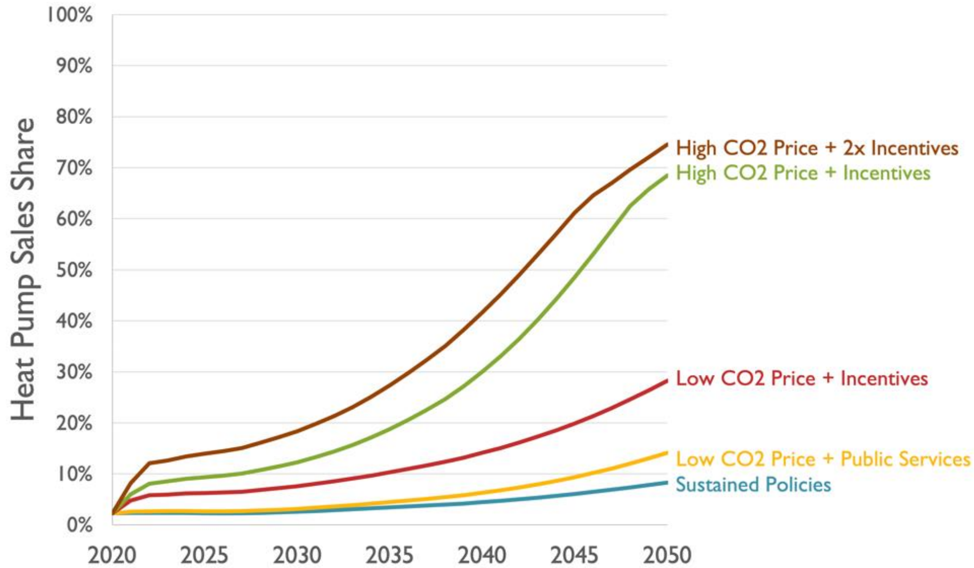
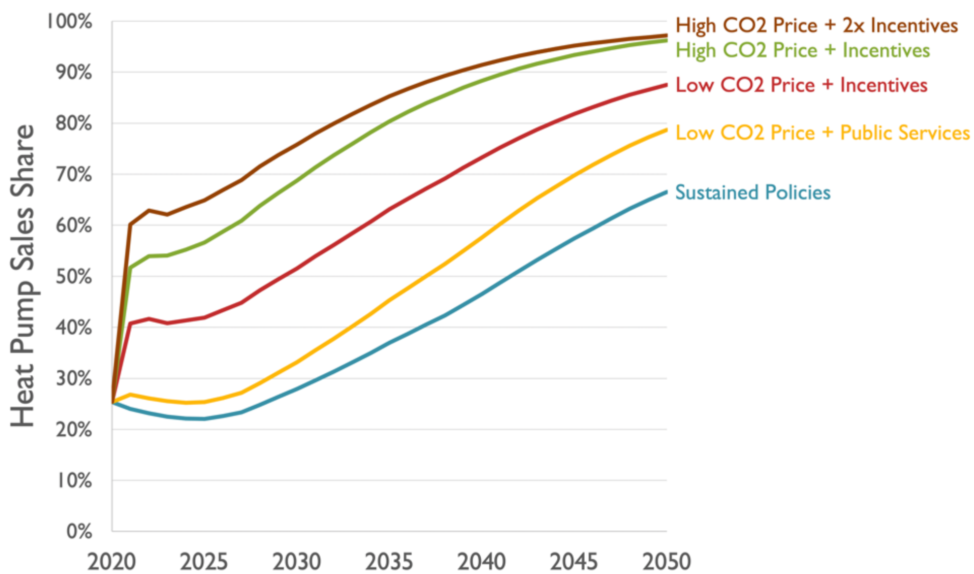


Figure 33. Heat pump space heating market share (on a square footage basis) in each policy case, for commercial buildings without access to natural gas



Water heating

Commercial water heating adoption of heat pump technology options is hindered by a lack of available products for cold climate applications, and by the relatively small average use of hot water on commercial buildings.

Figure 34. Heat pump water heating market share (on a square footage basis) in each policy case, for commercial buildings with access to natural gas

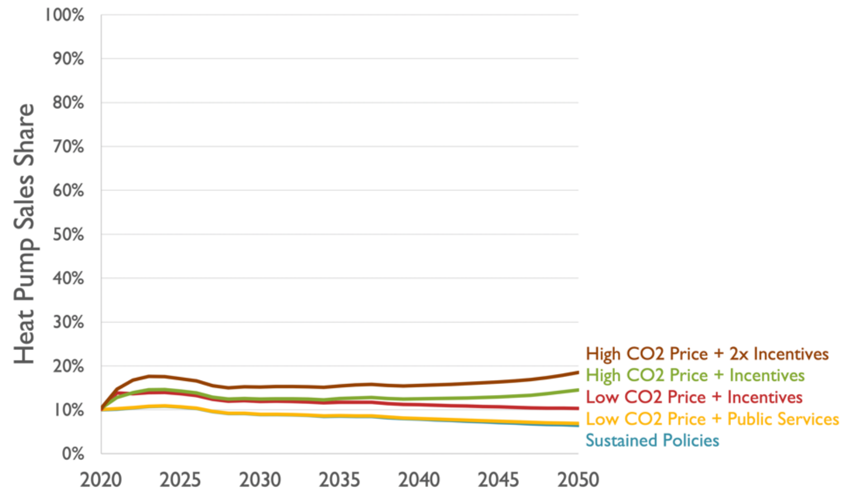
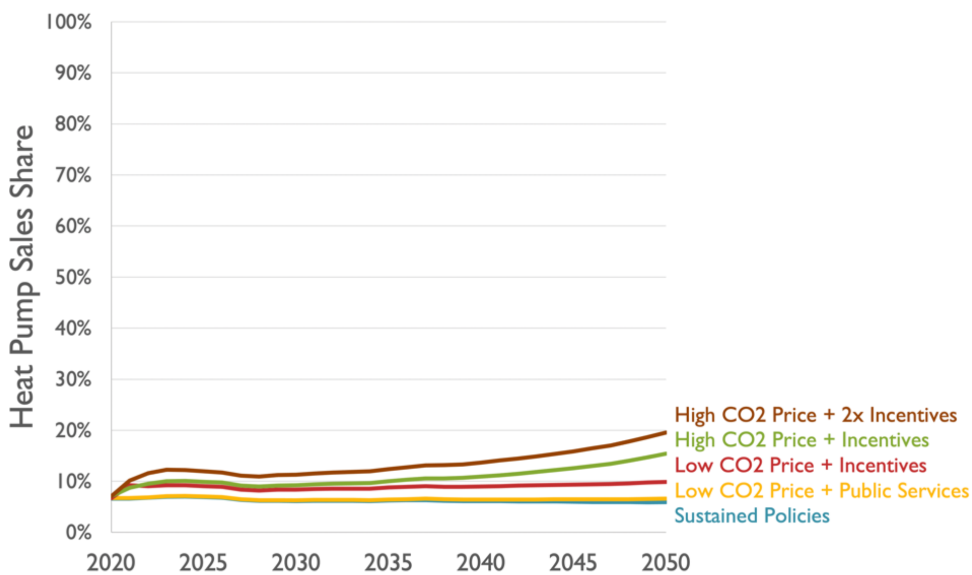
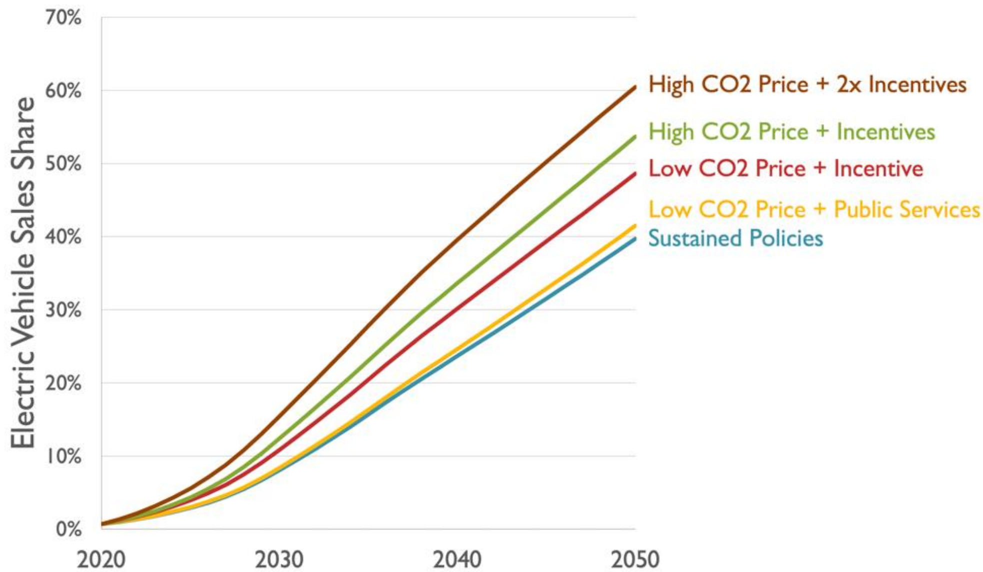


Figure 35. Heat pump water heating market share (on a square footage basis) in each policy case, for commercial buildings without access to natural gas



Light-duty electric vehicle adoption

Figure 36. Electric vehicle sales share in each policy case



Economic impact modeling results

Low Carbon Price + Incentives

Buildings

Figure 37. Annual economy-wide job-year increases and decreases resulting from changes in building-related spending patterns in the Low Carbon Price + Incentives case

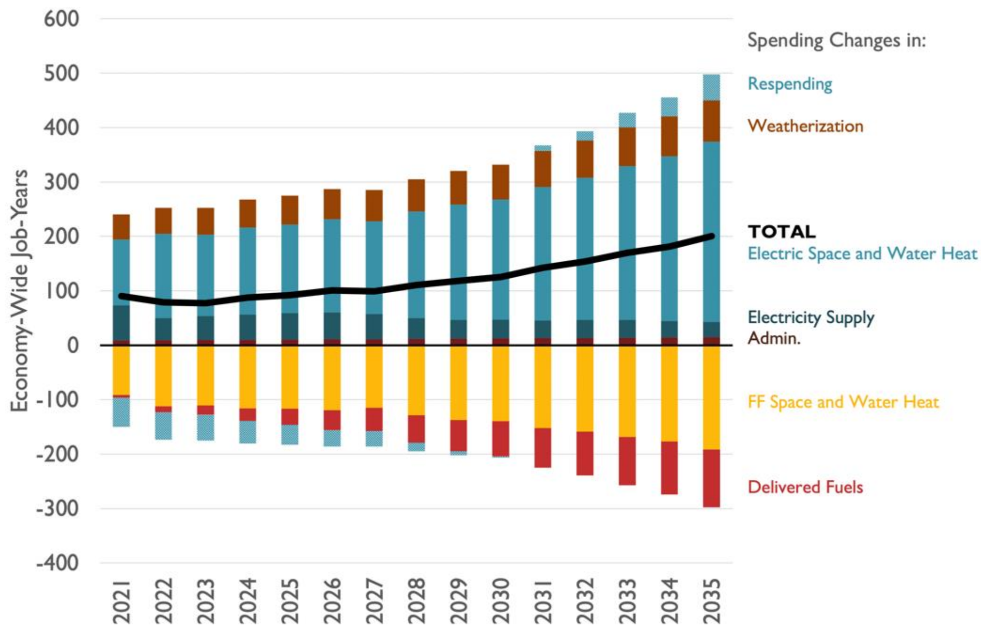
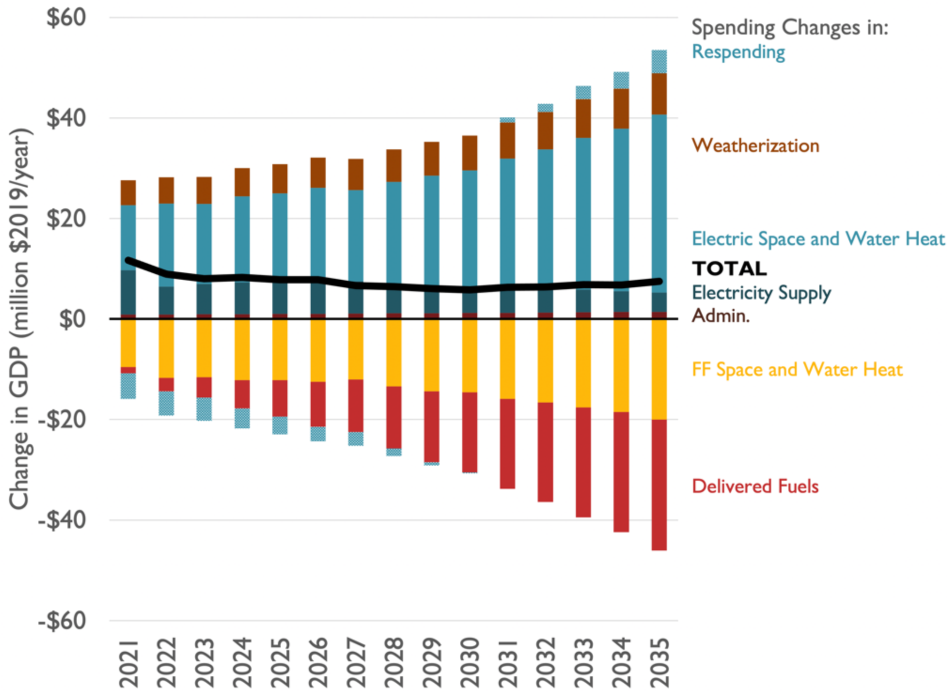


Figure 38. Annual GDP increases and decreases resulting from changes in building-related spending patterns in the Low Carbon Price + Incentives case



Transportation

Figure 39. Annual economy-wide job year increases and decreases resulting from changes in transportation-related spending patterns in the Low Carbon Price + Incentives case

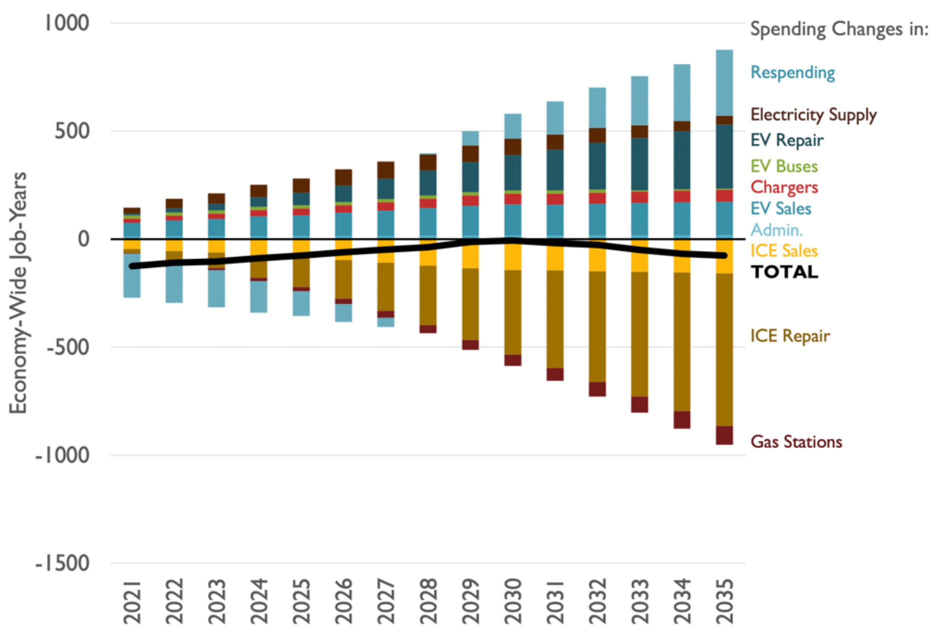
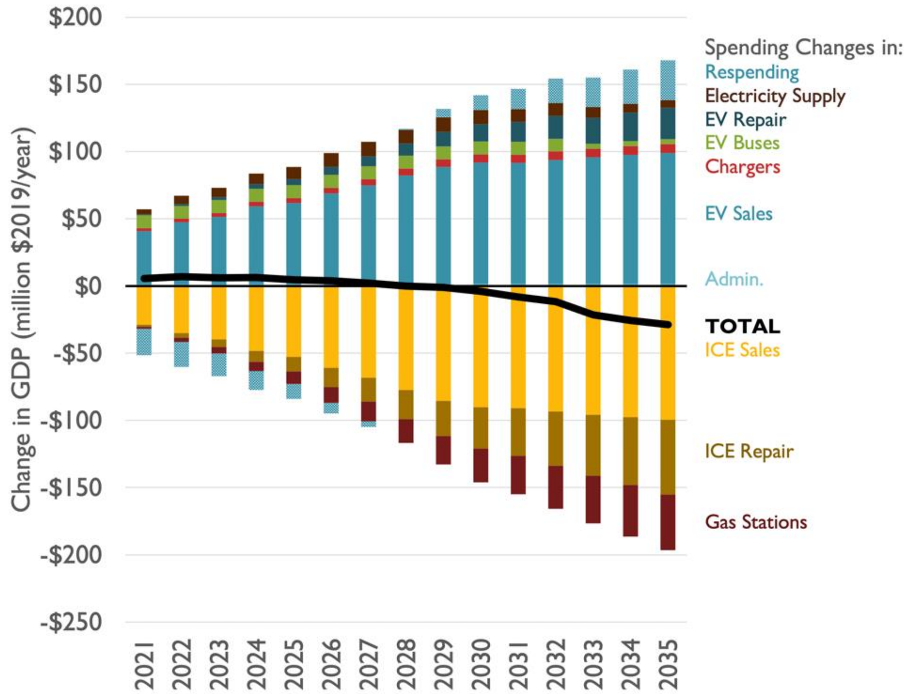


Figure 40. Annual GDP increases and decreases resulting from changes in transportation-related spending patterns in the Low Carbon Price + Incentives case



Low Carbon Price + Public Services

Buildings

Figure 41. Annual economy-wide job year increases and decreases resulting from changes in building-related spending patterns in the Low Carbon Price + Public Services case

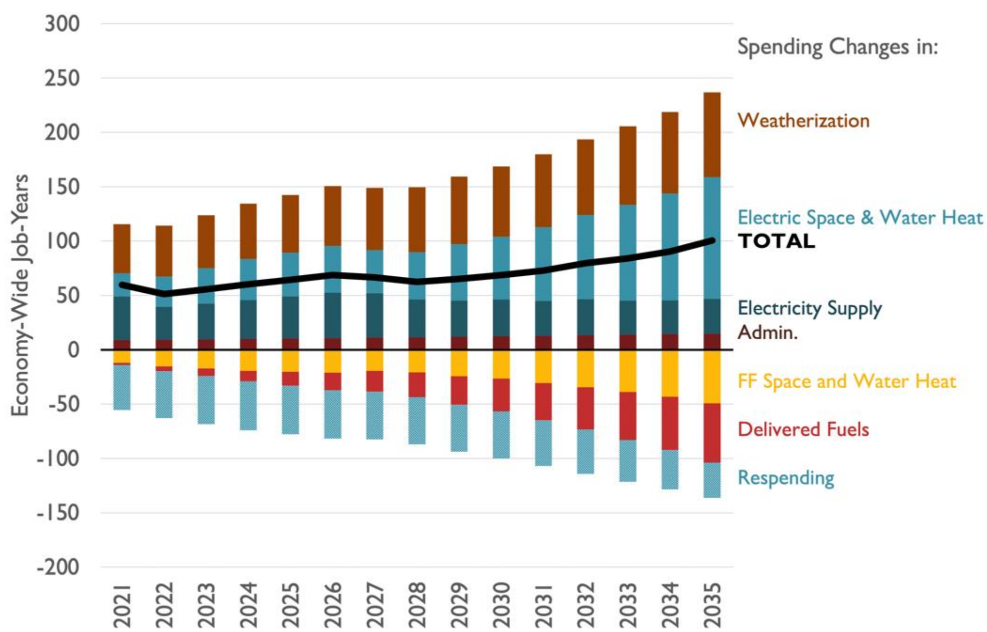
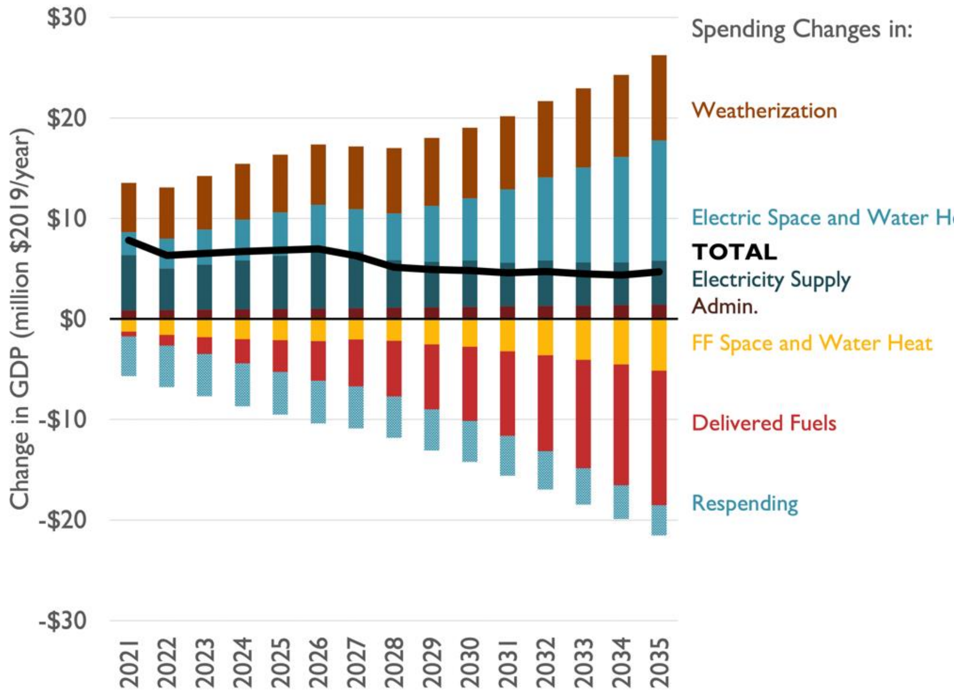


Figure 42. Annual GDP increases and decreases resulting from changes in building-related spending patterns in the Low Carbon Price + Public Services case



Transportation

Figure 43. Annual economy-wide job year increases and decreases resulting from changes in transportation-related spending patterns in the Low Carbon Price + Public Services case

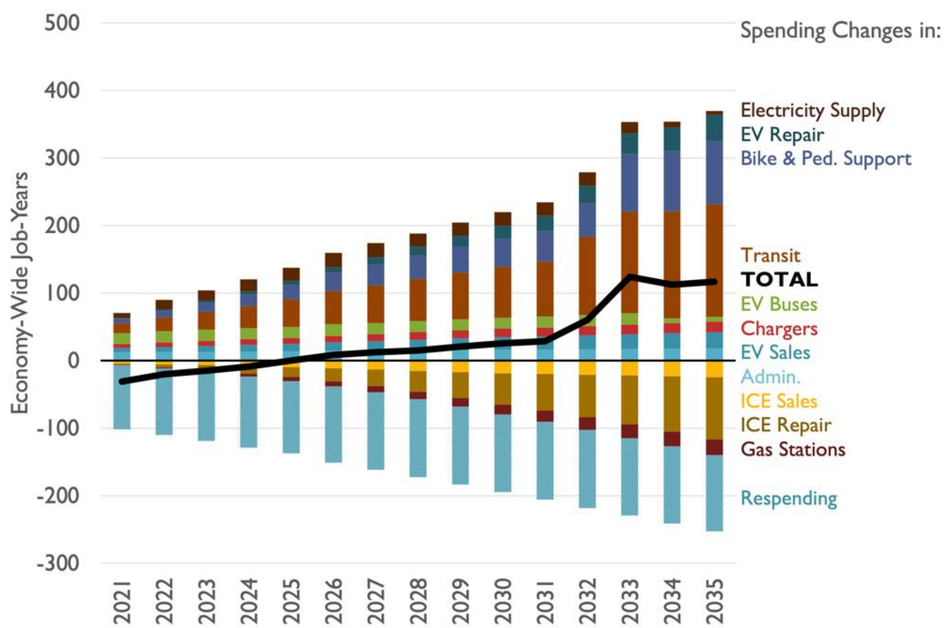
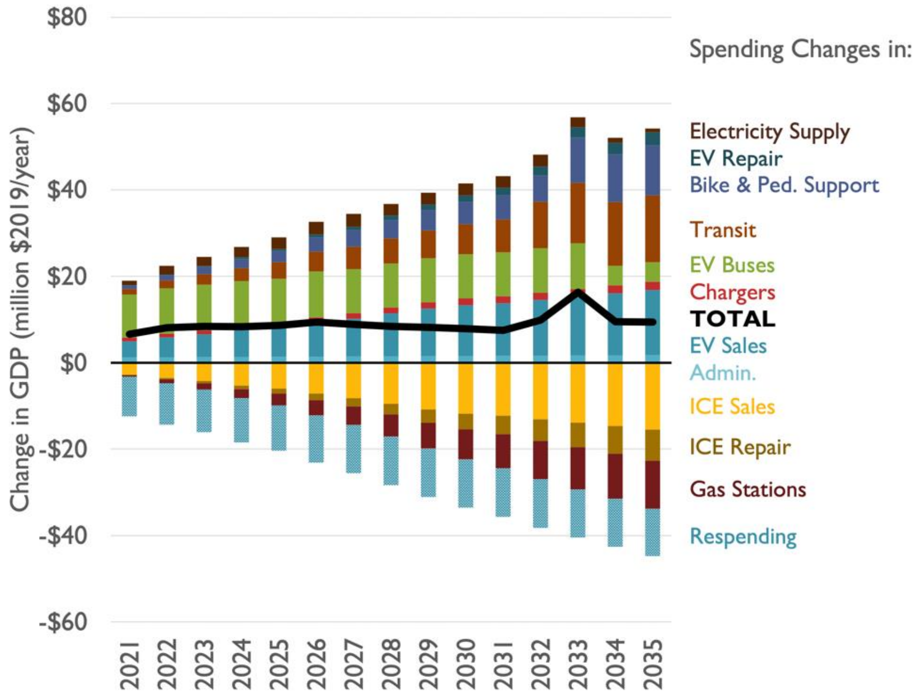


Figure 44. Annual GDP increases and decreases resulting from changes in transportation-related spending patterns in the Low Carbon Price + Public Services case



High Carbon Price + Incentives

Buildings

Figure 45. Annual economy-wide job-year increases and decreases resulting from changes in building-related spending patterns in the High Carbon Price + Incentives case

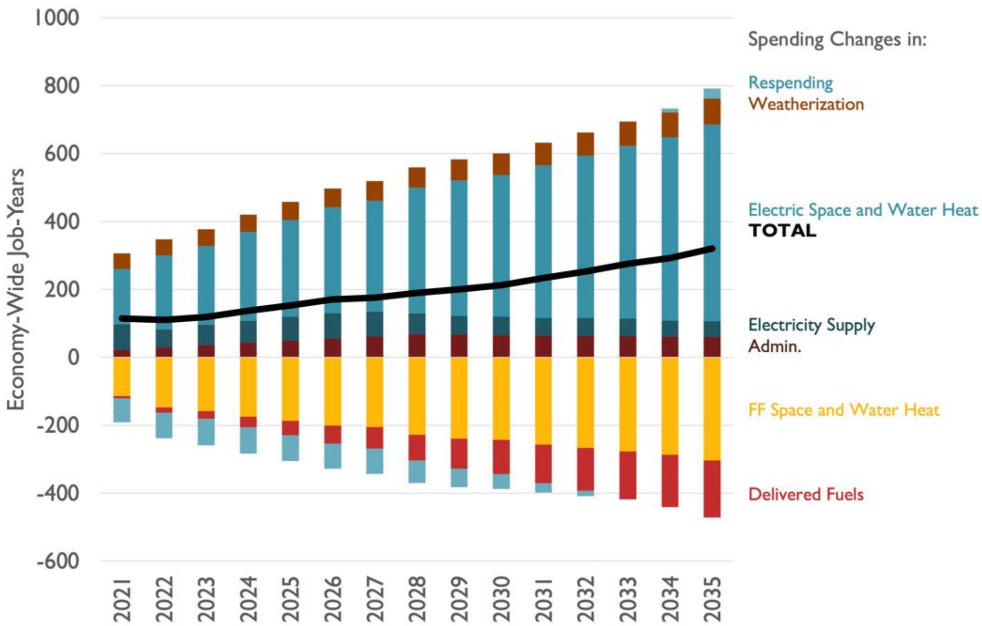
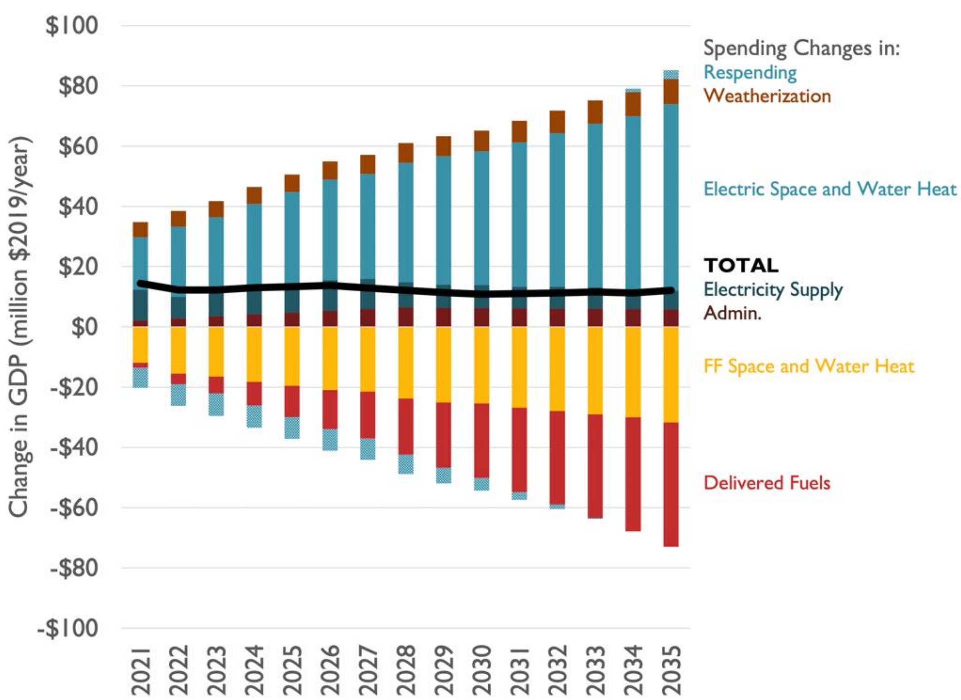


Figure 46. Annual GDP increases and decreases resulting from changes in building-related spending patterns in the High Carbon Price + Incentives case



Transportation

Figure 47. Annual economy-wide job year increases and decreases resulting from changes in transportation-related spending patterns in the High Carbon Price + Incentives case

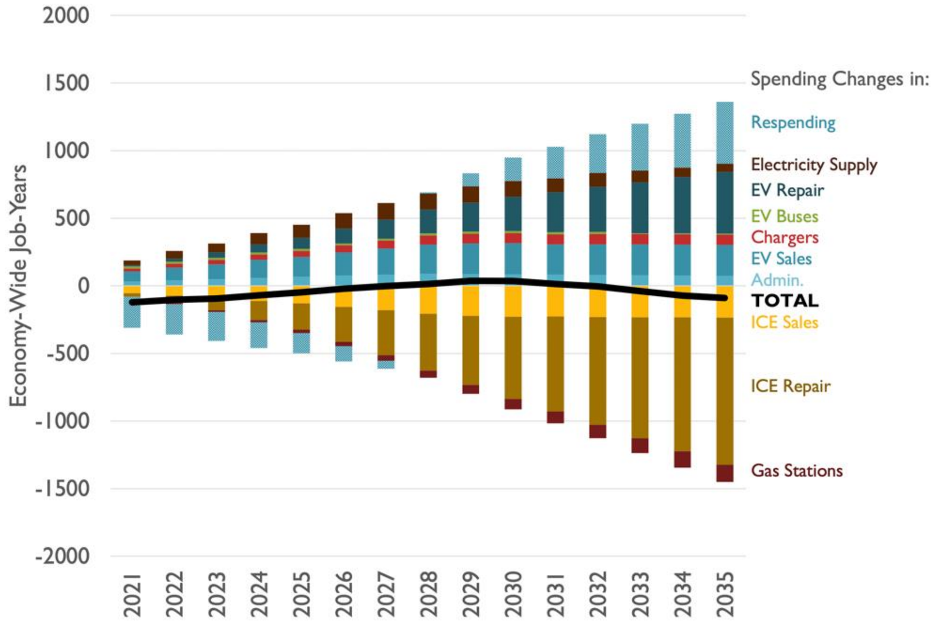
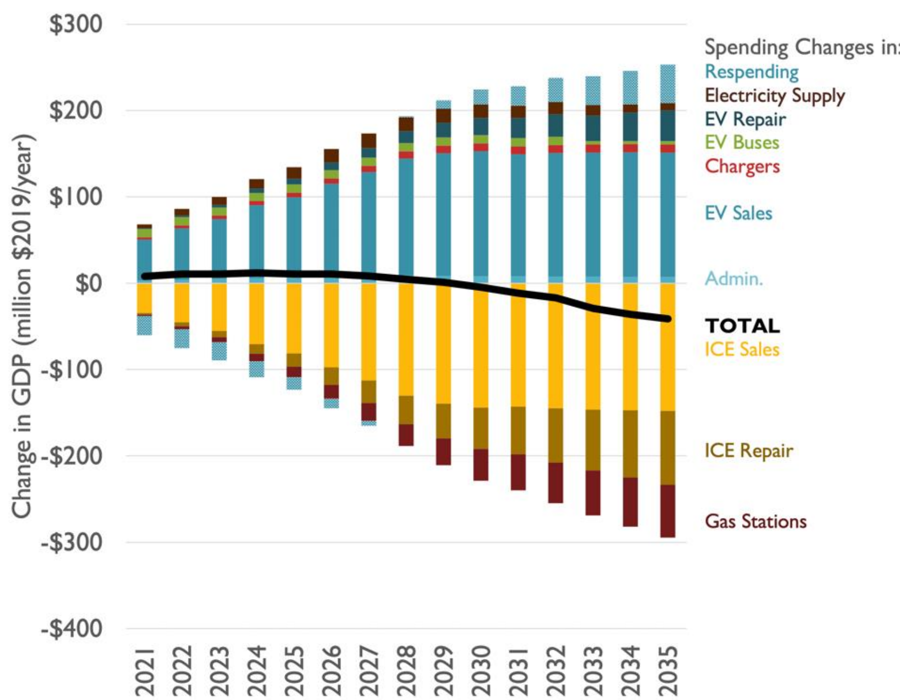


Figure 48. Annual GDP increases and decreases resulting from changes in transportation-related spending patterns in the High Carbon Price + Incentives case



High Carbon Price + 2x Incentives

Buildings

Figure 49. Annual economy-wide job-year increases and decreases resulting from changes in building-related spending patterns in the High Carbon Price + 2x Incentives case

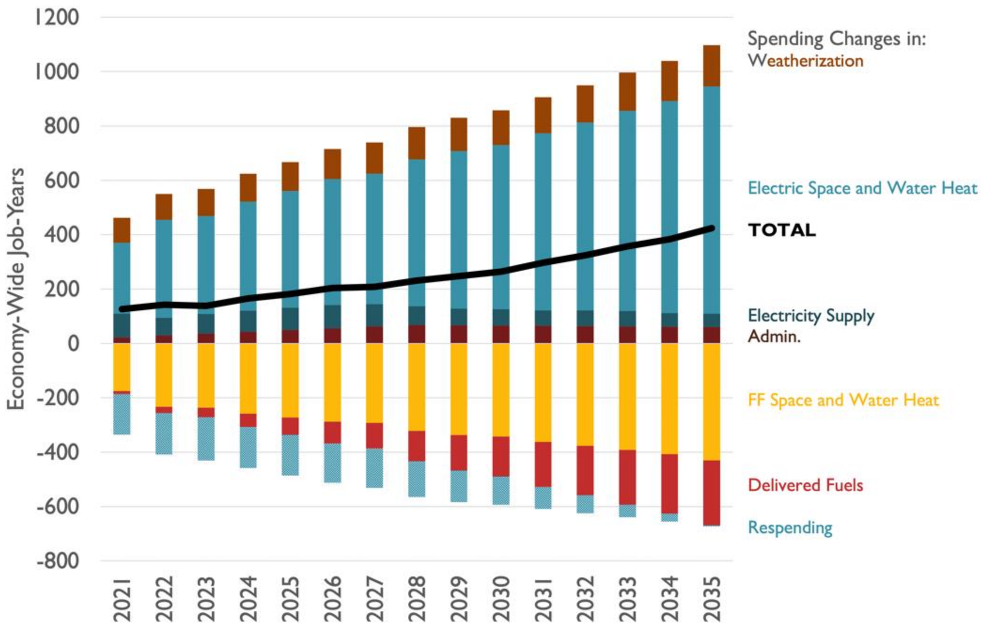
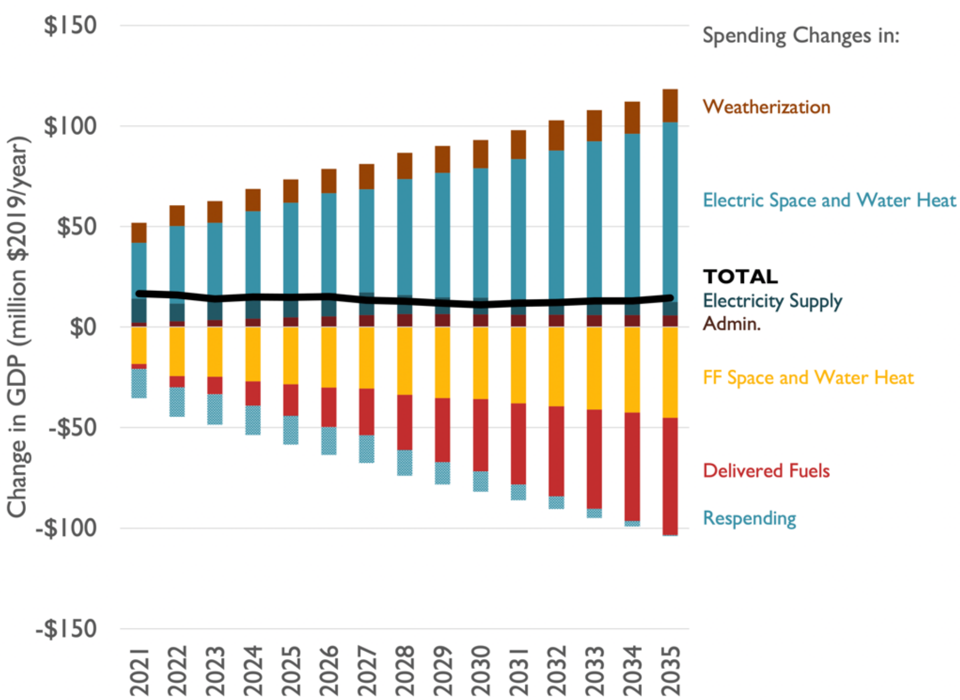


Figure 50. Annual GDP increases and decreases resulting from changes in building-related spending patterns in the High Carbon Price + 2x Incentives case



Transportation

Figure 51. Annual economy-wide job year increases and decreases resulting from changes in transportation-related spending patterns in the High Carbon Price + 2x Incentives case

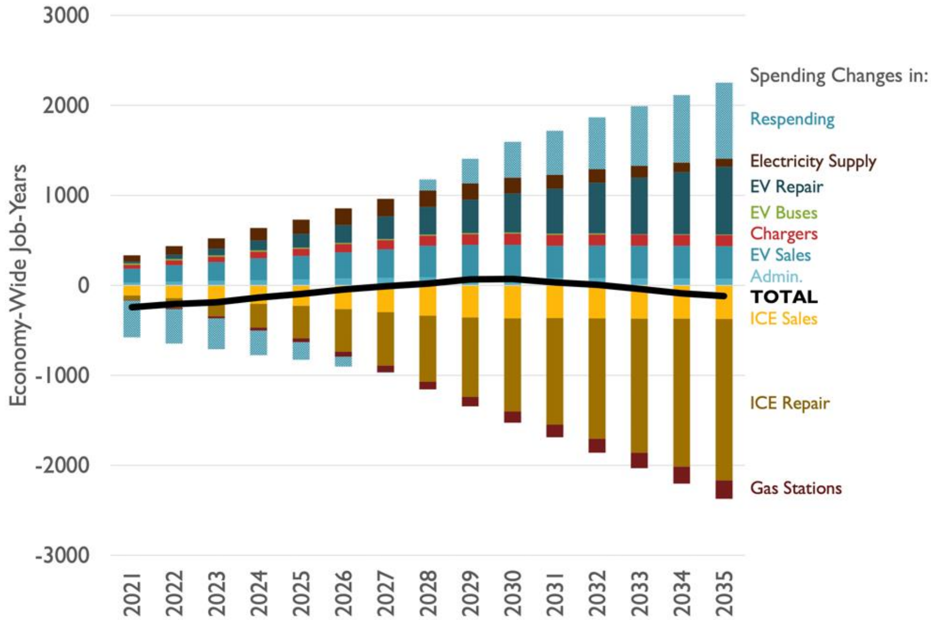
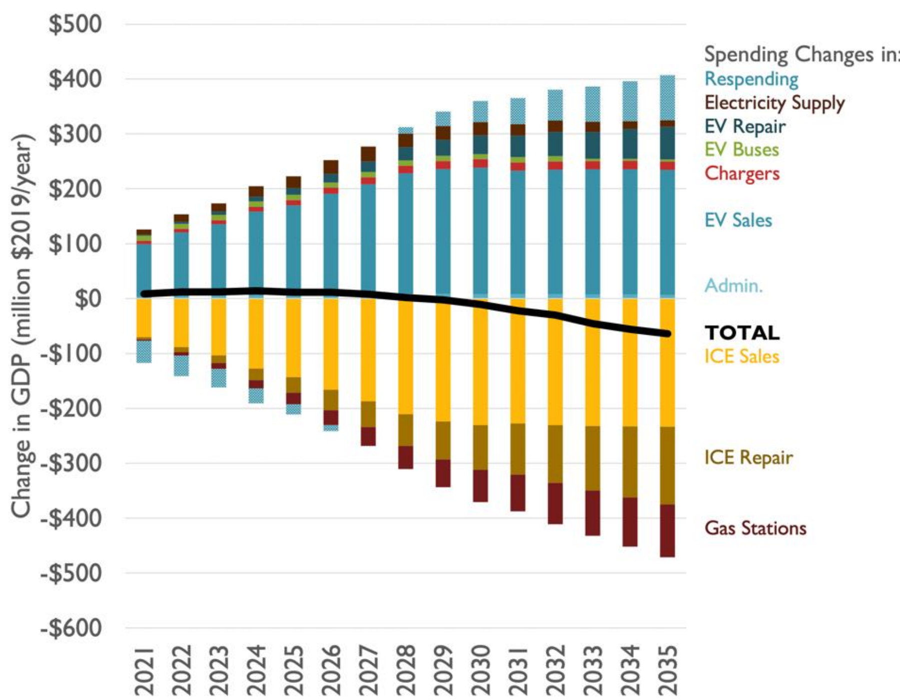


Figure 52. Annual GDP increases and decreases resulting from changes in transportation-related spending patterns in the High Carbon Price + 2x Incentives case



Appendix B: Stakeholder Engagement Summary

Overview

To ensure that the findings of this report reflected feedback from Rhode Island residents and businesses that would be impacted by a carbon pricing policy, the Project Team conducted multiple stakeholder engagement efforts at key points throughout the study, including:

1. Equity interviews with representatives of frontline communities	**2. Sector-specific focus groups** with key representatives of Rhode Island's building thermal and transportation sectors	3.Three 1-hour **webinar updates to the public and EC4**

An overview and key findings from each of these engagements can be found below.

Equity Interviews

Overview

To better understand the potential impact of carbon pricing policies on environmental justice and frontline communities in Rhode Island, the Project Team worked with the Rhode Island Carbon Pricing Team to identify organizations and individuals who could provide valuable insight on this topic.

With this information, the Project Team connected with and interviewed four representative stakeholders to learn more about:

1. How decarbonization efforts are impacting Rhode Island frontline communities
2. The social acceptability of a carbon pricing policy within these communities
3. How the revenue from a carbon pricing policy can be used to best support these communities

Interviewees

A list of stakeholders interviewed can be found below. It should be noted that all stakeholders agreed to be listed as an interviewee for this work under the condition that no statement or opinion is ascribed to them directly. As such, the Project Team has anonymized interview findings.

Name	Organization
Leah Bamberger	City of Providence
Monica Huertas	Racial & Environmental Justice Committee (REJC) of Providence
Angel Lopez	Tenant and Homeowner Association (THA) of Direct Action for Rights & Equality (DARE)
Terri Wright	Tenant and Homeowner Association (THA) of Direct Action for Rights & Equality (DARE)
Yasmin Yacoby	Rhode Island Office of Energy Resources (OER)

Findings: Impacts of Decarbonization Efforts in Frontline Communities

Most interviewees have not noticed many decarbonization initiatives in their daily lives to-date, but did note that some planned initiatives they were expecting had been postponed due to COVID-19. However, when discussing the topic of decarbonization, interviewees did highlight a number of issues they hope decarbonization efforts will help alleviate, as well as outcomes they hope decarbonization efforts will help them achieve.

Category	Feedback
Challenges to Alleviate	High rates of asthma and other respiratory illnesses
	Flooding and backed up drains
	Increased traffic and congestion
Objectives to Achieve	Increased deployment of RE technologies
	More green zones and healthier living spaces
	Increased investment in communities
	Increased community control over energy supply and use

Findings: Social Acceptability of Carbon Pricing within Frontline Communities

Several interviewees expressed skepticism about the overall concept and design of carbon pricing policies (mostly in regard to carbon taxes). Key stakeholder concerns are summarized below:

Category	Feedback
Concerns about the Concept of carbon Pricing	It's a distraction from the important work of deeply transforming the energy system
	It does not center/inherently support frontline communities or people of color
	It prioritizes reducing GHG emissions over other co-pollutants
Concerns about the Design of Carbon Pricing	Lack of transparency in the emissions disclosure process/formula
	Emitters will be able to pass costs onto customers
	There will not be enough revenue to do anything more than offset these additional costs, which preclude meaningful support for frontline communities.

Findings: How the Revenue Could Best Support these Communities

Most interviewees saw value in returning revenue to communities in the form of a rebate and/or through programmatic offerings, with a slight preference for rebates. When discussing revenue use, most interviewees emphasized several takeaways, including:

- The revenue should be used in a way that will benefit local communities and economies
- Communities should be involved in the process of determining how revenue is used
- The revenue should be used in ways that connect to supporting existing needs

Regarding programmatic offerings, interviewees provided several suggestions, summarized in the table below:

Category	Topic	Category	Topic
Housing	Investing in home repairs	**Mobility**	Invest in the public transportation system
	Energy efficient homes		Clean and improved buses/bus stops
Healthy Living Spaces	More green spaces		Increased access to public transportation
	More shade		Ozone days
	More parks and other gathering spaces		Supporting a transition away from cars
	Community gardens	**Other**	Ozone Days
Energy System	Increased deployment of RE		
	Smart grid		

Sector-Specific Focus Groups

Overview

To inform the policy analysis and ensure the findings of this report reflect stakeholder perspectives, the Project Team organized two sector-specific focus groups with key representatives of the Rhode Island building thermal and transportation sectors. Information on the agenda, attendees, and key takeaways from each focus group can be found below.

Building Thermal Focus Group

The RI Carbon Pricing Study Building Thermal Focus Group discussion took place on August 31, 2020. The purpose of the discussion was to better understand stakeholder perspectives on the potential impact of a carbon pricing policy on the Rhode Island building thermal sector.

Attendees:

The following individuals attended the focus group discussion. Invitees were identified in collaboration with the Rhode Island Carbon Pricing Study Team. Invitees who attended meetings are listed below.

Organization	Name
Green Energy Consumers Alliance	Kai Salem
Center for Justice	Jennifer Wood
Brown University	Timmons Roberts
National Grid	Meghan McGuiness
Energy Marketers Association of RI	Roberta Fagan
Aquidneck Island Planning Commission (Board of Directors)	Eric Martin
Northeast Energy Efficiency Partnerships (NEEP**)**	David Lis
Rhode Island Department of Health	Rachel Calabro

Key Takeaways

- Attendees provided feedback on the key initiatives in this space that a carbon price would interact with, including:
  - The Heating Sector Transformation initiative
  - The Rhode Island Weatherization Assistance Program (WAP)
  - National Grid's Energy Efficiency Programs
  - The Efficient Buildings Fund
  - PACE Financing
- In regards to the social and political feasibility of a carbon tax in the building thermal sector, participants noted that it will likely be challenging for a number of reasons, including the fact that the costs of a carbon price are more transparent than in other policies, a lack of trust in state government to handle the money appropriately, and the presence of stakeholders who have sought to delay or defeat carbon pricing policies.

- However, stakeholders did note that there are strategies that can improve the social and political feasibility of a carbon price. Key strategies include expanding the scale of a carbon price to a regional level, applying the price to multiple sectors as opposed to a single sector, marketing the positive impacts of a carbon price as opposed to just the costs, and getting support at the local level.
- Regarding the investment scenarios, participants feedback largely focused on the role of heat pumps. Participants generally agreed with revenue being used for air- and ground-source heat pump incentives and/or installation given the longer-term need to electrify the heating sector. Participants shared additional points to consider related to heat pump deployment, including the need to ensure housing stock is suitable for these advanced technologies and the importance of providing heat pump education and outreach to homeowners to increase participation. Participants also noted it will be important to ensure jobs are being created, the livelihood of those leaving the fossil fuel industry is protected, and those switching to electric heating aren't faced with additional financial burden.
- Participants identified complementary policies that would be necessary to ensure the success of either investment scenario. Identified policies include both heating and cooling bill pay assistance to mitigate the cost impact of low-income households and a primary focus on energy efficiency in the near-term that will set the stage for electrification in the medium- to long-term.
- Lastly, participants shared concerns or considerations that did not come up in the discussion, but are relevant to the implementation of a carbon price and/or the investment options. Participants also noted that energy efficiency historically had two components: home heating and electricity use. As a carbon price is implemented and heating is converted to air source heat pumps, which use electricity, the line between these two components of energy efficiency is becoming blurred, which provides an opportunity for a broader policy discussion on energy efficiency. In regard to the investment options, participants highlighted a need for training, education, and licensing reform to ensure there is a sufficient workforce to support these activities.

Transportation Focus Group

The RI Carbon Pricing Study Transportation Focus Group discussion took place on Tuesday, September 1, 2020. The purpose of the discussion was to better understand stakeholder perspectives on the potential impact of a carbon pricing policy on the Rhode Island transportation sector.

Attendees:

The following individuals attended the focus group discussion. Invited participants were identified in collaboration with the Rhode Island Carbon Pricing Study Team. Attendees include the below.

Organization	Name
Conservation Law Foundation	James Crowley
Green Consumers Alliance	Priscilla De La Cruz
National Grid	Meghan McGuinness
Northeast Clean Energy Council (NCEC)	Jeremy McDiarmid
Rhode Island Trucking Association	Chris Maxwell
Tesla	Zach Kahn
Tesla	Michael Delponte

Key Takeaways

- Attendees provided feedback on the key initiatives in this space that a carbon price would interact with, including:
    - The Transportation and Climate Initiative Program
    - ZEV mandate
    - Volkswagen settlement investment
    - Charge Up! (EV/EVSE incentive)
    - Advanced Clean Trucks rule
- Regarding the political and social acceptability of a carbon price in the transportation sector, stakeholders agreed that it will likely be challenging given the ability of the opposition to frame it as a tax. However, stakeholders also highlighted several strategies for improving the feasibility, including placing an emphasis on the benefits of carbon pricing, such as the ability to generate revenue that can be reinvested with a focus on equity. Stakeholders emphasized that it's important to ensure the benefits are flowing to Rhode Island residents and businesses, especially frontline communities. Lastly, stakeholders also noted that a broader, regional price is more cost-effective and will thus help improve feasibility.
- Regarding the investment scenarios, participants generally agreed on several pros, including the fact that these investment scenarios would help drive adoption of EVs and increase investment in charging infrastructure. Participants also highlighted several drawbacks, including a limited focus on active transportation and the excludes certain vehicles in the electrification investment scenario (e.g., medium duty trucks). For both scenarios, participants emphasized the need to ensure there is equitable access to clean transportation for all Rhode Islanders and a need to concentrate support to groups that need it most.

- Participants also provided suggestions on how to target the dollars for either or both of the investment scenarios, including targeting non-urban populations to ensure they are not left out, as well as targeting areas that will reduce the most carbon and/or will have the greatest public health benefits.
- Lastly, participants shared what complementary policies would be necessary to make either or both investment scenarios successful, including robust education and outreach to end-use costumers, rate structure reform, a low carbon or clean fuel standard, incentives to reduce costs, a ZEV in state fleet, and a weight exemption for natural gas vehicles. Additionally, participants emphasized a need to mitigate potentially excessive costs and to consider the potential for unintended consequences of policy design in the short- and long-term.

Webinar Updates

The Project Team held three stakeholder webinars throughout the project to ensure stakeholders were up to date on project progress and findings. Webinars were held in May, September, and October 2020. The Project Team's summary of and response to feedback for each session can be found below:

May 2020 Stakeholder Update Webinar: Response to Stakeholders

Dear RI Carbon Price Study Stakeholders,

Thank you for attending the May 19th webinar on the Rhode Island Carbon Price Study and for sharing your thoughts during the written comment period. For those who may not have been able to attend, the presentation slides (including webinar polling results) are attached to this email.

The Project Team has received several comments that will help inform this study. Below is a summary of key themes from the followed by responses from the Project Team. While the Project Team has reviewed all comments closely, note that the below list is not comprehensive of every comment received.

Several stakeholders expressed interest in examining alternative scenarios, including:

- **GHG-based scenarios**: There was interest in examining GHG-based scenarios, primarily in scenarios built on the carbon prices that would achieve 50 percent reduction in GHG emissions by 2035 and net zero emission by 2050.
- **Social cost of carbon-based scenario:** There was interest in using the social cost of carbon as a basis for a scenario.
- **Legislation-based scenario:** There were several comments requesting that the Economic and Climate Resilience Act of 2019 (previously Energize RI Act) be used as the basis for a scenario.

Several stakeholders also indicated views that the study would **benefit from engagement with Environmental Justice communities** or associated advocacy groups to understand the concerns and priorities of those groups.

<u>**Project Team Responded**</u>

GHG-based scenarios

Rhode Island is pursuing a number of strategies to reduce emissions, each contributing independently and in tandem with others to the state's GHG reduction goals. This analysis aims to evaluate the potential contribution of a carbon price to support a portfolio of carbon reduction strategies. The fee alone would not drive all carbon reductions needed to meet the state's goals; rather, it would complement other policies in achieving the target. That said, the Project Team agrees that a close understanding of the GHG impacts of each scenario should be detailed in the report. To deliver the state a study that best aligns with its broad set of policies while also considering this feedback, the Project Team will include the extent to which the carbon price scenarios are expected to contribute to Rhode Island's carbon reduction goals in the final report.

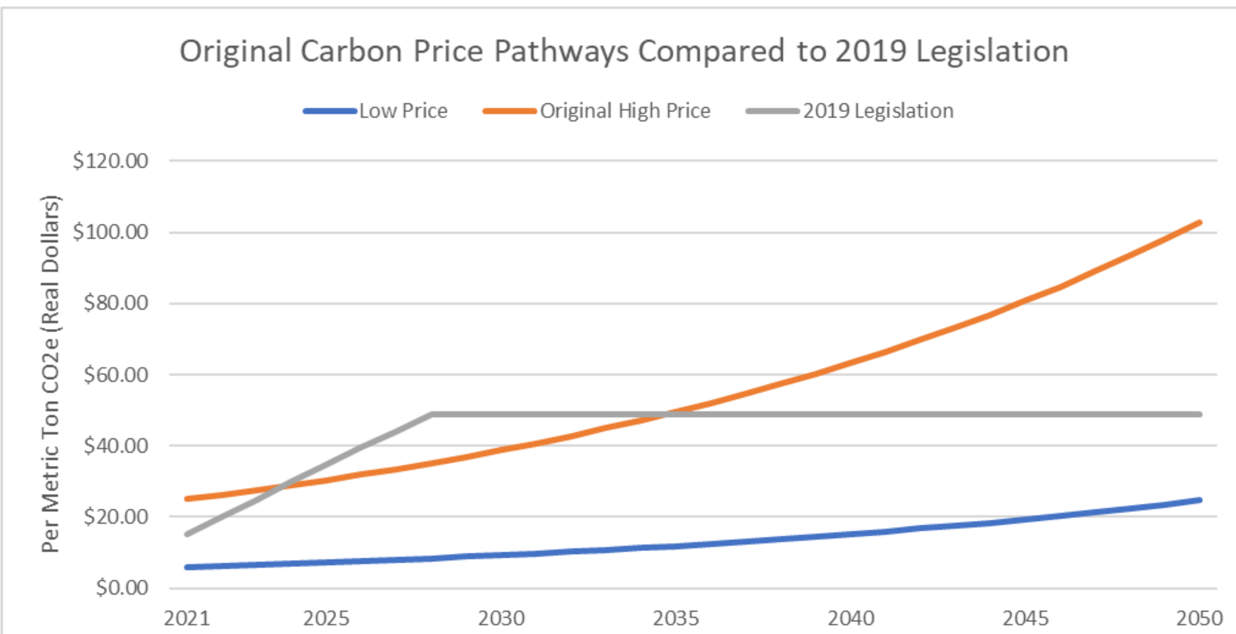
Social cost of carbon-based scenario

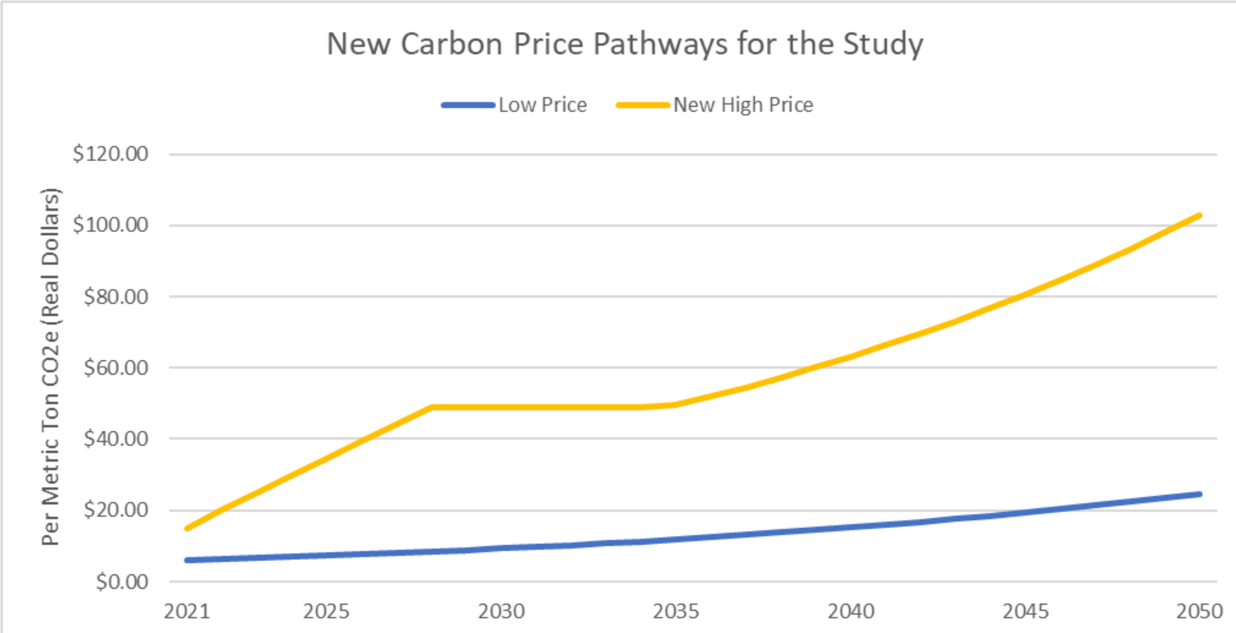
As noted above, Rhode Island is pursuing a portfolio of decarbonization strategies through which the social cost of carbon can be addressed. In addition to a carbon tax, such strategies could include a clean energy standard, or incentive programs among other options. Our goal is to evaluate the ability of a carbon tax to complement these strategies. Estimates on the social cost of carbon vary widely and can change drastically over time and global decarbonization scenarios. While the estimation of a social cost of carbon is important for broad policy setting it is contingent on a number of assumptions that are outside the scope of the study. Our high-price scenario - as redesigned below - aims to reflect both pending legislation and long-term expectations about reflecting a higher-social cost of carbon that overlaps with existing initiatives on the topic (for example, the Interagency Working Group on the Social Cost of Carbon).

Legislation-based scenarios

The Economic and Climate Resilience Act of 2019 reflects the following price pathway: $15 starting price, increasing by $5 per year, then leveling off at $50 at which point it increases annually with inflation. The proposed legislation creates a regime in which prices rapidly escalate but are capped off in 7 years.

To be responsive to this feedback, the Project Team will examine a new high price pathway instead of the originally proposed high price pathway. The new high price pathway will utilize the legislation-based pathway over the next 15 years (grey line in first figure below). After 2028, the proposed legislation levels off. From 2035 onward, the Project Team will begin a rate of escalation equal to the originally proposed pathway of 5 percent a year above inflation though 2050 to be consistent with the post-2035 behavior of the high carbon price below (orange line of first figure). This higher price in latter years will generate more distinctive and interpretable results in the modeling performed in the study. The second figure below shows the pathways that will be examined in the study.





Engagement with Environmental Justice Communities

The Project Team recognizes the importance of engaging frontline communities to understand their views on climate change, carbon pricing, and priorities for investment of revenue. The Project Team is in the process of developing plans for stakeholder engagement that will include a focus on frontline communities. Stakeholders can expect further communication regarding opportunities for engagement by mid-late July. Findings from the stakeholder engagement will be incorporated into the analysis and final report.

September 2020 Stakeholder Update Webinar: Response to Stakeholders

Overview

Thank you for attending the September 18th webinar on the Rhode Island Carbon Pricing study and for sharing your thoughts during the written comment period. For those who may not have been able to attend, the presentation slides are available at the Rhode Island Office of Energy Resources website here.

The comments received will help inform the final outputs of this study. Below is a summary of key themes from stakeholder feedback, followed by responses from the Project Team. While the Team has reviewed all comments closely, please note that the below list is not comprehensive of every comment received.

Stakeholder Feedback and Responses

1. Several stakeholders noted that the report will need framing and additional context as to why carbon pricing has been proposed and what problems it will address. Specifically some stakeholders requested the inclusion of background information on climate change, as well as price distortions and externalities associated with fossil fuels.
    - **Project Team Response:** The Project Team plans to integrate information about the context of climate change and the broader decarbonization efforts underway in the report, as well as

discuss carbon dioxide emissions as an externality and the role of a carbon price in reflecting this cost in the market.

2. Stakeholders were generally pleased with outreach efforts done to date, especially efforts to include voices from frontline communities. However, multiple stakeholders requested additional outreach to ensure all voices are heard.
    - **Project Team Response:** The Project Team has made efforts to maximize the amount of engagement that could be done within the scope of the project. The Project Team plans to allow for an additional round of stakeholder feedback, following the webinar on Friday, October 30th, and will be sure to provide a robust report out of all stakeholder engagement within the report. Additionally, the report will highlight the importance of further engagement with stakeholders when designing a carbon price in Rhode Island, ideally early in the process and frequently throughout program development.

3. Some stakeholders pushed back on the Project Team's framing and evaluation of political feasibility in relation to a carbon price due to concerns it may constrain eventual policy design.
    - **Project Team Response:** After discussion with the Rhode Island Team, the Project Team has refocused on "social acceptability" instead of "political feasibility" to better reflect the intent of the analysis. Additionally, the Project Team will be explicit in the report on the limitations of this analysis as it reflects findings from the interactions with stakeholders within the project and limited desk research, but does not necessarily capture the overall sentiment in Rhode Island.

4. Several stakeholders expressed interest in more ambitious carbon price scenarios. Some stakeholders suggested using the EnergizeRI price as the low scenario and the AOCFA as the high scenario, while other stakeholders suggested designing the scenarios around the need to achieve net zero by 2050.
    - **Project Team Response:** Regarding the first suggestion of using EnergizeRI as the low scenario and the AOCFA as the high scenario, this was discussed with the Rhode Island Team at the outset of the project. Ultimately the Rhode Island Team decided to focus in-depth on the two scenarios included within the report, and also conduct an initial demand analysis on the AOCFA that will be included in the report. The initial demand analysis shows the GHG impacts of the AOCFA price, but does not examine pairing it with revenue use or the economic and health outcomes. The AOCFA was not studied further as it was designed as a national-level policy. Examining Rhode Island legislation (Economic and Climate Resilient Act of 2019 – previously Energize RI Act) and the general price trajectory of RGGI and TCI were deemed as more appropriate for this study.
    - Regarding the latter suggestion of designing the scenario around achieving net zero by 2050, the report will outline the several initiatives Rhode Island is pursuing to reduce emissions, each contributing independently and in tandem with others to achieve that state's GHG reduction goals. This analysis aims to evaluate the potential contribution of a reasonable carbon price to support a portfolio of carbon reduction strategies, rather than design a price to independently achieve the state's goals. Rhode Island is continuing to examine their carbon goals; the study will reflect both pending legislation and long-term expectations about decarbonization efforts.

5. Several stakeholders noted that the reinvestment scenarios presented are limited and provided suggestions for alternative reinvestment scenarios or processes for applying the study's findings to other potential reinvestment scenarios.
    - **Project Team Response:** The Project Team recognizes there are many ways the revenue of a carbon price could be used. To develop an appropriate study, we have selected specific

spending characterizations for analysis and modeling purposes. The report will acknowledge that these are an illustrative subset of options for how the revenue could be spent and will outline, at a high-level, that there are several criteria the state could consider in determining how to best invest the revenue.

The Project Team is appreciative of the stakeholder feedback and looks forward to sharing the final round of updates on Friday, Oct. 30th.

October 2020 Stakeholder Update Webinar: Response to Stakeholders

Overview

Thank you for attending the October 30th webinar on the Rhode Island Carbon Pricing study and for sharing your thoughts during the written comment period. For those who may not have been able to attend, the presentation slides are available at the Rhode Island Office of Energy Resources website here.

The comments received will help inform the final outputs of this study. Below is a summary of key themes from stakeholder feedback, followed by responses from the Project Team. While the Team has reviewed all comments closely, please note that the below list is not comprehensive of every comment received.

Stakeholder Feedback and Responses

1. Several stakeholders highlighted the importance of stakeholder engagement throughout this process. To strengthen stakeholder engagement efforts, one stakeholder suggested that the Office of Energy Resources (OER) maintain a robust, user-friendly public website to help educate and inform residents and potentially creating a space for virtual public comment and feedback.
    - **Project Team Response:** To-date, OER does maintain a public project site for the Rhode Island Carbon Pricing Study that houses all the key documents that have come out of this study, including slides and the Project Team's response to stakeholder feedback for each of the webinar updates that have occurred throughout the project process. This stakeholder feedback is appreciated and will be taken under consideration.

2. Some stakeholders expressed concern about the price levels examined in this report, and emphasized the importance of an appropriately aggressive price. These stakeholders noted the need to reduce emissions to net zero by 2050, and that the prices in the report are too low.
    - **Project Team Response:** As shared in prior responses, this analysis aims to evaluate the potential contribution of a reasonable carbon price to support a portfolio of carbon reduction strategies, rather than design a price that would independently achieve the state's goals. However, it should be noted that it is not intended to set or constrain eventual policy design.

3. Stakeholders noted that it was helpful to see the illustrative households demonstrating how a carbon price would impact certain residential households, and noted it would be helpful to see how a carbon price may impact Rhode Island businesses.
    - **Project Team Response:** If the state of Rhode Island moves forward with developing a carbon price, it will certainly continue to consider the potential impacts across the state, including on businesses. However, the inclusion of illustrative businesses within this study does not appear to be the most effective path for analysis. Given the diversity of businesses in the state, selecting profiles and assumptions of a set of businesses would involve a more complex

process than the illustrative households analysis, and would also not necessarily result in example businesses that are reflective of a broad set of state businesses.

4. One stakeholder noted that the program design of incentives and investments that benefit low-income and frontline communities should be paramount in carbon pricing and that these communities should be involved in the program design process. As such, this stakeholder suggests including the creation of a state environmental justice advisory committee to inform this process as a recommendation in the final report.
    - **Project Team Response:** As stated in the presentation, ensuring equity is centered in both process and policy design is a key finding of the study. This report is not a stand-in for future policy and programmatic design, which could provide a forum for such considerations to be more fully vetted. More broadly, it is anticipated that the state's EC4 will be discussing energy and environmental justice considerations at upcoming public meetings.

The Project Team is appreciative of all stakeholder feedback received and will be sharing the final report with the public in early 2021.