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# The Analysis of Buildings / Thermal Energy Sector Emissions Reduction Policies for Vermont

Prepared by:

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**Energy Futures Group, Inc**

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| Acronym | Definition |
|---|---|
| ACCII | Advanced Clean Cars II |
| ACT | Advanced Clean Trucks |
| AEO | Annual Energy Outlook |
| ANR | Agency of Natural Resources |
| APB | Advanced Pellet Boilers |
| ASHP | Air-Source Heat Pump |
| ATW | Air-to-Water |
| BED | Burlington Electric Department |
| BioCHPDH | Biomass Combined Heat/Power District Heat |
| BioD | Biodiesel |
| C/I | Commercial/Industrial |
| CAP | Climate Action Plan |
| CBES | Commercial Building Energy Standards |
| CEDF | Clean Energy Development Fund |
| CEP | Comprehensive Energy Plan |
| CHP | Combined Heat Power |
| CHS | Clean Heat Standard |
| CI2030 | Climate Initiative 2030 Scenario |
| CI2035 | Climate Initiative 2035 Scenario |
| CO2 | Carbon dioxide |
| CO2e | Carbon dioxide equivalent |
| Com Red | Commercial Reduction |
| CSM Subcommittee | Cross-Sector Mitigation Subcommittee |
| DRP | Demand Resource Plan |
| Ecook | Electric Cooking |
| EEUs | Energy Efficiency Utilities |
| EFG | Energy Futures Group |
| EV | Electric vehicle |
| EVT | Efficiency Vermont |
| GHG | Greenhouse gas |
| GSHP | Ground-Source Heat Pump |
| GWhs | Gigawatt hours |
| GWP | Global warming potential |
| GWSA | Global Warming Solutions Act |
| HE | High Efficiency |
| HFC | Hydrofluorocarbon |
| HHs | Households |
| HPWH | Heat Pump Water Heater |
| HR | Human Resources |
| ICEV | Internal combustion engine vehicles |
| IIJA | Infrastructure Investment and Jobs Act |
| Ind Red | Industrial Reduction |
| IRA | Inflation Reduction Act |
| IRS | Internal Revenue Service |

| | |
|---|---|
| ISO-NE | Independent System Operator of New England |
| IT | Information Technology |
| LEAP | Low Emissions Analysis Platform |
| LI | Low-Income |
| LMI | Low-and-Moderate Income |
| LULUCF | Land use, land use change, and forestry |
| MF | Multi-Family |
| MMBTu | One million British thermal units |
| MMTCO2e | Million metric tons of carbon dioxide equivalent |
| ODS | Ozone depleting substance |
| OEO | Office of Economic Opportunity |
| PHEVs | Plug-in Hybrid Electric Vehicles |
| PSD | Vermont Department of Public Service |
| PSt | Pellet Stoves |
| PUC | Public Utility Commission |
| RBES | Residential Building Energy Standards |
| RCI | Residential Commercial Industrial Sector |
| RES | Renewable Energy Standard |
| RegBund | Regulatory Bundle Scenario |
| RNG | Renewable Natural Gas |
| RPS | Renewable Portfolio Standard |
| SEI | Stockholm Environment Institute |
| SF | Single-Family |
| TCI | Transportation Climate Initiative |
| MTCO2e | Thousand metric tons of carbon dioxide equivalent |
| TWhs | Terawatt hours |
| Ty | Typical |
| UE | Unit of Energy |
| VCC | Vermont Climate Council |
| VHFA | Vermont Housing Finance Agency |
| VMT | Vehicle miles traveled |
| VT | Vermont |
| WRAP | Weatherization Repayment Assistance Program |
| WS | Wood Stoves |
| Wx | Weatherization |

## About the Authors

Energy Futures Group (EFG) is a clean energy consulting firm based in Hinesburg, Vermont and a satellite office in New York. EFG specializes in the design, implementation, and evaluation of programs and policies to promote investments in energy efficiency, renewable energy, other distributed resources, and strategic electrification. EFG staff have worked on these issues on behalf of energy regulators, other government agencies, utilities and advocacy organizations across the United States, Canada, Europe, and China.

Stockholm Environment Institute (SEI) has offices in five continents and works locally, regionally, and globally as a trusted independent non-partisan institute conducting research to support a sustainable future for all. SEI has developed the Low Emissions Analysis Platform (LEAP) model to assist jurisdictions with integrated energy and environmental planning. The LEAP model has been used to support Vermont's Comprehensive Energy Plan and the Pathways Report conducted for the Vermont Climate Council.

The Cadmus Group is an environmental consultancy with over 550 consultants and teams skilled in climate program development, including greenhouse gas inventories, economic analysis, and policy design. They have supported states across the country, including Massachusetts, Pennsylvania, Vermont, Wisconsin, Oregon, Hawaii, New York, New Jersey, and Rhode Island, to develop climate action programs that meet their unique needs.

## Acknowledgements

This study was conducted under contract and guidance from a project management team with representatives from the State of Vermont Agency of Natural Resources, and Department of Public Service. In addition to the feedback and support from the project management team, a thermal sector task group from the Vermont Climate Council's Cross-Sector Mitigation Subcommittee provided valuable review and comment on the analysis. The EFG team greatly appreciates these contributions. Any omissions or errors in the report are the responsibility of the EFG team.

# I. Executive Summary

Vermont has a legislated mandate, the Global Warming Solutions Act (GWSA), passed in 2020, to reduce greenhouse gas emissions.[1] The GWSA codifies legally binding emissions reduction requirements, including emissions reductions of 26% below 2005 levels by 2025; 40% below 1990 levels by 2030; and 80% below 1990 levels by 2050. This study, conducted under the management of the Agency of Natural Resources and Department of Public Service, compares building sector policy options designed to meet the emissions reduction requirements for energy use in the residential, commercial, and industrial (RCI) building sectors. The study builds on economy-wide modeling of Vermont decarbonization pathways economy-wide that our team completed for the state in 2022.

This study team, led by Energy Futures Group Inc, with support and assistance from Stockholm Environment Institute, and the Cadmus Group, updated the business-as-usual (BAU or baseline) scenario developed for the 2022 decarbonization pathways analysis and designed and conducted additional scenario modeling and complementary analyses to examine three additional greenhouse gas (GHG) emission reduction scenarios and several policy options within those scenarios:

- **Scenario 1: Business-as-Usual**. This is a forecast of energy system costs and emissions absent any new state climate policies.
- **Scenario 2: Meet Economy-Wide GHG Requirements by 2030**. Under this scenario, emission reductions from the residential, commercial, and industrial (RCI) sectors are greater than their proportional share to compensate for shortfalls in other sectors. Three different sets of policies are analyzed under this scenario:
    - 2: Expanding existing programs,
    - 2b: Clean heat standard, and
    - 2c: GHG emissions cap and investment
- **Scenario 3: Meet Economy-Wide GHG Requirements by 2035**. Under this scenario, the emission reductions from the RCI sectors meet their proportional share of reductions necessary to meet the state's 2030 goals, but because of shortfalls in other sectors the state's 2030 goals are not met until 2035. As with Scenario 2, three different sets of policies are analyzed under this scenario:

[1] General Assembly of the State of Vermont. "Vermont Global Warming Solutions Act of 2020." VT LEG #350685 v.1. https://legislature.vermont.gov/Documents/2020/Docs/ACTS/ACT153/ACT153%20As%20Enacted.pdf.

    - 3: Expanding existing programs,
    - 3b: Clean heat standard, and
    - 3c: GHG emissions cap and investment
- **Scenario 4: Regulatory Bundle to Meet Economy-Wide Requirements by 2030**. As with Scenario 2, the state's 2030 emission reduction goals are met with the RCI sectors collectively achieving more than their proportional share of reductions to compensate for other sectors achieving less than their proportional shares. However, the mix of emission reduction measures is different from Scenario 2, with more reliance on reductions from commercial and industrial customers (and less from residential) because they are assumed to be easier to directly regulate.

This study presents analysis of the costs and benefits of emissions reductions from the RCI sector, under each of the seven different scenario and policy combinations, from several different perspectives. This includes (1) the societal benefits and costs;[2] (2) an assessment of the program and state administration costs;[3] (3) an analysis of customer economics for adoption of key decarbonization measures; and (4) an analysis of the impacts on fuel and rates for fossil fuels and electricity associated with program costs and changing volumes of fuel consumption. This work is intended to inform future policy making, regulatory activities, and program design, funding, financing, and implementation activities.

## Key Findings

The key findings and conclusions in this report include:

- **<u>Reaching Requirements Made Easier by Recent Federal and State Funding:</u>** The revised BAU scenario that includes the effects of recent state and federal funding and initiatives

[2] The societal perspective includes all changes in costs, including changes in energy consumption and fuel costs, changes in capital costs, and changes in environmental externality and public health costs (i.e., the social cost of carbon). This study uses the same social cost of carbon (staring value of $122/ton) used in the previous Pathways study. Conceptually, the societal perspective should include other benefits or costs to customers (e.g., changes in comfort, changes in operations and maintenance costs, etc.). However, they have not been valued here. Under the societal perspective, the full cost of decarbonization measures is included, regardless of how much of the cost is born by regulated fossil fuel suppliers (e.g., through program rebates), participating customers or government; program rebates and tax credits are all viewed as transfer payments rather than as cost reductions.

[3] Program costs are costs that regulated fossil fuel companies would have to incur to persuade customers to make investments in clean heat measures as heat pumps, advanced wood heating systems and weatherization of buildings. They include rebates or other financial incentives, marketing costs and program administration costs.

(e.g., IIJA and IRA[4]) reduces estimated BAU emissions for the RCI sector by 423 MMT (16%) in 2025 and by 639 MMT (26%) in 2030 relative to the previous BAU scenario from the 2022 Pathways Report. As Figure 1 shows, this significantly reduces the emissions reductions required in the RCI sector to meet the 2025 and 2030 GWSA sector proportional reductions. However, as discussed further below, substantial, policy-driven emission reductions will still be required to meet the state's goals.

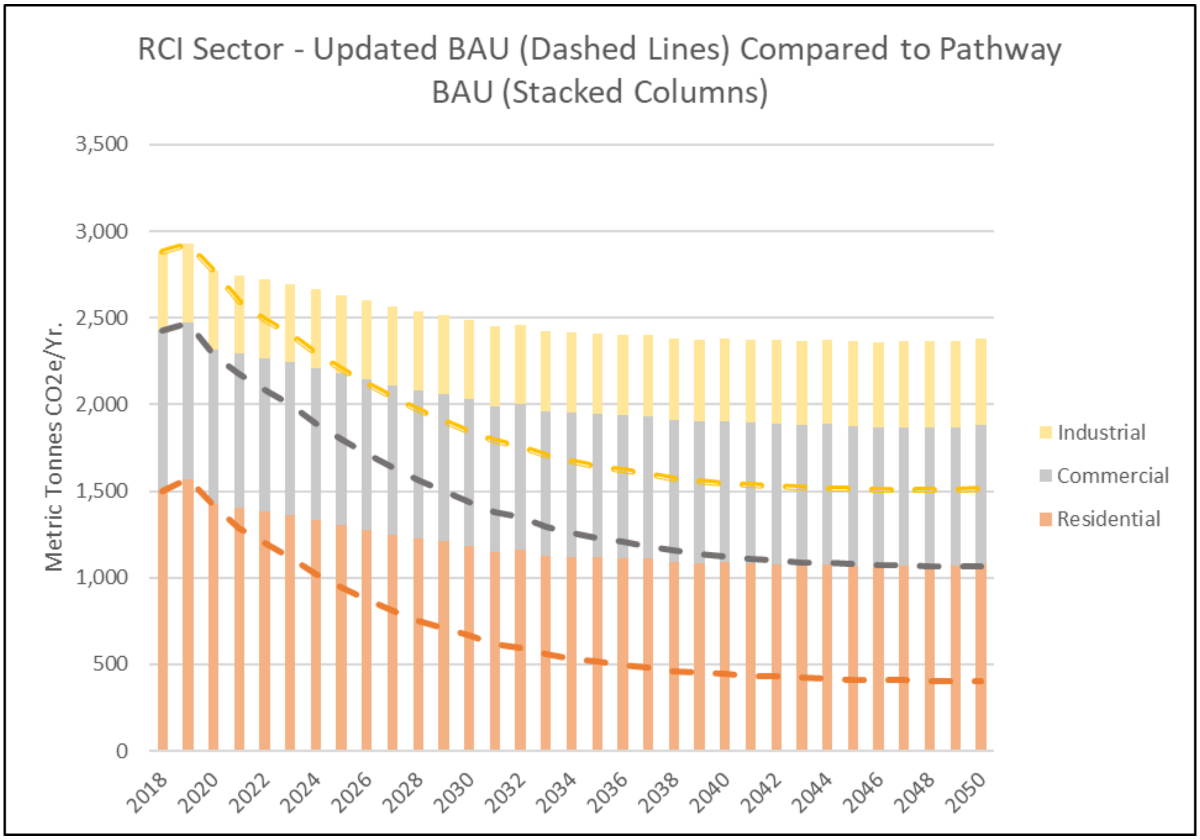


***Figure 1: Updated Business-as-Usual Anticipates Lower Emissions as New Federal and State Initiatives Contribute to Reductions***

- **<u>The Estimated Net Societal Costs of Meeting GWSA Requirements are a small fraction (0.9% to 2.36%) of Energy Spending Over the Study Horizon.</u>** In comparison to the revised

[4] Inflation Reduction Act of 2022, https://www.govinfo.gov/content/pkg/PLAW-117publ169/pdf/PLAW-117publ169.pdf. Infrastructure Investment and Jobs Act, https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf.

BAU (scenario 1), the three policy scenarios that we analyzed are estimated to increase societal costs for Vermont's entire energy economy – including transportation, electricity, residential and commercial customers, and industry – by $0.57 billion to $1.48 billion over the 30-year study horizon (Figure 2). That is equivalent to an annual levelized cost of $25 to $66 million. For context, Vermont's total energy expenditures in 2021 were $2.814 billion.

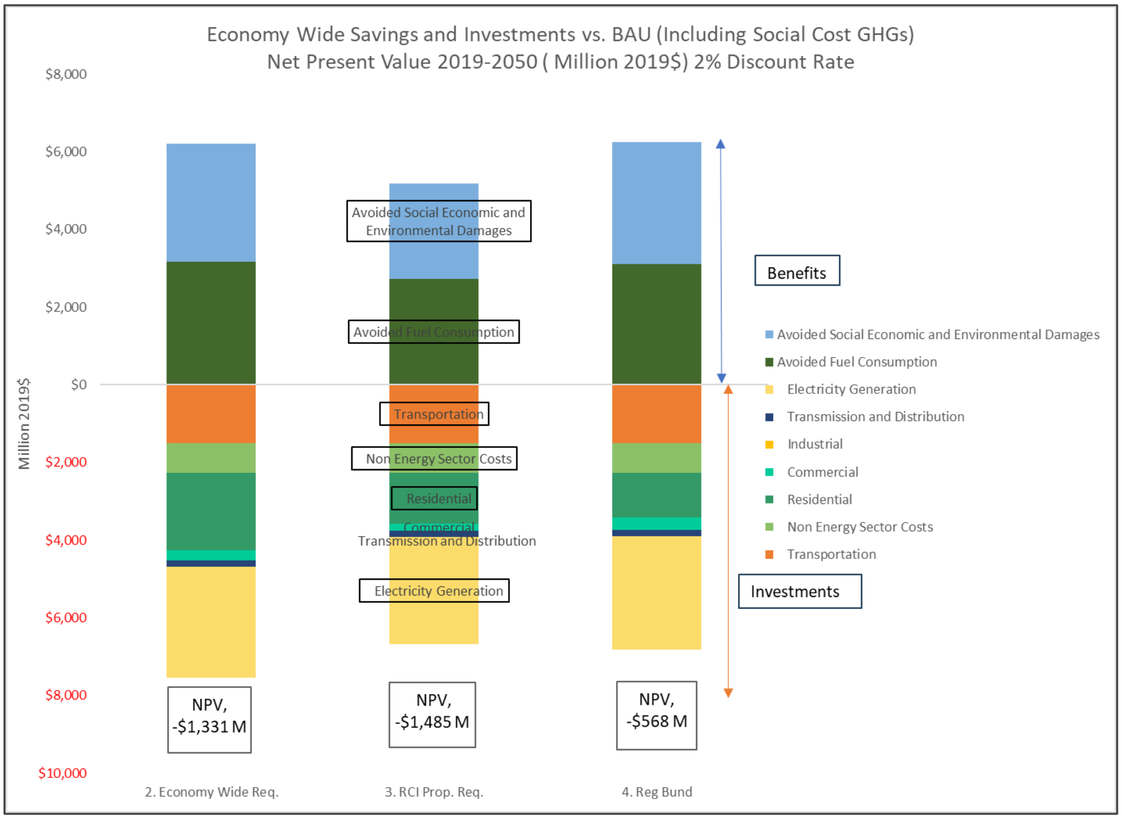


***Figure 2: Societal Benefit Cost Summary of Scenarios[5]***

The societal cost benefit results show the regulatory bundle as having the lowest net cost, of $0.57 billion over the study horizon. This regulatory bundle scenario relies more on compliance enforcement and less on incentives to catalyze transitions. Thus, it has higher state administrative costs, but much lower program and incentive costs. The practicality and acceptability of relying on the more compliance and enforcement-based approach of the regulatory bundle in comparison to market and incentive driven approaches – including

[5] The LEAP societal benefit cost results have been adjusted to account for end effects. See discussion in Section IV (B) for discussion.

impacts on the state budget – are important qualitative factors for policy makers to consider.

- **Additional Program Initiatives Beyond BAU are Necessary to Meet GWSA Requirements.** The analysis examined the three policy options to achieve the required reductions: a) expansion of existing programs and initiatives, b) a clean heat standard, and c) a cap and invest program for thermal fuels. The program and administrative costs associated with the policy and scenario combinations are illustrated in Figure 3.

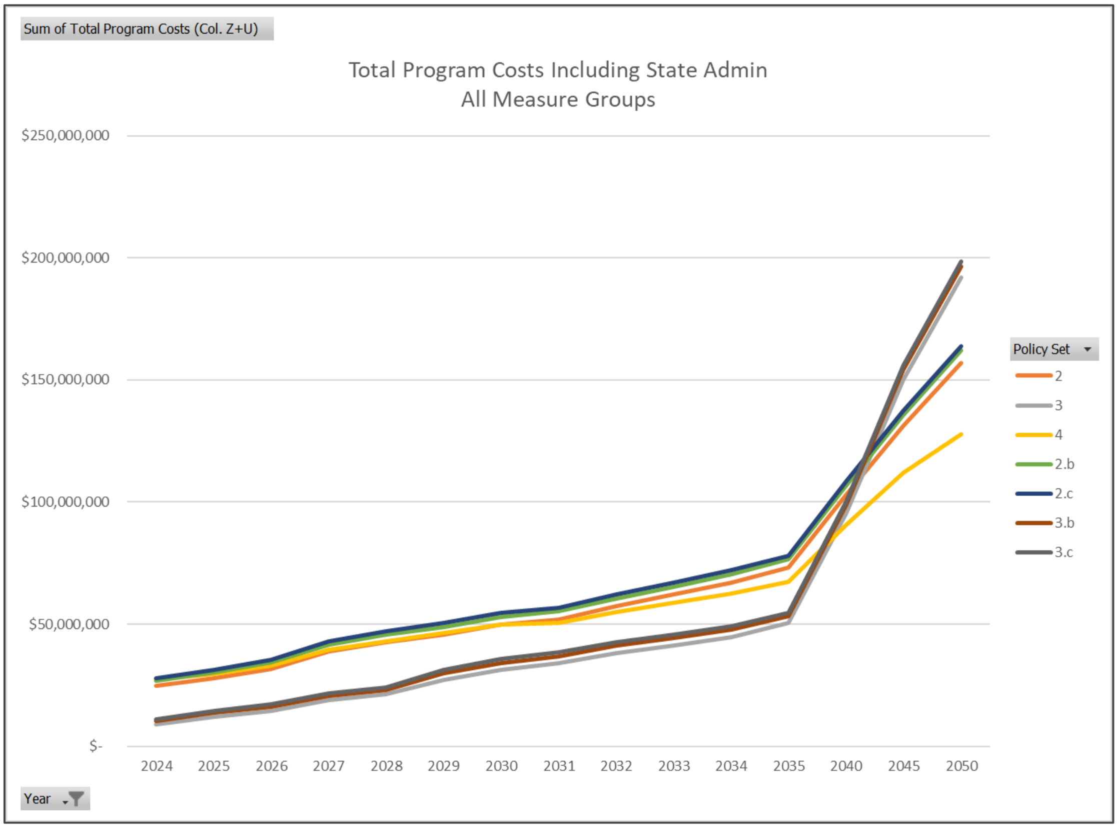


*Figure 3: Program and Administrative Cost Estimates*[6]

Program and administrative costs ranged from $11 million to $28 million above the BAU for 2024, from $31 to $53 million above BAU in 2030, and $130 to $200 million above BAU by 2050.

[6] For analysis and discussion of amortized and unamortized program costs see Section IV D)of this report. Figure 16 includes amortization of costs for measures with greater than one year lifetime.

The expansion of existing programs and initiatives (represented by policy set 2 and 3 in Figure 3 above) are estimated to have slightly lower program and administrative costs than the development and implementation of a clean heat standard (CHS) and the cap and invest (Cap&Inv) initiatives (2b and 3b and 2c and 3c). This is because there are fewer requirements for the development of new programmatic and administrative structures and functions. The CHS and Cap&Inv initiatives, as market-based initiatives may result in obtaining emissions reductions in a lower cost manner than the programmatic initiatives though this remains uncertain. However, the variation between the estimated program and administrative costs between these initiatives (e.g., $3.4 million in 2030 between expanding existing programs and CHS) is very small in comparison to the overall investments and benefits associated with meeting the state's GHG emission reduction goals.

- **For Many Consumers Adopting Measures to Reduce Emissions will Save Money** – Our analysis of residential customer economics indicates most customers would realize annual energy bill savings and even total energy costs (including the cost of financing new equipment, net of program and tax incentives) if they transition from fuel oil and propane to electric heat pumps for space and water heating, or to advanced wood technologies for space heating.

  Our analyses incorporate the assumption that low-income households would need financial incentives equal to 100% of the costs for the new technologies or for weatherization and moderate-income households receive an incentive equal to 75% of costs. These incentives for low- to moderate- income households account for approximately 60% of all (residential, commercial, and industrial) program costs. However, based on decades of experience with efficiency programs in Vermont and other states, we have assumed that such high incentives are necessary to ensure low-and moderate- income households participate at levels at least proportional to their share of the population and realize at least a proportional share of total energy savings as they transition off fuel oil and propane. The customer economics of transitioning from natural gas are less favorable, so additional incentives and programmatic support may be necessary to foster transitions from gas. The less favorable customer economics for gas transitions improve as gas costs increase over the study period.

  Figure 4 displays an example of the change in annual costs to switch to a central air source heat pump (ASHP) replacing a furnace, two head ASHP replacing a boiler as a retrofit, and heat pump water heater replacing a fossil fuel water heater for a moderate-income single-family household in 2025.

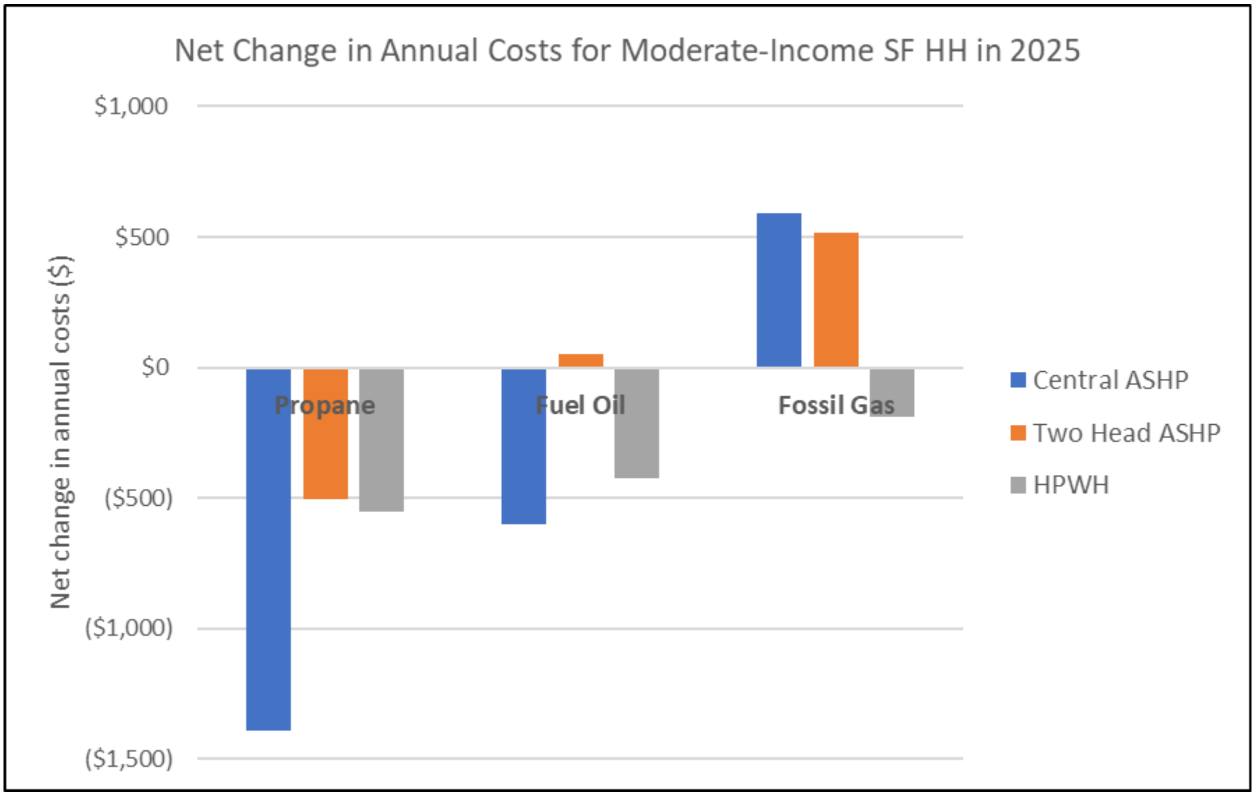


***Figure 4: Net Change in Annual Costs for Moderate-Income Single-Family Household in 2025 in the Clean Heat Standard in the RCI Proportional Requirement Scenario(3b).***

The results in Figure 4 reflect a 75% measure incentive for moderate-income households, annualized cost for the remaining measure upgrade cost, and reduced fuel consumption due to higher efficiency of units and change in fuel type. The household budget savings and emissions reductions could be further increased through weatherization. Additional customer economic results for our study are presented in Section IV. C).

- <u>**Fuel Costs Increase to Recover Program Costs**</u> – All of the scenarios and policy set combinations anticipate surcharges that increase fossil fuel prices to consumers. The increased prices will be used to fund the program and market activities such as weatherization or conversion to electric heat pumps that reduce emissions. Figure 3 above illustrates the anticipated increased funding needs by policy and scenario. Recovering the additional program costs through volumetric charges on fossil fuels will increase fuel prices and encourage reduced fossil fuel consumption and emissions. Figure 5 is an example of the estimated increase for residential heating oil in 2025, 2030 and 2035 under the study's scenario and policy set combinations.  Relative to the baseline forecast of fuel oil prices, which are considerably lower than the average of $4.73 per gallon experienced over the winter of 2022-2023, the percentage increases vary ranging from 0.3% to 2.2% in 2025, from 3.6% to 9.0% in 2030 and between 10% and 19% in 2035.

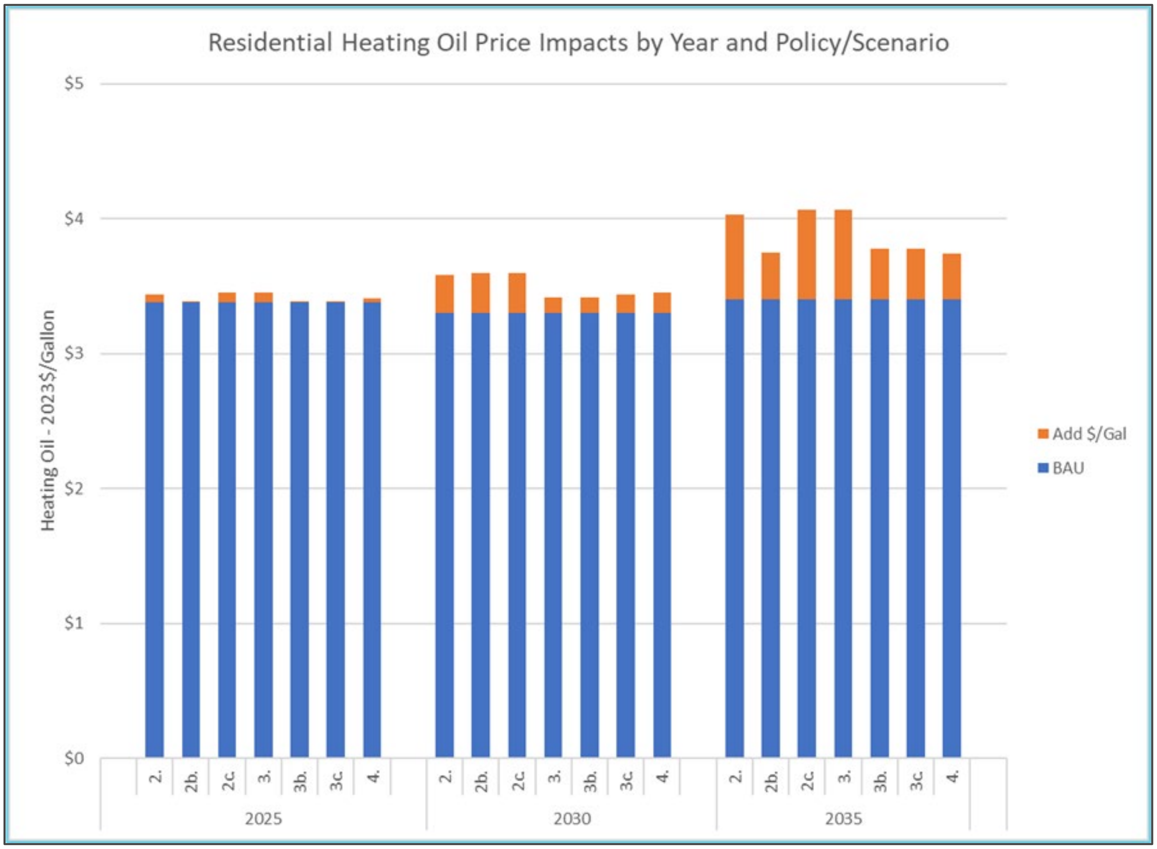


***Figure 5: Residential Heating Oil Prices Increase to Support Program Activities***

The fossil fuel price increases resulting from Vermont climate policies will primarily affect those customers who have not installed clean heat measures – what are sometimes called "non-participants".  For example, the cost of heating the average single-family home that is still completely reliant on fuel oil for space heating will be approximately $179 higher in 2030 under the 2.b. Economy-wide, CHS scenario than it would be if no decarbonization policies were adopted for the thermal sector.  Section IV. E) provides greater detail on the fuel and rate impacts analysis and results.

## Summary Table of Key Findings

Table 1 provides a summary comparison of key metrics from the analyses above.

| | Societal Perspective | State and Program Costs | Customer Perspective | |
|---|---|---|---|---|
| **Scenario/Policy Set** | **Societal Net Present Value (2019-2050) 2% Discount Additional Net Costs - Million 2019 $** | **2024 - 2030 Cumulative Program and Administrative Costs – Million 2019 $** | **2025 Residential Fuel Oil Price Impact** | **2030 Residential Fuel Oil Price Impact** |
| **Meets Economy Wide – 2030 Requirements** | $1,331 | | | |
| 2. Expand Existing Programs | | $762.1 | 1.8% | 8.5% |
| 2b. Clean Heat Standard | | $822.0 | 0.3% | 9.0% |
| 2c. Cap and Invest | | $830.4 | 2.1% | 9.0% |
| **Meets RCI Sector Proportional 2030 Requirements** | $1,485 | | | |
| 3. Expand Existing Programs | | $331.3 | 2.2% | 3.6% |
| 3b. Clean Heat Standard | | $377.9 | 0.3% | 3.6% |
| 3c. Cap and Invest | | $384.4 | 0.3% | 4.1% |
| **Regulatory Bundle Meets Economy Wide 2030 Requirements** | $568 | | | |
| 4. Compliance and Enforcement Mechanisms | | $570.5 | 0.9% | 4.3% |

*Table 1: Summary Cost Comparisons*

## Discussion

This report's findings confirm the understanding that attaining Vermont's GWSA requirements in the RCI sector depends fundamentally on four complementary activities, a) reduced demand through more efficient buildings, equipment and management, b) a supply of decarbonized electricity matched to loads, c) electrification of building and transportation end uses, and d) an increase in the use of biofuels as substitutes for fossil fuels.

While the updated BAU scenario narrows the gap between emissions reductions projected under current conditions and those required by the GWSA, without additional program and policy support compliance with GWSA emission reduction requirements is unlikely.

Our study also addresses qualitatively key issues and questions related to equity and just transitions, the impact of timing of emission reductions on costs and benefits, and on complementary supporting policies. The research and the analyses conducted for this study suggest these issues tend to cut across the policy options and deserve careful consideration regardless of the policy path selected.

# II. Introduction

## A) Background

In 2020, the Vermont Legislature passed the Global Warming Solutions Act (GWSA).[7] The GWSA codifies legally binding emissions reduction requirements, including emissions reductions of 26% below 2005 levels by 2025; 40% below 1990 levels by 2030; and 80% below 1990 levels by 2050.

The GWSA also established the Vermont Climate Council, which was charged with developing the first Vermont Climate Action Plan (CAP). The Vermont CAP was adopted on December 1, 2021, and provides guidance for meeting the emissions requirements of the GWSA. The Vermont CAP "aims to dramatically reduce greenhouse gas emissions, help protect Vermont communities and landscapes from the greatest risks of climate change and create a new clean energy industry and jobs".[8]

The Vermont CAP includes a recommendation for the adoption of a Clean Heat Standard as a state-level policy measure to ensure emissions reductions from the buildings sector. A Clean Heat Standard is a "performance standard, applied to the providers of fossil heating fuels in Vermont, requiring them to deliver a gradually-increasing percentage of low-emission heating services to Vermont customers".[9] The 2022 Vermont Comprehensive Energy Plan calls for *consideration* of a Clean Heat Standard, studying "the potential cost and equity implications under different design parameters and expected measures, including the expected resources necessary to administer such a program," in order to better understand its impacts prior to implementation.[10] This study provides information to better understand the economic implications of the Clean Heat Standard relative to other policy options. In 2023, the Clean Heat Standard was re-introduced to the Vermont Legislature as the Affordable Heat Act, and

[7] General Assembly of the State of Vermont. "Vermont Global Warming Solutions Act of 2020." VT LEG #350685 v.1. https://legislature.vermont.gov/Documents/2020/Docs/ACTS/ACT153/ACT153%20As%20Enacted.pdf

[8] https://climatechange.vermont.gov/about

[9] The Clean Heat Standard EAN White Paper https://www.eanvt.org/chs-whitepaper/

[10] 2022 Vermont Comprehensive Energy Plan, page 188. https://publicservice.vermont.gov/sites/dps/files/documents/2022VermontComprehensiveEnergyPlan_0.pdf

ultimately became law.[11] The Public Utility Commission (PUC) has now opened proceedings to begin the process of designing the rules and regulations for a Clean Heat Standard.

An initial analysis completed during development of the CAP, the Vermont Pathways Report,[12] included an overall assessment of the costs and benefits for meeting the GWSA requirements. It did not, however, estimate the program and administrative costs, fuel impacts, or customer economics in detail, which are the subjects of this report and the supporting analyses completed for this report.

The State of Vermont Agency of Natural Resources (ANR), in close collaboration with the Vermont Department of Public Service (PSD), contracted with Energy Futures Group to assess multiple policy options - including the Affordable Heat Act - to reduce emissions in the buildings/thermal energy sector in Vermont necessary to meet emission reduction requirements of the GWSA. The analysis included assessing the relative economic impacts of achieving the GWSA greenhouse gas reduction requirements to society and Vermont compared to an updated business-as-usual reference case.

In addition to the buildings/thermal energy sector analysis, the State is working on an analysis of transportation policies to reach the emissions reductions requirements from the transportation sector in Vermont. The two assessments have been conducted concurrently and the policies and inputs incorporated in both analyses have been aligned. Together these efforts will help inform decision making on the development and implementation of policies that benefit Vermonters and reduce emissions to meet the GWSA requirements.

## B) Objectives

This analysis provides an assessment of multiple policy options available to Vermont to reduce emissions in the buildings/thermal energy sector necessary to meet the buildings sector's proportional share of the GHG emission reduction requirements of the GWSA. This assessment is intended to inform decision making at the State to guide future policy decisions.

[11] https://legislature.vermont.gov/bill/status/2024/S.5

[12] Vermont Pathways Analysis Report 2.0, February 11, 2022, prepared for the Vermont Agency of Natural Resources, https://climatechange.vermont.gov/sites/climatecouncilsandbox/files/2022-03/Pathways%20Analysis%20Report_Version%202.0.pdf.

The analysis includes an assessment of the relative costs, benefits, and impacts of emissions reduction policy options across multiple criteria and from several perspectives. The analysis considers the social, programmatic, and administrative costs of the policies relative to a business-as-usual reference case. The analysis also includes an assessment of the impact on Vermont households, with consideration of the impact on low- and moderate- income (LMI) households, as well as contributions and impacts from federal support.  To reflect impacts on non-participating households and businesses our research also includes estimates of the increase in fossil fuels prices required to fund the program initiatives that create the emission reductions.

For this analysis, low-income is defined as below 80% of the statewide median income.[13] Incentives for low-income households are 100% of measure costs. Moderate-income households are 80-120% state median income and receive an incentive of 75% of measure costs.

## C) Approach

The buildings/thermal analysis is comprised of several tasks that build upon each other. The project team began with a review of possible policies to analyze and conducted a qualitative assessment of the policies. Based on this qualitative assessment and in collaboration with the ANR and PSD team, the project team decided on policies to include in the quantitative analysis. The next task was to revise the BAU scenario developed during the analysis of the initial Vermont CAP. The project team then built upon the new BAU scenario to conduct the quantitative analysis. This task included several different components: modeling the policy sets in the Low Emissions Analysis Platform (LEAP) model and analyzing costs using complementary workbooks outside of LEAP. These include an evaluation of the program and administrative costs, customer economics, and rate and fuel price impacts.

### 1. Review Policy Options, Qualitative Assessment, and Policy Set Creation

The process began with a review of policy options available to reduce emissions in the buildings/thermal sector based on recommendations from ANR and PSD. This policy review included a brief description of the policy and how it is implemented; what would be regulated and who the obligated entities would be if the policy is implemented; the revenue generating

[13] Vermont Statewide Median Income is $67,477 based on U.S. Census Bureau American Community Survey. https://data.census.gov/table?q=Vermont+median+income&t=Income+and+Poverty&y=2020

potential (if any); what other jurisdictions have implemented the policy; what data is required to implement the policy; any features unique to the policy; and equity considerations.

The team then conducted a qualitative assessment of each of the policy options. The qualitative assessment reviewed 12 policies through the lens of five evaluation criteria including confidence the policy would attain GHG emissions reductions; cost per metric ton; state economic impacts; health impacts; and implementation feasibility. Equity was assessed narratively - including a consideration of the additional potential cost burdens that LMI households could experience under the policy and how to address hardships during the transition away from fossil fuels. Table 2 summarizes the qualitative analysis results.

| | Attain2030 Building Sector Reductions | Cost per Metric Ton | State Economic Impact | Health Effects | Implementation Feasibility |
|---|---|---|---|---|---|
| **Programs and Incentives** | | | | | |
| 1) Expand Existing Programs and policies | Better | Best | Best | Best | Best |
| 2) Feebates | Least Favorable | Better | Better | Better | Better |
| **Pricing, Cap, and Credit Approaches** | | | | | |
| 3) A. Carbon Pricing and Invest – **Building Sector** | Least Favorable | Least Favorable[3] | Better | Better | Best |
| B. Carbon Pricing and Invest – **All Fuels** | Least Favorable | Better | Least Favorable | Better | Best |
| 4) A. Cap and invest – **Building Sector** | Best | Better | Best | Best | Better |
| B. Cap and invest -**All Fuels** | Better | Best | Best | Best | Better |
| 5) A. Cap and trade – **Building Sector** | Best | Better | Better | Best | Better |
| B. Cap and trade – **All Fuels** | Better | Best | Better | Best | Better |
| 6) Sector wide performance standards | Best | Better | Best | Best | Better |
| 7) Economy-Wide GHG Performance Standard | Better | Best | Best | Best | Least Favorable |
| **Direct Regulatory Approaches** | | | | | |
| 8) Targeted performance std for heating appliances | Least Favorable | Better | Better | Best | Best |
| 9) Direct regulation of fuel - Clean Fuel Standard | Least Favorable | Least Favorable | Better | Least Favorable | Better |
| 10) Fossil infrastructure moratorium | Least Favorable | Better | Least Favorable | Better | Best |
| 11) Building performance standards | Least Favorable | Better | Better | Better | Better |
| 12) Emissions limits on individual emitters | Better | Better | Least Favorable | Better | Least Favorable |

***Table 22: Qualitative Assessment of Policy Options***

The qualitative assessment informed discussion with the State's project management team and members of the Climate Council's Buildings and Thermal Task Group and led to the creation of the policy sets to be quantitatively modeled and studied in more detail during the remainder of the study. Some policies were combined into one "policy set" to evaluate the combined impacts of the policies. The qualitative assessment report is provided in Appendix B.

## 2. Revise and Build Upon the Business-as-Usual Scenario Established for the Climate Action Plan

The next step in conducting the analysis was to update the BAU scenario against which the policy sets are compared. The BAU scenario incorporates climate actions that are currently in place as well as activities and funding that will be enacted in the future based on legislation that has passed. The BAU scenario is important in the analysis as it allows us to predict the emissions impacts of policies, programs, and funding sources currently in place. It is also used to compare costs for the policy scenarios and to identify the size of the emissions reduction gap between the anticipated BAU and the GWSA requirements. This then serves as the basis for what each of the policies are built upon.

A BAU scenario was established for the CAP analysis in 2021, which provided an analysis of the emissions reductions and costs associated with policies in the CAP.[14] In order to incorporate policies and mechanisms enacted since the initial modeling of the CAP, the team began the buildings/thermal analysis with an update to t this scenario. The updated BAU scenario includes changes due to the Inflation Reduction Act (IRA) and the Infrastructure Investment and Jobs Act (IIJA) [15], two significant sources of funding to support electrification of buildings and vehicles and as well as higher levels of building efficiency.

[14] Vermont Pathways Analysis Report 2.0, February 11, 2022, prepared for the Vermont Agency of Natural Resources, https://climatechange.vermont.gov/sites/climatecouncilsandbox/files/2022-03/Pathways%20Analysis%20Report_Version%202.0.pdf.

[15] Inflation Reduction Act of 2022, https://www.govinfo.gov/content/pkg/PLAW-117publ169/pdf/PLAW-117publ169.pdf. Infrastructure Investment and Jobs Act, https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf.

**Baseline Update Objectives**

1. Latest adoption levels – information from EEU's and other sources
2. Consider impacts of new policies and programs
   - Federal Inflation Reduction Act
   - Federal Infrastructure and Jobs Act
   - Vermont Weatherization Act 185
   - Multi-State Advanced Clean Cars II adoption
   - Multi-State Advanced Clean Trucks
3. Major changes in economic/demographic drivers
4. Fuel prices, calibration, and model streamlining

***Figure 6: BAU Update Objectives***

The revised BAU scenario that includes the effects of recent state and federal funding and initiatives reduces estimated BAU emissions for the RCI sector by 423 MMT or 16% in 2025 and by 639 MMT or 26% in 2030 as compared to the previous BAU scenario from the 2022 Pathways Report. Figure 6 illustrates the anticipated emission reduction impacts in the updated BAU scenario in comparison to the prior BAU from the Pathways Report.

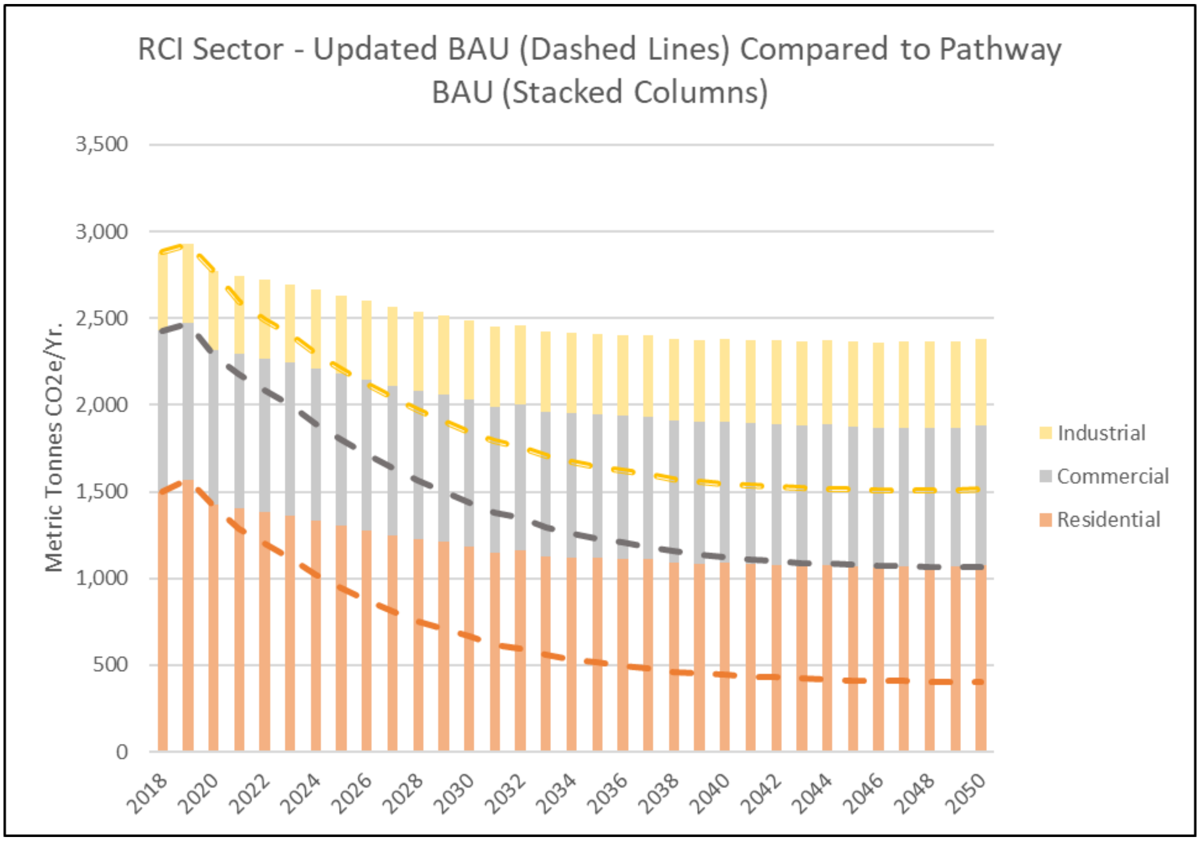


***Figure 7: Updated BAU Compared to Pathways BAU***

Appendix C provides further details on the updates made to the BAU scenario in this analysis.

## 3. Quantitative Modeling

From the qualitative modeling, the project and State teams selected four policy sets for quantitative modeling and analysis of benefits, costs, and emissions reductions. From these policy sets, the teams agreed upon three core scenarios to model in LEAP: the Economy-wide Scenario 2030, the RCI Proportional Scenario, and the Regulatory Bundle Scenario (explained further in Section 3 below).

The quantitative analysis involves several inter-connected models. The four scenarios were developed in the Low Emissions Analysis Platform (LEAP) model. Complementary workbooks were used to estimate the program and administrative costs, customer economics, and rate and fuel price impacts. Figure 8 illustrates the relationships between the LEAP modeling and the complementary analyses included in the study.

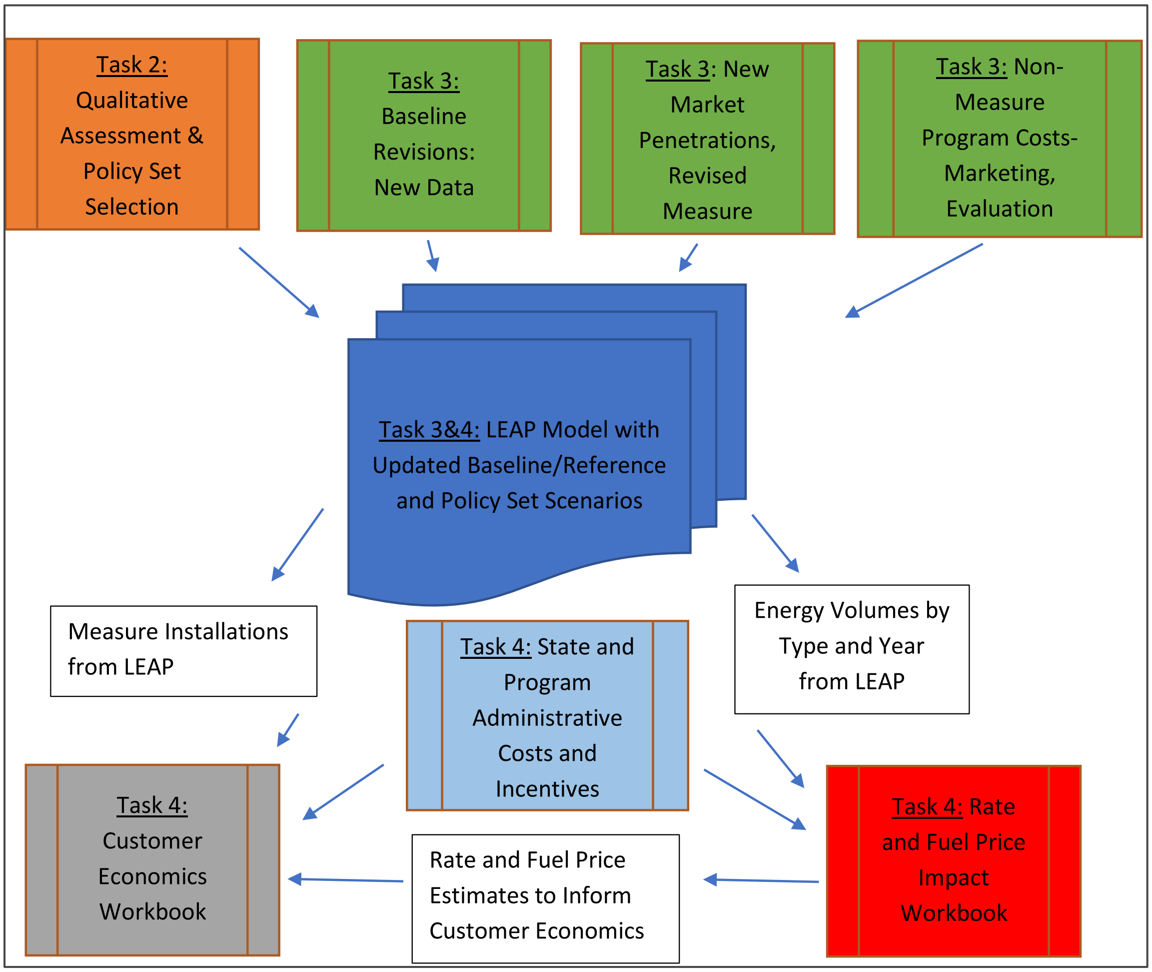


*Figure 8: Schematic of Modeling Approach and Data Relationships*

## LEAP Modeling

LEAP is an energy accounting framework-based tool, developed over decades to aid with integrated demand and supply-side planning. The LEAP model is demand driven, in that users define energy use branches in the demand module (such as residential buildings or road transportation), then the model uses processes in the transformation module (such as electric generation or natural gas distribution) and energy supplies in the resource module (such as solar, wind, and primary and secondary petroleum products) to meet demand. The structure is well-suited for long-term planning horizons, cost accounting, and assessing social and environmental impacts. LEAP enables users to compare these elements across user-defined scenarios that represent alternative future energy pathways.[16]

The Project Team built its LEAP modeling for this analysis upon versions of the Vermont Pathways model developed between 2020 and 2022 in support of Vermont's *Comprehensive Energy Plan* (CEP)[17] and the Vermont Pathways Report. The original foundational work on the LEAP model was conducted by SEI, under contract with the Vermont Department of Public Service. The model SEI developed to inform and support first the CEP and then the CAP has hundreds of branches and thousands of inputs. For example, the demand tree in the model represents significant levels of detail for each sector on the types of buildings or vehicles, end uses within buildings, and devices and vehicles used to provide services. LEAP does not include an optimization for the demand module, and therefore our team has worked with stakeholders to develop and refine the adoption profiles by measure type and sub-sector to meet the GWSA requirements.

### Rate, Bill, and Fuel Price Impacts

Using a workbook developed by Cadmus, the team was able to compare fuel prices, energy rates, and customer bills impacts of each of the decarbonization policy sets. The analysis included changes to utility revenue requirements and rate bases, incentive and implementation costs, changes in the rate base or alternative fuel usage from electrification, fixed recoverable costs and variable generation and fuel costs, avoided generation, and transmission and distribution costs and benefits.

### Customer perspective economics for building emissions reductions

To understand the costs associated with a switch from a fossil fuel measure to a decarbonization measure for a Vermont household in each of the policy scenarios, we developed a customer economics workbook. The workbook assesses the costs to consumers associated with fossil fuel measures and decarbonization measures, incorporating both annual operating costs as well as capital costs. For each policy scenario, we align the price of fossil fuels and the electric rate with the outputs from the rate and fuel price impacts workbook.

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[16] More information on LEAP and resources are available at https://leap.sei.org/Default.asp.

[17] 2022 Vermont Comprehensive Energy Plan, https://publicservice.vermont.gov/sites/dps/files/documents/2022VermontComprehensiveEnergyPlan_0.pdf

The analysis then incorporates incentives and tax credits associated with decarbonization measures to calculate the net change in annual costs for Vermont households for a switch from fossil fuel to decarbonization measure. The customer economics analysis distinguishes costs for both market rate and LMI households, utilizing different incentives for each. The incentives are aligned with the program and administrative costs workbook.

The decarbonization measures included in the customer economics analysis include central air source heat pumps, two head air source heat pumps, heat pump water heaters, high efficiency pellet boilers, high efficiency wood stoves, and weatherization. The fossil fuels incorporated in the analysis include propane, fuel oil, and fossil gas.

The customer economics workbook calculates the costs for both single family and multifamily households for participants for two snapshots in time- 2025 and 2030- to switch from a fossil fuel measure to a decarbonization measure. The analysis reflects the assumed measure costs, incentives, fuel costs and savings to transition measures in 2025 and 2030. The analysis calculates lifetime costs for a participating customer over the lifetime of the measure. In addition, the customer economics workbook calculates an annual cost for non-participants in 2025 and 2030 for each scenario.

### Program and State Administrative Cost Workbook

This part of the analysis estimates the program support and state administrative costs for attaining the GWSA requirements under each of the policy options. The LEAP modeling provides the profile of the required number of measures by year and policy scenario as inputs to the program and administrative cost workbook. The LEAP model does not address incentives or other program and administrative costs required to drive the levels of participation, investment, and measure adoption necessary to achieve GHG emission reductions for each policy set.

- Program costs include direct customer incentives, technical assistance and other forms of customer support, marketing, and other program delivery costs (such as information system, legal, and human resource costs incurred by the program administrators). These costs may be borne by program administrators providing statewide services, or they could be borne by individual obligated entities choosing to implement their own set of programmatic initiatives.

- Program costs, whether incurred by existing entities, default providers, or obligated entities are presumed to be recovered through increases in fuel prices or rates. The outputs on program costs are therefore an input to the rate and fuel price impact workbooks.

- Customer incentives impact the customer perspective economics for adopting transition measures. Incentive levels from the program and administrative cost workbook are therefore also used as inputs to the customer economics workbook.

- There are also state administrative costs associated with the oversight, verification, and evaluation of program initiatives. Unlike the program costs, state administrative costs are not anticipated to be recovered through fuel prices or rates, but to be embedded in the state's departmental operating budgets. A cap-and-invest program would generate revenue through the sale of allowances that can be used to fund administrative and program costs. Our analysis does not include an estimate of the size or use of such revenues.

# III. Policy Options for Meeting GWSA Building Sector Requirements

## A) Policy Sets for the Building Sector

To model the policies as scenarios in LEAP, the project team and State team grouped together the policies discussed in the qualitative assessment into three policy sets. These three policy sets, defined in more detail below, are Climate Initiatives 2030 (Meeting Economy-Wide Requirements by 2030), RCI Sector Proportional Reductions, and Regulatory Bundle and are the basis for the three scenarios modeled in LEAP.

This means that, each of the policies in the policy sets are modeled as one scenario and therefore have the same measure mix, meaning the same number of measures (for example, the same number of heat pumps) and level of penetration of measures (for example, a certain amount of energy use allocated to heat pumps). For example, each policy under the Climate Initiatives 2030 policy set - existing programs and policies, the Clean Heat Standard, and the building sector cap and invest program – are modeled as one scenario in LEAP. The policies are then differentiated in the complementary workbooks. This is where each of the costs of each of the individual policies in the Climate Initiatives scenarios are calculated.

### i) Revised Business-as-Usual Scenario

The project team began the analysis by updating the BAU scenario. The changes from the prior BAU scenario used for the Pathways Report and for Vermont Comprehensive Energy Plan include updated measure adoption levels based on new data on installed measures, incorporation of the impacts of new federal and state policies and initiatives enacted since the CAP BAU scenario was developed, and updates to fuel prices based on the latest forecasts. Below is a summary of the major changes to the BAU scenario. See Appendix C for more detailed documentation of updates to the BAU scenario.

An important element of the updates to the BAU scenario was incorporating the impacts of new federal and state policies and initiatives enacted since the CAP BAU scenario was developed. The updated BAU scenario now includes changes due to policies including the federal Inflation Reduction Act (IRA) and the Infrastructure Investment and Jobs Act (IIJA), two significant sources of funding to support electrification of buildings and vehicles and higher levels of efficiency. This federal funding has a direct impact on the projections of building electrification measures and weatherization efforts. The Federal funding is expected to have major impacts, with $30 million from the HOMES program of the IRA and $8.5 million from Clean Heat Homes. These translate into an additional 3,286 single-family, and 1486 multi-family units retrofit between 2025 and 2030. State policy and funding, such as updates to state funding for weatherization efforts, were also incorporated into BAU scenario projections.

In addition, the project team updated BAU scenario projections in the transportation sector to reflect updates to policy since the development of the CAP BAU scenario. This includes adjustments to the proportion of passenger car and light truck sales that are electric compared to fossil fuel internal combustion engine based on adoption of the Advanced Clean Cars II (ACCII) Rule. This also includes adjustments to the portion of light trucks, medium-duty vehicles, and heavy-duty vehicles sales that are electric, also based on adoption of the Advanced Clean Trucks (ACT) Rule. The project team coordinated with the State team on these adjustments, in line with ongoing separate efforts by the State to update the transportation sector analysis. This modification leads to greater assumed emission reductions in the BAU scenario than in our previous analysis for the state.

While these policies do not necessarily have a pre-determined impact on the penetration rates of decarbonization technologies or measures, the project team worked to estimate the impacts these policies will have in the BAU scenario. These estimates are based on outreach to Vermont stakeholders, including EEUs and others, as well as industry representatives which provided useful information on realistic projections for clean technologies based on expertise and experience from people in the field.

The project team also updated measure adoption levels to reflect the most recent data available on measures from EEU's and other sources. This includes, for example, an update to the heat pump forecast in the BAU scenario based on new data provided by Efficiency Vermont (EVT). This also includes an update to the number of building retrofits based on data from the Office of Economic Opportunity (OEO). The effect of these changes is a bigger reduction in emissions in the updated BAU scenario than in our previous analysis for the state.

In reviewing the BAU projections, the project team also made an adjustment to several assumptions regarding the impacts and/or costs of different emission reduction measures. Perhaps most notably, we reduced the assumed amount of heat that the average ductless mini-split heat pump provides – and therefore the amount of fossil fuel consumption that it eliminates – to better align with current Vermont Tier 3 assumptions and data from the Vermont Energy Investment Corporation on the mix of heat pump capacities being rebated in the state. We also increased the assumed cost of heat pumps to better reflect current market data. Both changes contribute to an increase in the cost per ton of emission reduction.

In addition, the project team updated the fuel prices in the updated BAU scenario to be in line with the Annual Energy Outlook (AEO) 2023 forecast.[18] The AEO 2023 forecast predicts fossil fuel prices will decline from current levels and be lower in the future than the forecast used in our previous analysis for the state. Thus, this update lowers the estimated economic benefits of electrification.

### ii) Climate Initiatives 2030

The Climate Initiatives 2030 (CI203) Economy-wide scenario includes three policy variations. These are: 2) expansion of existing programs and policies, 2.b) implementation of a building sector Clean Heat Standard, and 2.c) development of a building sector cap-and-invest program. This policy set meets the 2030 economy-wide GWSA emissions reductions requirements by 2030. The three policies are described below. See Appendix B for a complete description of the policies in the Qualitative Assessment.

[18] https://www.eia.gov/outlooks/aeo/

### 2) Expand existing programs and policies

Existing programs and policies in Vermont included in this policy are the following:

1. Weatherization efforts conducted in the state by the Office of Economic Opportunity (OEO), Efficiency Vermont, and Vermont Gas Systems
2. Residential and commercial building energy codes (RBES and CBES)
3. Appliance rebates and financing through the EEUs
4. The Renewable Energy Standard (RES) Tier 3
5. Biofuels incentives through the Clean Energy Development Fund (CEDF)
6. Weatherization Repayment Assistance Program (WRAP) through VHFA
7. Direct technology/sector investments

An expansion of one or more of these programs would require additional funding and would need to be implemented in combination with another revenue-generating policy or an external source of funds.

Regarding equity considerations, the existing programs and policies, including the many weatherization initiatives, appliance rebates and financing programs, and the biofuels heating and cooking incentive, all seek to lower the cost of energy efficient technologies for households and therefore have elements of equity impacts in their existing design. Continued outreach to LMI households is needed to make them aware of these energy efficiency programs and policies, and the benefits they provide to reduce energy cost burdens.

### 2.b) Building Sector Clean Heat Standard

A building sector Clean Heat Standard is an obligation imposed on fossil fuel suppliers to reduce the carbon footprint associated with their products through investments in GHG reducing measures. The obligation is commonly articulated in terms of annual emission reduction "credits". Different measures have different credit values, with the values based on the amount of emission reduction each measure provides. The performance standard aspect of the policy means that fossil fuel suppliers can decide for themselves what mix of measures they use to meet each annual requirement. To reduce overall costs, credits can also typically be bought and sold.

A Clean Heat Standard is similar in many ways to a renewable portfolio standard for electric utilities. It also has similarities to energy efficiency savings obligations imposed on regulated electric and gas utilities – or comparable non-utility parties such as Efficiency Vermont.

Equity considerations: A sector-wide performance standard has the potential to increase the energy cost burden for LMI households who use fossil fuels for heating to the extent that obligated entities pass down the increase in costs to their fossil fuel customers. On the other hand, LMI households can be prioritized for access to and benefits from clean heat measures, thereby lowering energy cost burdens for those customers who participate in the program. Such participation may result in increasing overall program costs, however.

### 2.c) Cap and Invest Building Sector Only

Cap and invest is based on establishing a regulatory limit on emissions, either through emission allowances or requirements for clean heat credits. For a cap and invest program, revenues are generated through the auctioning of emission allowances (as opposed to a cap-and-trade program, in which allowances are allocated without revenue generation). The analysis considers a cap and invest program that would apply to just the building sector.

In a cap and invest program, GHG emissions are regulated by establishing a declining number of emissions allowances for each year. Wholesale and/or retail fuel suppliers are obligated entities and must have sufficient allowances to cover their fuel sales or face penalties. Some levels of carry-forward or banking of allowances for use in future years can be permitted.  Emission allowances can be auctioned, allocated based on historic emissions, or a combination of the two.

The revenue generated depends on how many emission allowances are auctioned versus allocated, and the auction clearing price. Revenues from a cap and invest system can be used to augment other decarbonization policies and programs. Auction proceeds can also be used to fund program administration, which differentiates cap and invest from other options that require a separate funding source. To address equity considerations, program proceeds can be preferentially directed towards support for low-income households or for environmental justice initiatives.

## 3. RCI Sector Proportional Requirements

The RCI Sector Proportional Requirements policy set incorporates the same three policies as the Climate Initiatives 2030 policy set (3) Expand existing programs and policies, 3.b) implement the building sector Clean Heat Standard, and 3.c) implement a building sector cap and invest program). Instead of meeting economy-wide GHG emissions reduction requirements laid out by the GWSA, this scenario meets proportional RCI sector emission reduction requirements. The scenario is designed such that the RCI sector meets the proportional sectoral requirements of the GWSA for the building sector only, and therefore does not meet economy-wide emission reductions requirements on its own.

### 4. Regulatory Mechanisms

The Regulatory Mechanisms policy set incorporates policies with a focus on state control of emissions reduction requirements as opposed to providing incentives to meet requirements. The Regulatory Mechanisms policy set meets the 2030 GWSA requirements by 2030.

Because of the relative ease of compliance monitoring for a smaller number of facilities required by the regulatory approach in the Commercial and Industrial sectors, as compared to monitoring compliance across a much larger number of buildings in the Residential sector, the team assumed that a greater proportion of emissions reductions would be coming from the Commercial and Industrial sector in the Regulatory Mechanisms policy set than the previous two policy sets.

The policies included in the Regulatory Mechanisms policy set are:

1. Targeted performance standards for heating appliances
2. Direct regulation of fuel emissions (e.g., specifying maximum emissions per volume of per energy content of fuel)
3. Fossil infrastructure moratorium
4. Building performance standards (for new and existing buildings)
5. Emission limits on individual emitters

# IV. Results: Comparing Policy Sets

## A) Emissions Reductions

The policy options analysis starts with consideration of the emissions reductions, both economy-wide and for the RCI building sector, and how these related to the requirements of the GWSA. Figure 9 illustrates the 2018 economy-wide emissions, a 40% proportional reduction for each sector by 2030, and the emissions modeled in the CI2030, RCI Sector Proportional Requirements and Regulatory Measures Bundle scenarios.

Note that modeling of emissions from the agriculture sector is unchanged from the Pathways 2.0 report. Emissions from the agriculture sector based on the methodology used for the Greenhouse Gas Emissions Inventory and Forecast report are scaled down by a factor of 0.5 based upon the results of the September 2021 Carbon Budget report. The modeled economy-wide emissions for the GWSA compliance years of 2025, 2030 and 2050 presented in this report should not be viewed as indicative of the state's likelihood of achieving those emission levels in those years.

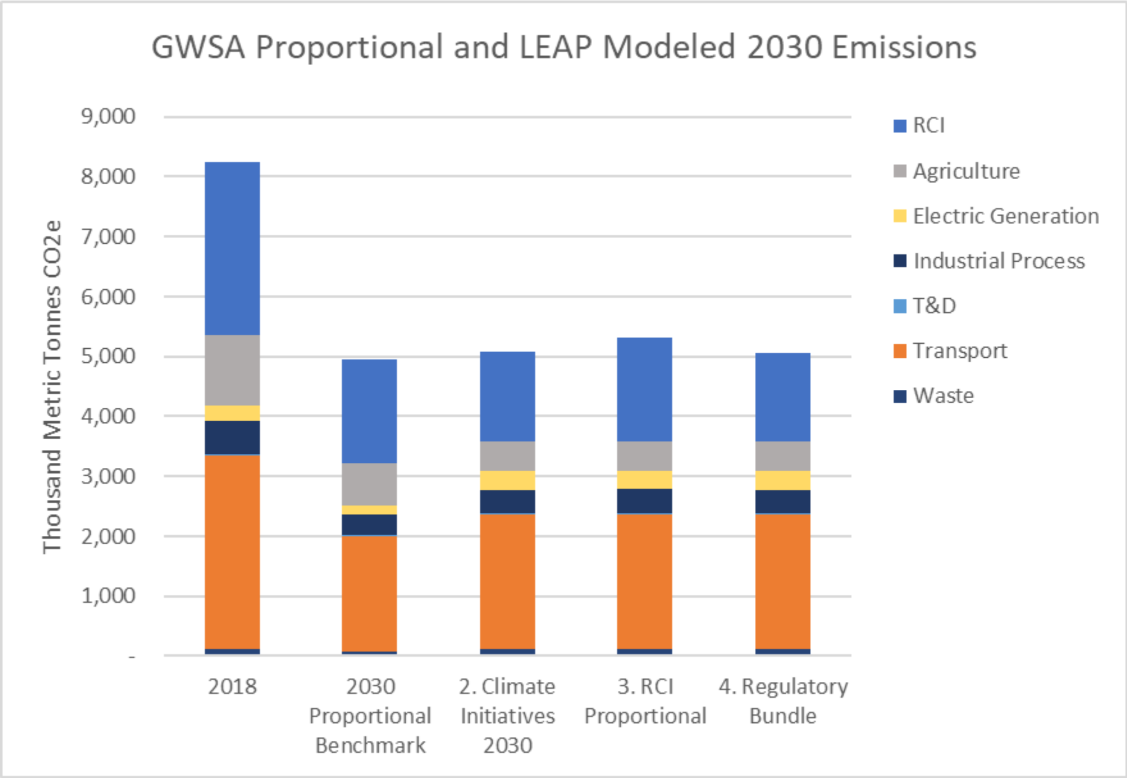


***Figure 9: GWSA Proportional and LEAP Modeled 2030 Emissions***

Our analysis and the results in Figure 9 are based on prioritizing economy-wide compliance with the GWSA requirements by modifying the RCI sector. Except for BAU scenario adjustments, we did not adjust the non-RCI sectors in the scenarios. To meet the 2030 economy-wide GWSA requirement the modeled RCI sector provides roughly 245,000 metric tonnes CO2e (14%) more in emissions reductions than a strict 40% proportional sector reduction would entail.

Figure 10 illustrates the economy-wide emissions for the Climate Initiative 2030 scenario by sector and the emissions avoided from the BAU scenario. The RCI sector is illustrated by the three green/blue bar segments on the top of each stacked column.

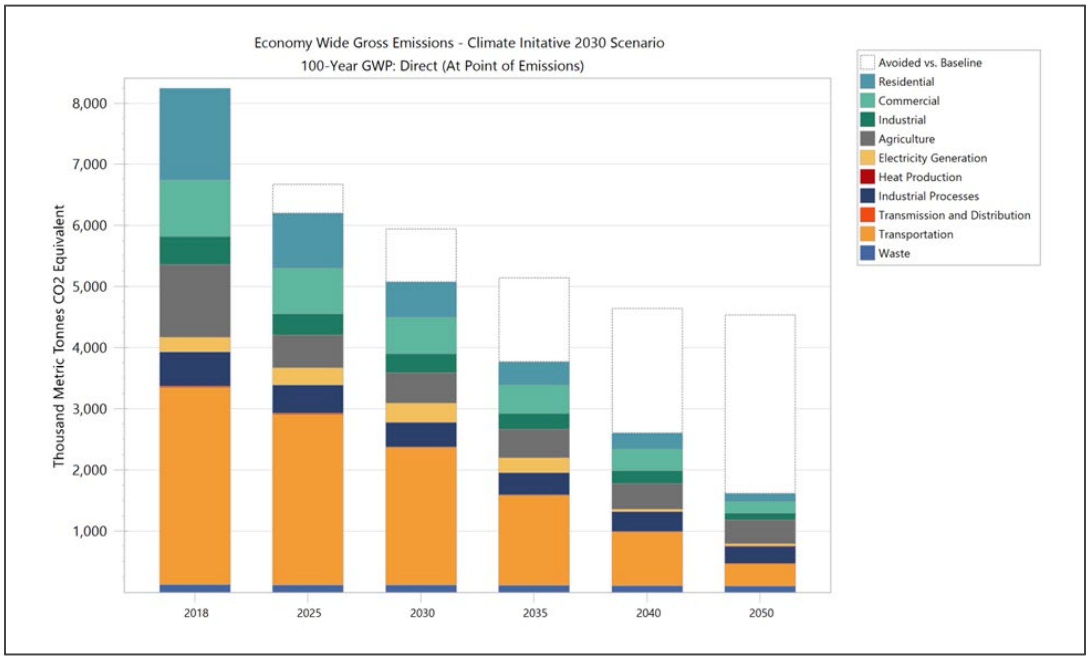


***Figure 10: Climate Initiatives 2030 Economy-Wide Emissions***

Figure 11 isolates the RCI sector and subsector emissions by year and scenario.

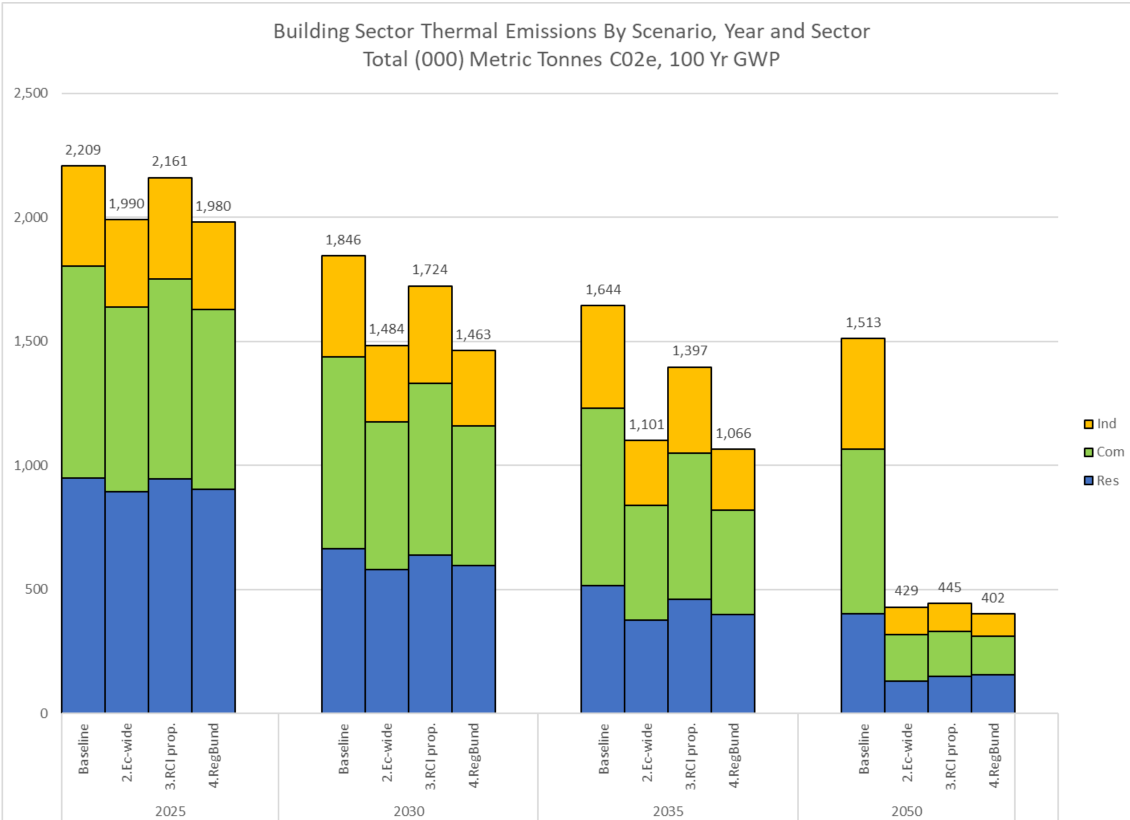


*Figure 11: RCI Emissions by Scenario, Year, and Sub-Sector*

The economic costs and benefits associated with the modeled emission reductions are considered from a variety of perspectives, including societal, program and administrative costs, customer economics and impacts on fuel prices and rates.

## B) Societal Benefits and Costs

The societal perspective includes all changes in costs, including changes in energy consumption and fuel costs, changes in capital costs, changes in environmental externality and public health costs, and other benefits or costs to customers (e.g., changes in comfort, changes in operations and maintenance costs, etc.). Under the societal perspective, the full cost of decarbonization measures are included, regardless of how much of the cost is born by regulated fossil fuel suppliers, participating customers or government; rebates and tax credits are all viewed as transfer payments (not as cost reductions).  The costs of program and state administration are not included in the societal benefit cost estimates.   Societal costs include an estimate of avoided social and economic damages based on the social cost of carbon.  The societal cost of greenhouse gas emissions used in this study are based on the analysis and values used in the 2022 Pathways Report.[19] Investments in mitigation measures in the later years of the modeling period may result in savings after 2050 that are not quantified in LEAP.

Figure 12 illustrates the economy-wide benefits (above the horizontal axis), and investments (below the horizontal axis) by cost category. The net present value over 2019-2050 for each scenario based on a 2% social discount rate appears at the bottom of the column for each of the three scenarios. In comparison to the updated BAU scenario, these results indicate the three thermal sector analysis scenarios entail additional net social costs of $568 million to $1.485 billion. In 2021 Vermont's total energy expenditures were $2.814 billion.[20] In this context the net additional costs for meeting the economy-wide emissions reduction requirements are in the range of 0.9% to 2.4% of the present value of annual energy expenditures over the study horizon.[21] The benefit/cost ratios are 0.82 for the 2. RCI Economy-wide 2030 Scenario, 0.78 for the 3. RCI Proportional Scenario, and 0.92 for the 4. Regulatory Bundle scenario.

[19] Cadmus Group and EFG, 2022, Vermont Pathways Report.

[20] Energy Information Administration, Vermont State Energy Profile, August 2023 update: https://www.eia.gov/state/data.php/notes-sources.cfm?sid=VT

[21] Annual Expenditures of $2.8 billion x 31 years discounted at 2% = $64.5 billion. $1.8/$64.5 = 2.79%, and $2.8/$64.5 = 4.34%.

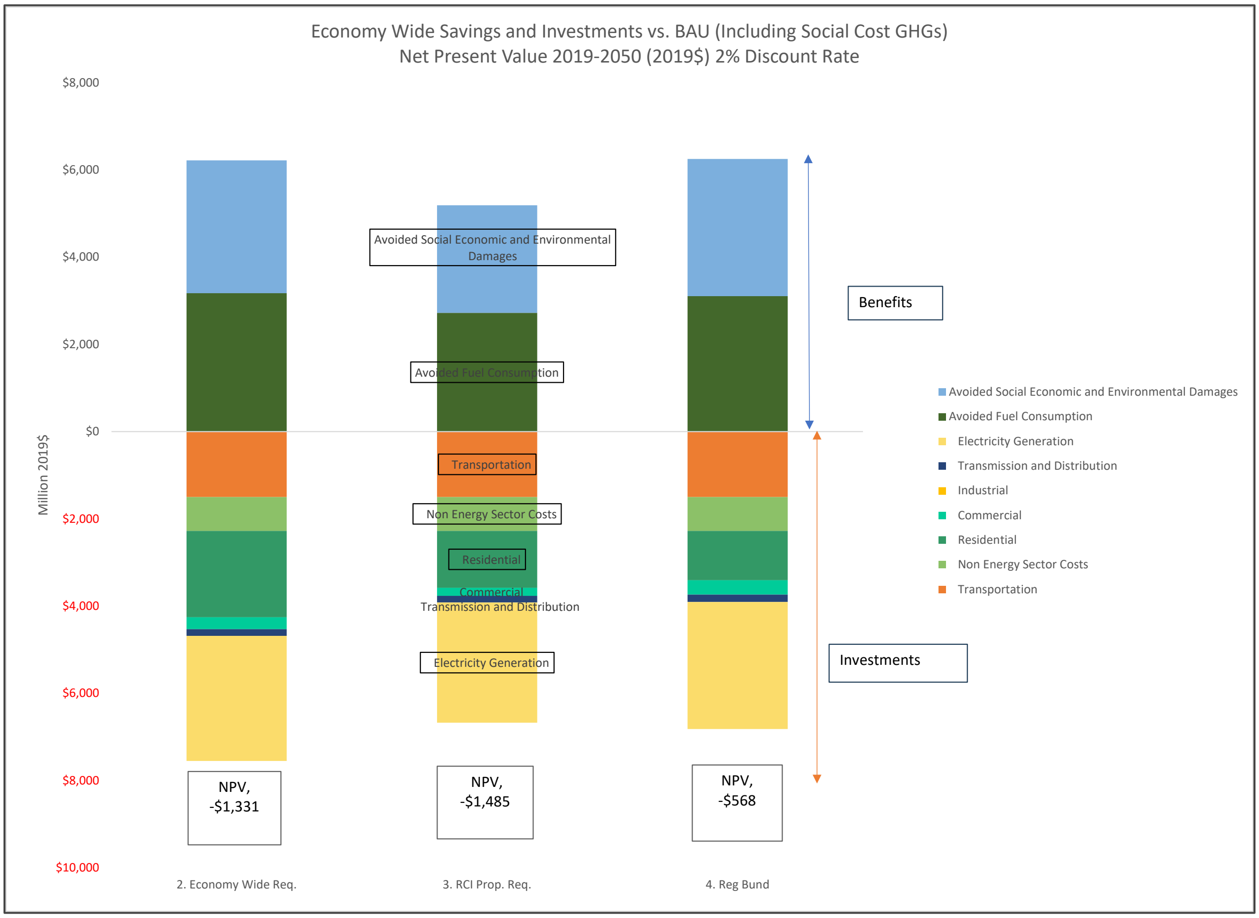


***Figure 12: Societal Benefit/Cost Results by Scenario***

These societal cost impacts are derived principally from LEAP modelling runs. However, an adjustment has been made to the LEAP outputs to account for "end effects". Capital costs for heat pumps, weatherization of homes, electric vehicles and several other measures are input into LEAP in their entirety in the year in which such capital investments are assumed to be made. However, many of these measures will provide benefits (including emission reductions) well beyond the 2050 horizon of this analysis. In other words, the LEAP model outputs include the full costs of all measures installed through 2050, but not all the benefits. For example, a heat pump that is installed in the model in 2046 would have the full cost of the heat pump included in LEAP outputs, but only five of its expected 15 years of emission reductions and other fuel cost changes included. This is what is commonly called an "end effects" problem. We have addressed this issue through calculations exogenous to the LEAP model. Specifically, we have levelized all capital costs input into the model, computed the NPV of levelized annual costs through 2050, and then computed the difference between the NPVs of levelized capital costs through 2050 and the full capital costs included in LEAP. Those differences, which add up to between $0.9 and $1.0 billion (mostly in the transportation sector), were then subtracted from the LEAP cost outputs to generate the end effects corrected societal costs estimates in Figure 12.

A sensitivity analysis based on the 2023 Annual Energy Outlook's high oil price forecast for the RCI Proportional Reductions Scenario is presented in Figure 13. The sensitivity shows a very slight increase (1.1%) in the estimated net societal costs, with higher benefits from avoided fuel consumption being slightly offset by higher electric generation costs.

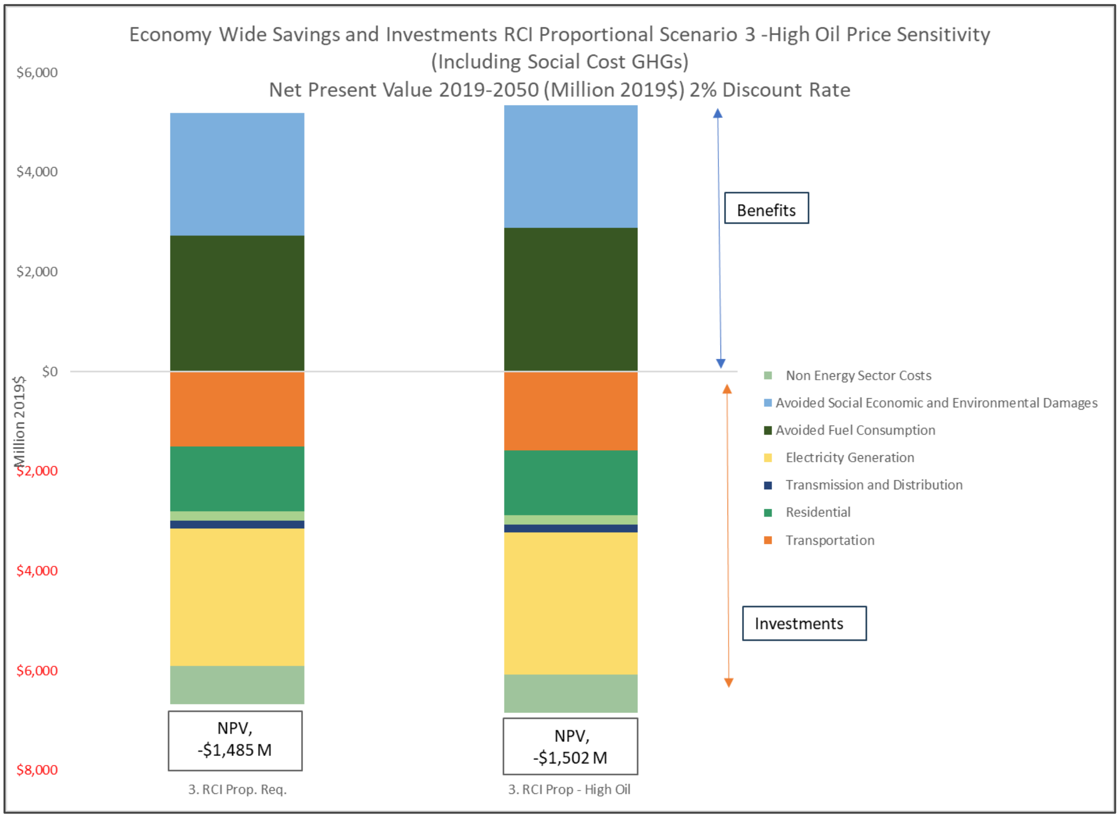


*Figure 13: High Oil Price Sensitivity, RCI Proportional Scenario*

**Comparison of the Societal Benefit Cost Results to the Pathways Study.** The economy-wide societal cost benefit results from the Pathways Study our team completed in 2022 differ substantially from the results presented in Figures 12 and 13 with the net present value of economy-wide impacts estimated as a positive $6.4 billion.[22] While the scope of work for this study does not include a detailed comparison of the current study to the Pathways Report we highlight here the major factors driving this change in the summary economic results. These are:

- The updated BAU scenario reflects impacts of the federal Inflation Reduction Act, the Infrastructure Investment and Jobs Act, and increased state funding for weatherization, which reduced the gap between BAU scenario and the GWSA requirements.
- Fuel price projections in both analyses were based on the edition of the Annual Energy Outlook (AEO) that was available at the time of each analysis – AEO 2021 for the Pathways Report, and AEO 2023 for this report. The future prices for avoided fuels were higher in the Pathways Report analysis than they are in the current study.
- Price and performance adjustments were made for some technologies. For example, heat pump prices were increased in the thermal analysis based on recent market data and the share of annual heating load provided by mini-split heat pumps was reduced in the current study, also based on more recent market data.

Figure 14 illustrates a comparison of the societal economy-wide results by impact category from the Pathways Report and the current study.

[22] Cadmus Group and EFG, 2022, Vermont Pathways Report. Figure 41.

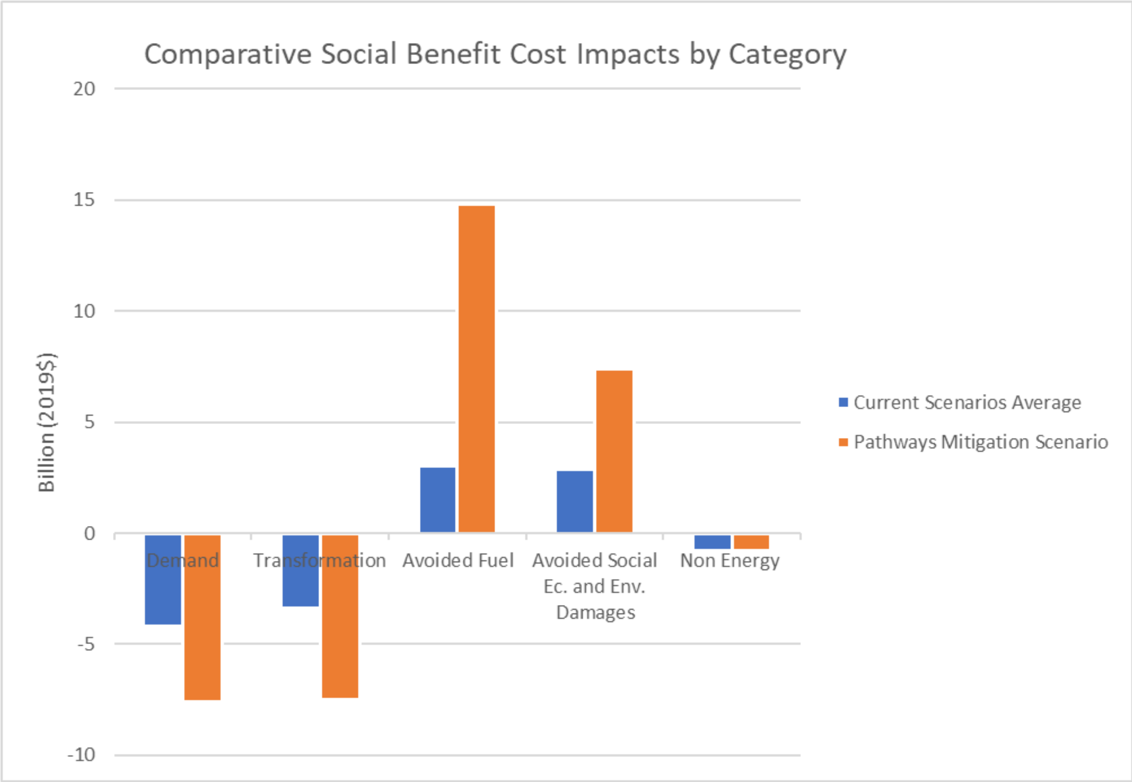


*Figure 14: Comparison of Societal Benefit Cost Estimates for Pathways and Thermal Sector Studies*

The orange bars represent estimated impacts from the Pathways Report central mitigation scenario, while the blue bars are averages of the three scenarios from the current study.[23] The lower impacts across all the categories except non-energy illustrate how the BAU scenario updates reduced the necessary levels of activity to meet GWSA requirements.

**Societal cost per tonne of emissions reduction** – LEAP's native benefit/cost structure is aligned with social costs, and the social cost per tonne of avoided emissions for each policy set can be

[23] In Figure 14, "Demand" represents the additional costs and investments for technologies that reduce emissions in the demand module. This includes weatherization and electrification measures in the RCI sector. "Transformation" costs are associated with the capital and non-fuel operating expenses for the electric system and delivery of natural gas. The "Avoided Fuel" category represents all avoided fuel costs for the demand and transformation modules, the "avoided social economic and environmental damages" represents the benefits from avoided emissions, and the "non-energy" are costs for non-energy reduction measures in agriculture, waste and industrial processes.

compared to the BAU scenario and the other policy sets. Figure 15 illustrates the comparative cost per tonne of reduction and the cumulative level of emissions reductions for the three scenarios in comparison to the BAU scenario.[24]

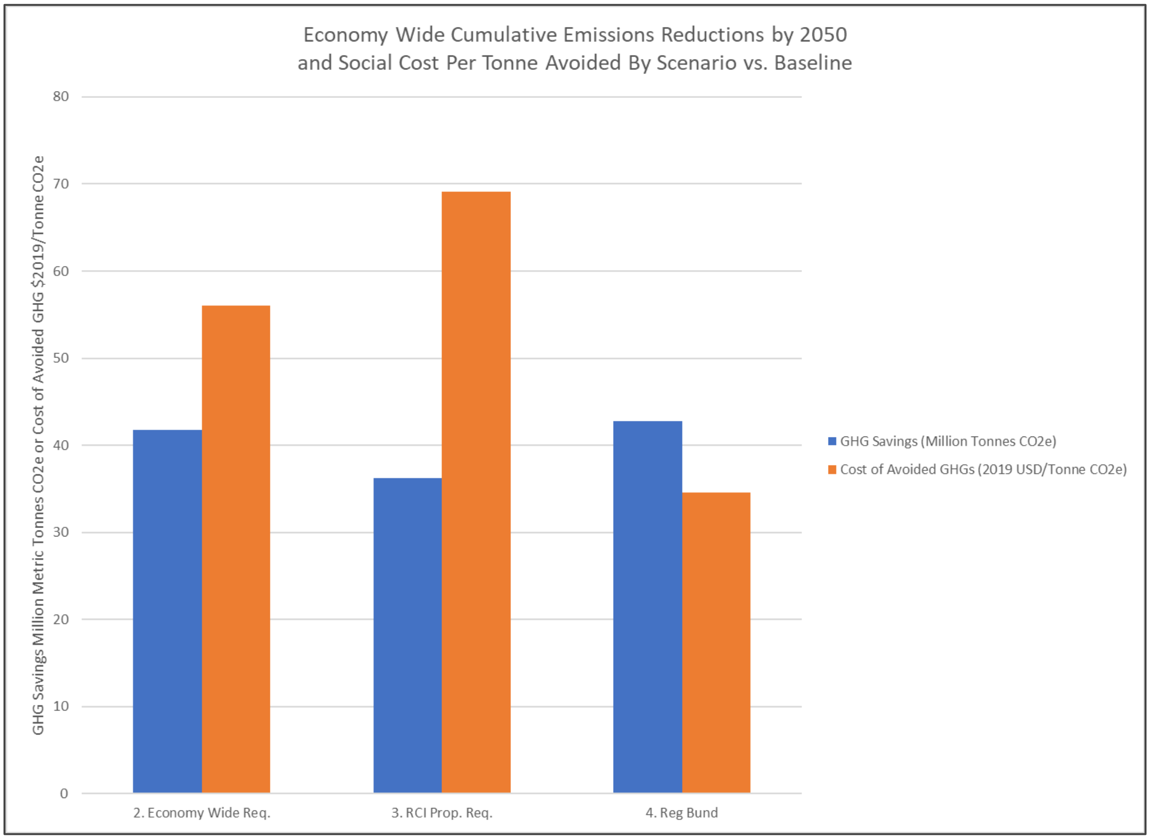


***Figure 1515: Cumulative Emissions Reductions and Societal Cost per Metric Ton***

## C) Consumer Perspective Benefits and Costs

### Methodology

The project team developed an analysis to understand the costs associated with a switch from a fossil fuel measure to a decarbonization measure for a Vermont household in each of the policy scenarios. The customer economics workbook assesses the costs, including annual costs and capital costs, to consumers associated with fossil fuel measures and decarbonization measures.

[24] The cost per tonne of avoided GHG emission results in Figure 11 include the social benefits of avoided economic and environmental damages based on the Social Cost of Carbon values adopted for the 2022 Pathways Analysis.

We then incorporate the incentives and tax credits associated with decarbonization measures to calculate the net change in annual costs for Vermont households for a switch from fossil fuel to decarbonization measure. Capital costs, net of any financial incentives, are annualized over the lifetime of the measure, as if the capital cost was financed.[25]

We incorporate considerations of both market rate and LMI consumers. The difference between the two is the incentives available to these different segments for the decarbonization measure. These incentives are aligned with the program and admin costs workbook. Electric rates are aligned with the electric rate impacts workbook, and fuel prices are aligned with the fuel price impacts workbook. Electric rates are calculated as a statewide average. A description of fuel prices and electric rates is in Section (IV. E) below.

In addition, the analysis incorporates differences in single family and multifamily buildings. The differences between single family to multifamily analyses include the BAU scenario energy consumption for space heating is lower in multifamily, heating equipment and weatherization costs are lower in multifamily, market rate incentives vary between multifamily and single family, and some measures don't apply to multifamily (boilers and wood stoves).

The workbook looks at the customer economics of measures at two snapshots in time, 2025 and 2030, and a simple calculation of lifetime costs for the measures. The lifetime costs are a calculation of the net present value of the measure over the lifetime of the measure, using a 5% discount rate.

In addition, the customer economics workbook calculates the costs to non-participants in 2025 and 2030. This is done by calculating the difference between the fuel costs in the BAU scenario and each of the policy scenarios. This is then multiplied by the average fuel consumption for each measure, calculating an annual cost for non-participants in 2025 and 2030 for each scenario.

### Results

The workbook ultimately calculates the net change in annual costs for LMI and market rate households. Below are snapshots of tables for the Expand Existing Programs 2035 policy for electrification measures, advanced wood heat measures, and weatherization. The cases in which customer costs are reduced for a decarbonization measure are highlighted in green;

[25] We used a 5% real discount rate, which is equivalent to a nominal market rate of 8.15% if inflation is 3% per year

those for which customer costs are increased – not accounting for emission reduction benefits or other non-energy benefits - are highlighted in red.

An important takeaway is the benefit that the incentive for LMI households provides. The incentives for low-income households – which are equal to the capital cost of the decarbonization measure - allow low-income households to implement a decarbonization measure and immediately realize reduced household energy costs.

| | Electrification Measures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Furnace Full Displacement (Central Air Source Heat Pump) (Time-of-Replacement) | | | Boiler Partial Displacement (Two Head Air Source Heat Pump) (Retrofit) | | | Water Heater (Heat Pump Water Heater) (Time-of-Replacement) | | |
| | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas |
| Net Change in Annual Costs for Low-Income | ($1,573) | ($784) | $412 | ($671) | ($115) | $351 | ($608) | ($477) | ($244) |
| Net Change in Annual Costs for Moderate-Income | ($1,391) | ($602) | $594 | ($502) | $53 | $520 | ($553) | ($422) | ($189) |
| Net Change in Annual Costs for Market Rate | ($1,126) | ($337) | $859 | ($246) | $309 | $776 | ($482) | ($350) | ($117) |

*Table 3: Changes in Annual Costs in Expand Existing Programs Scenario (3).*

| | Advanced Wood Heat Measures | | | | | | | | Weatherization | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Biofuels Blend | RNG Blend | HE Wood Stoves | | | HE Pellet Boilers | | | Weatherization | | |
| | Retrofit | Retrofit | Time of Replacement | | | Time of Replacement | | | Retrofit (from furnace) | | |
| | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas |
| Net Change in Annual Costs for Low-Income | $64 | ($32) | ($844) | ($591) | ($50) | ($1,448) | ($531) | $537 | ($621) | ($405) | ($224) |
| Net Change in Annual Costs for Moderate-Income | $64 | ($32) | ($773) | ($520) | $21 | ($1,046) | ($130) | $939 | ($466) | ($250) | ($69) |
| Net Change in Annual Costs for Market Rate | $64 | ($32) | ($657) | ($404) | $137 | ($581) | $336 | $1,404 | ($331) | ($116) | $66 |

*Table 4: Changes in Annual Costs in Expand Existing Programs Scenario (3).*

Table 3, for example, illustrates that a single-family low-income household in the Expand Existing Programs 2035 policy set switching from a propane furnace to an air source heat pump is estimated to save $1,573 in 2025. This represents only the value of one year's worth of savings for a measure that will last an average of 15 years. Similarly, a single-family low-income household in the Clean Heat Standard 2035 policy set making that switch is also estimated to save $1,573 in 2025 (see Table 5 below). While market rate households also have estimated annual savings in these years, the incentives for LMI customers to switch to a decarbonization measure result in significant annual savings for households who face the highest energy burden. If equity is considered in incentive design, meeting the GWSA requirements can mean significant positive benefits for LMI customers that adopt measures.

| | Electrification Measures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Furnace Full Displacement (Central Air Source Heat Pump) (Time-of-Replacement) | | | Boiler Partial Displacement (Two Head Air Source Heat Pump) (Retrofit) | | | Water Heater (Heat Pump Water Heater) (Time-of-Replacement) | | |
| | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas |
| Net Change in Annual Costs for Low-Income | ($1,573) | ($784) | $410 | ($671) | ($115) | $350 | ($608) | ($477) | ($244) |
| Net Change in Annual Costs for Moderate-Income | ($1,391) | ($602) | $592 | ($502) | $53 | $519 | ($553) | ($422) | ($189) |
| Net Change in Annual Costs for Market Rate | ($1,126) | ($337) | $857 | ($246) | $309 | $775 | ($482) | ($350) | ($118) |

*Table 5: Change in Annual Costs in Clean Heat Standard Scenario (3b).*

| | Advanced Wood Heat Measures | | | | | | | | | Weatherization | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Biofuels Blend | RNG Blend | HE Wood Stoves | | | HE Pellet Boilers | | | Weatherization | | |
| | Retrofit | Retrofit | Time of Replacement | | | Time of Replacement | | | Retrofit (from furnace) | | |
| | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas |
| Net Change in Annual Costs for Low-Income | $64 | ($32) | ($844) | ($591) | ($51) | ($1,448) | ($531) | $535 | ($621) | ($405) | ($225) |
| Net Change in Annual Costs for Moderate-Income | $64 | ($32) | ($773) | ($520) | $20 | ($1,046) | ($130) | $936 | ($466) | ($250) | ($69) |
| Net Change in Annual Costs for Market Rate | $64 | ($32) | ($657) | ($404) | $136 | ($581) | $336 | $1,402 | ($331) | ($116) | $65 |

*Table 6: Change in Annual Costs in Clean Heat Standard Scenario (3b).*

The customer economics analysis across policy scenarios, building types, and years also illustrates that the switch from propane or fuel oil to a decarbonization measure is economical for customers. And, for a switch from fossil gas to electricity or wood, in most scenarios, LMI households will be saving on annual energy bills. However, as illustrated in the tables above, in the case of market rate customers, a switch from fossil gas to electricity or wood for most measures (other than heat pump water heaters) suggests that annual energy bill savings are not big enough to cover capital costs necessary to make the fuel switch. The relatively low price of fossil gas in the scenarios likely contributes to this result. This result indicates that market rate incentives to switch from fossil gas to a decarbonization measure may need to be higher than those for propane and fuel oil to encourage the switch from fossil gas.[26]

The lifetime costs of each measure in an example scenario – the Clean Heat Standard in the CI2035 scenario – for a single-family household in 2025 are displayed in Tables 7 and 8. A negative cost means that a household would be saving money in the scenario for the decarbonization measure; a positive cost means there is a cost to the switch to the decarbonization measure. For many decarbonization measures in this scenario, there are savings for households using propane and fuel oil. Like the analysis of annual costs above, there are some measures which have a lifetime cost when switching from fossil gas to

[26] If the retail electric rate is increased by 1 cent per kWh (to reflect efficiency charges), annual electric costs increase accordingly, although this does not change which cases have overall positive or negative savings.

decarbonization measure – which again indicates the potential importance of incentives to switch from fossil gas to a decarbonization measure.

| | Electrification Measures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Furnace Full Displacement (Central Air Source Heat Pump) | | | Boiler Partial Displacement (Two Head Air Source Heat Pump) | | | Water Heater (Heat Pump Water Heater) | | |
| | (Time-of-Replacement) | | | (Retrofit) | | | (Time-of-Replacement) | | |
| | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas |
| Lifetime Costs (NPV) Low-Income | ($18,383) | ($9,159) | $4,793 | ($6,965) | ($1,198) | $3,633 | ($5,715) | ($4,480) | ($2,296) |
| Lifetime Costs (NPV) Moderate-Income | ($16,258) | ($7,034) | $6,918 | ($5,215) | $552 | $5,383 | ($5,196) | ($3,961) | ($1,778) |
| Lifetime Costs (NPV) Market Rate | ($13,158) | ($3,934) | $10,018 | ($2,555) | $3,212 | $8,043 | ($4,524) | ($3,289) | ($1,105) |

***Table 7: Lifetime Costs in CI 2030 Clean Heat Standard Scenario (3b).***

| | Advanced Wood Heat Measures | | | | | | | | | Weatherization | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Biofuels Blend | RNG Blend | HE Wood Stoves | | | HE Pellet Boilers | | | | Weatherization | | |
| | Retrofit | Retrofit | Time of Replacement | | | Time of Replacement | | | | Retrofit (from furnace) | | |
| | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | | Propane | Fuel Oil | Fossil Gas |
| Lifetime Costs (NPV) Low-Income | $61 | ($30) | ($9,864) | ($6,910) | ($594) | ($18,040) | ($6,616) | $6,668 | | ($8,754) | ($5,713) | ($3,165) |
| Lifetime Costs (NPV) Moderate-Income | $61 | ($30) | ($9,034) | ($6,080) | $236 | ($13,040) | ($1,616) | $11,668 | | ($6,568) | ($3,527) | ($980) |
| Lifetime Costs (NPV) Market Rate | $61 | ($30) | ($7,678) | ($4,724) | $1,592 | ($7,236) | $4,188 | $17,472 | | ($4,671) | ($1,630) | $918 |

***Table 8: Lifetime Costs in CI 2030 Clean Heat Standard Scenario (3b).***

Non-participant costs measure for a single-family household in 2025 are displayed in Table 9 and in 2030 are displayed in Table 10. This is an example scenario, the Clean Heat Standard in the CI2035 scenario. This is the cost of household using fossil fuel for space heating and water heating in the BAU scenario compared to the cost of household using fossil fuel for space heating and water heating in the policy scenario. This illustrates the change in annual costs to households to remain on fossil fuels in the policy scenario.

| **2025** | Single Family | | | | | | Multi-Family | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Space Heating | | | Water Heating | | | Space Heating | | | Water Heating | | |
| | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas |
| Btus | 82.8 | 82.8 | 82.8 | 15.2 | 15.2 | 15.2 | 38.9 | 38.9 | 38.9 | 15.2 | 15.2 | 15.2 |
| Gallons/ therms | 905 | 598 | 828 | 166 | 110 | 152 | 425 | 281 | 389 | 166 | 110 | 152 |
| No policy fuel price | $ 3.42 | $ 3.38 | $ 1.34 | $ 3.42 | $ 3.38 | $ 1.34 | $ 3.42 | $ 3.38 | $ 1.34 | $ 3.42 | $ 3.38 | $ 1.34 |
| Policy fuel price | $ 3.43 | $ 3.39 | $ 1.36 | $ 3.43 | $ 3.39 | $ 1.36 | $ 3.43 | $ 3.39 | $ 1.36 | $ 3.43 | $ 3.39 | $ 1.36 |
| Annual cost w/o policy | $ 3,096 | $ 2,021 | $ 1,113 | $ 568 | $ 371 | $ 204 | $ 3,096 | $ 2,021 | $ 1,113 | $ 568 | $ 371 | $ 204 |
| Annual cost w/policy | $ 3,105 | $ 2,027 | $ 1,123 | $ 570 | $ 372 | $ 206 | $ 3,105 | $ 2,027 | $ 1,123 | $ 570 | $ 372 | $ 206 |
| Change in annual cost | $ 9 | $ 6 | $ 10 | $ 2 | $ 1 | $ 2 | $ 9 | $ 6 | $ 10 | $ 2 | $ 1 | $ 2 |
| % change in cost | 0% | 0% | 1% | 0% | 0% | 1% | 0% | 0% | 1% | 0% | 0% | 1% |

***Table 9: Non-Participant Costs in CI 2030 Clean Heat Standard Scenario (3b) in 2025.***

| 2030 | Single Family | | | | | | Multi-Family | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Space Heating | | | Water Heating | | | Space Heating | | | Water Heating | | |
| | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas | Propane | Fuel Oil | Fossil Gas |
| Btus | 82.8 | 82.8 | 82.8 | 15.2 | 15.2 | 15.2 | 38.9 | 38.9 | 38.9 | 15.2 | 15.2 | 15.2 |
| Gallons/ therms | 905 | 598 | 828 | 166 | 110 | 152 | 425 | 281 | 389 | 166 | 110 | 152 |
| No policy fuel price | $ 3.79 | $ 3.30 | $ 1.48 | $ 3.79 | $ 3.30 | $ 1.48 | $ 3.79 | $ 3.30 | $ 1.48 | $ 3.79 | $ 3.30 | $ 1.48 |
| Policy fuel price | $ 3.91 | $ 3.42 | $ 1.63 | $ 3.91 | $ 3.42 | $ 1.63 | $ 3.91 | $ 3.42 | $ 1.63 | $ 3.91 | $ 3.42 | $ 1.63 |
| Annual cost w/o policy | $ 3,431 | $ 1,973 | $ 1,224 | $ 630 | $ 362 | $ 225 | $ 3,431 | $ 1,973 | $ 1,224 | $ 630 | $ 362 | $ 225 |
| Annual cost w/policy | $ 3,540 | $ 2,045 | $ 1,349 | $ 650 | $ 375 | $ 248 | $ 3,540 | $ 2,045 | $ 1,349 | $ 650 | $ 375 | $ 248 |
| Change in annual cost | $ 109 | $ 72 | $ 125 | $ 20 | $ 13 | $ 23 | $ 109 | $ 72 | $ 125 | $ 20 | $ 13 | $ 23 |
| % change in cost | 3% | 4% | 10% | 3% | 4% | 10% | 3% | 4% | 10% | 3% | 4% | 10% |

***Table 10: Non-Participant Costs in CI 2030 Clean Heat Standard Scenario (3b) in 2030.***

## D) Program and Administrative Costs

Programmatic and policy initiatives are necessary to facilitate and catalyze the adoption of measures needed to meet the GWSA requirements. While the updated BAU scenario narrows the gap between emissions reductions projected under current conditions and those required by the GWSA, without additional program and policy support compliance with GWSA emission reduction requirements is unlikely.

The societal benefits and costs as well as consumer costs associated with policy scenarios that meet the GWSA requirements are discussed in the preceding sections of this report. Here, we focus on the costs associated with the delivery and administration of programs designed to meet the requirements. Vermont is fortunate to have a strong history and infrastructure of energy sector programmatic initiatives to draw upon.

Our analysis of the program and administrative costs is complementary to – but interconnected with – the LEAP scenario modeling, the customer economics workbook, and the rate and fuel price impact workbook, as illustrated in Figure 8 in Section C above.

Table 11 summarizes the primary outputs from the program and administrative cost workbook analysis. The full program administrative cost workbook and model is being submitted as a deliverable for this study, along with the other complementary workbooks and the LEAP model.

| Result | Description | Notes |
|---|---|---|
| **Low- and Moderate - Income (LMI) Incentive Costs** | Total for households with income <= 80% of State median income receiving 100% incentive, plus a 75% of installed cost incentive for households with income between 80% and 120% of state median income. | Design assumption to support equity and ability to transition for LMI households. |

| | | |
|---|---|---|
| **Market Incentive Costs** | Total incentives for measures installed by non-LI households, commercial sector and industry. Percent of measure cost, varies by year and technology. | Appendix F Table 28 provides measure incentive cost by year and technology. |
| **Total Incentive Costs** | Sum of LI and Market Incentives | Total program rebates or financial incentives estimated to be necessary to achieve emission reduction targets. |
| **Resource Acquisition Costs** | Resource acquisition costs include direct incentives, technical assistance, and other direct program delivery costs | Resource Acquisition and Program Administration will be borne by existing providers, obligated entities, or default providers. |
| **Program Administration Costs** | Direct support services for program delivery including IT, Legal, HR. | Clean Heat Standard and Cap and Invest Policies estimated to have increased program administrative costs based on new tracking verification and reporting. |
| **Total Program Costs** | Sum of Resource Acquisition Costs and Program Administration Costs. | The program costs for measures with greater than one year life is amortized over the measure life using a 5% real cost of capital. Each year's program costs are then calculated based on cumulative amortized costs plus annual expense for measures with one year life. |
| **State Administration Costs** | Monitoring, oversight, evaluation and reporting of program activities. | Estimated as share of Program Administrative Costs – cross referenced with estimates of start-up and operating costs for cap and invest and building performance standards from other jurisdictions. |
| **Tax Incentives** | Estimate of Federal Tax Incentives for measures, varies by measure type. | Reduces costs to Vermont consumers and economy. Share of measures claiming tax incentives estimated at 40% see Appendix F Table 27 Row 2 Notes. |

***Table 11: Program and Administrative Cost Workbook Outputs***

The program and administrative cost workbook calculates annual activity and impacts to 2035 along with snapshots of annual program and administrative costs in 2040, 2045 and 2050. Our reporting and narrative focus on the period up to 2035.

**Program and Administrative Cost Results.** The results from the program and administrative cost workbook provide indicators of the magnitude and comparative cost differences between the policy options and the BAU scenario. These results are not isolated, and they should be viewed in context of the other analyses conducted for this study. Our analysis and the results are also not a substitute for more detailed program design and delivery planning and budgeting.

Figure 16 illustrates the total amortized program and state administrative costs above BAU scenario for each policy.

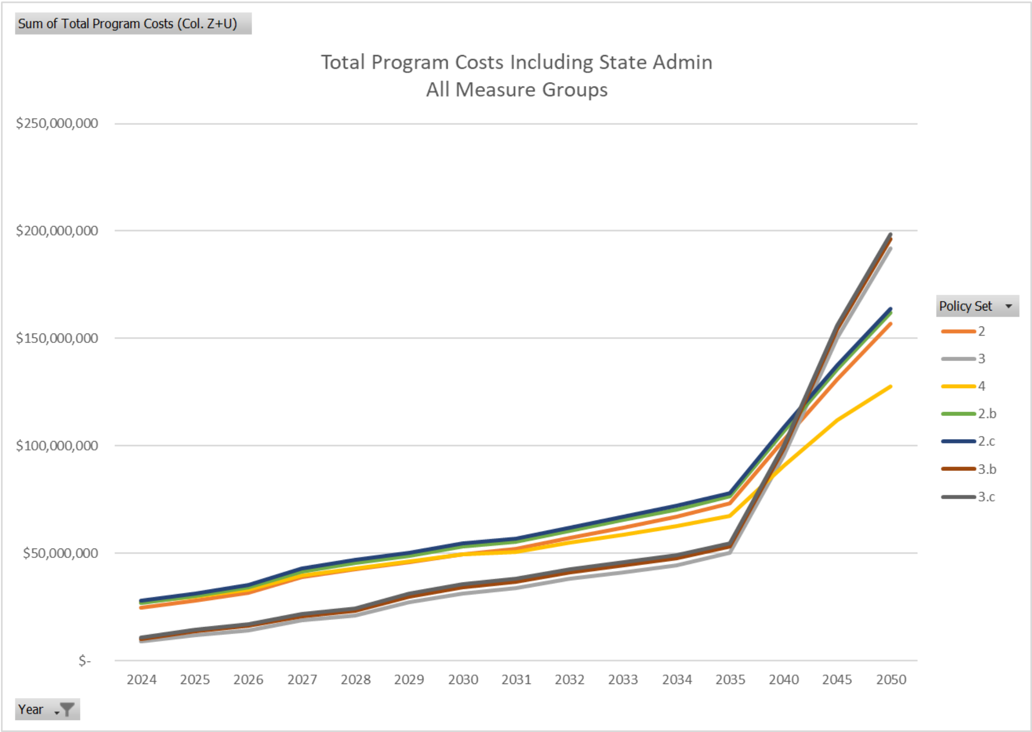


***Figure 16: Total Program and State Administration Costs***

For all policies, the program and administrative costs increase as amortized costs accumulate. For the Scenario 2, 2b, and 2c, the Climate Initiative 2030 Scenarios and the Regulatory Bundle Scenario 4 these costs begin in the range of $24 to $28 million above BAU increasing to $62 to $72 million per year above the BAU scenario by 2034. The RCI proportional scenarios (3, 3b, and 3c) start with costs above BAU in the range of $9 million to $11 million, increasing to $41 to $46 million above BAU in 2034. After 2034 the total program and state administration costs for Scenario 3 increase steeply reaching $200 million by 2050.

The Clean Heat Standard and Cap and Invest policies are projected to have slightly higher (in the range of 8% to 13% over 2024 to 2030) program and administrative costs than expansion of existing initiatives due to new costs for tracking verification and reporting of credits. The Regulatory Bundle has lower program costs and incentives than the other policies, but higher state administrative costs due to increased needs for compliance monitoring, verification, and enforcement. The cap and invest policy can be expected to generate revenues through the auctioning of emission allowances. Our study did not estimate the level of such revenues.

The development of the Regulatory Bundle scenario for this study included a design assumption that due to the practicality and costs of monitoring and enforcing emissions restrictions for larger customers, a greater share of emissions reductions would come from the commercial and industrial sub-sectors with fewer emission reductions from the residential sector. Other policies could also be designed to target greater reductions from the commercial and industrial sectors, and the market dynamic elements of the Clean Heat Standard or Cap and Invest could be expected to rebalance, with a greater focus on emissions reductions from the commercial and industrial sectors, if expectations about the level of low income and residential participation are relaxed.

As noted above, our estimates of program costs assume that low-income households would need financial incentives equal to 100% of the capital costs for heat pumps, weatherization and other measures requiring capital investments and moderate-income households receive an incentive equal to 75% of capital costs. These incentives for low to moderate income households account for approximately 60% of all (residential, commercial, and industrial) program costs.

Based on decades of experience with efficiency programs in Vermont and other states, we have assumed that such high incentives are necessary to ensure low- and moderate-income households participate at levels at least proportional to their share of the population and therefore realize at least a proportional share the benefits of the energy transition. Put another way, the near-term and medium-term emission reductions modeled in this study could be achieved at much lower program cost if the focus was solely on minimizing costs. The significant costs we have modeled for including proportional participation by low- and moderate-income households reflect the program "cost premium" associated with a more equitable energy transition.

Figure 16 represents the cumulative amortized plus annual expensed program costs. These costs, by policy scenario and year, are used in the fuel and rate impact workbook to estimate increases in fuel prices needed to fund the program activities required to meet GWSA requirements. These are lower than the values in Figure 17, due to exclusion of state administrative costs, but otherwise incentives are the main driver of program costs and show a pattern that is generally consistent with Figure 17. The leveling and decline of the costs in the latter years reflects the roll-off of previously amortized costs.

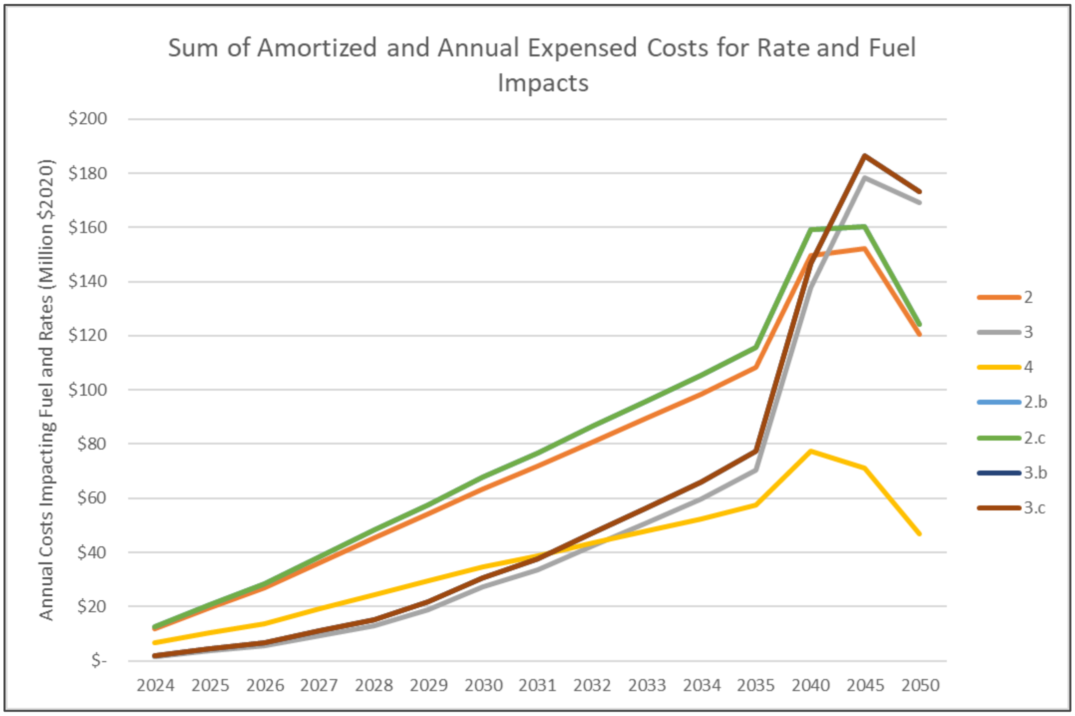


***Figure 17: Program Costs Excluding State Administration***

State administrative costs are illustrated in Figure 18. These are estimated to be higher for the Regulatory Bundle than for other policies, with the expansion of existing initiatives having the lowest state administrative costs.

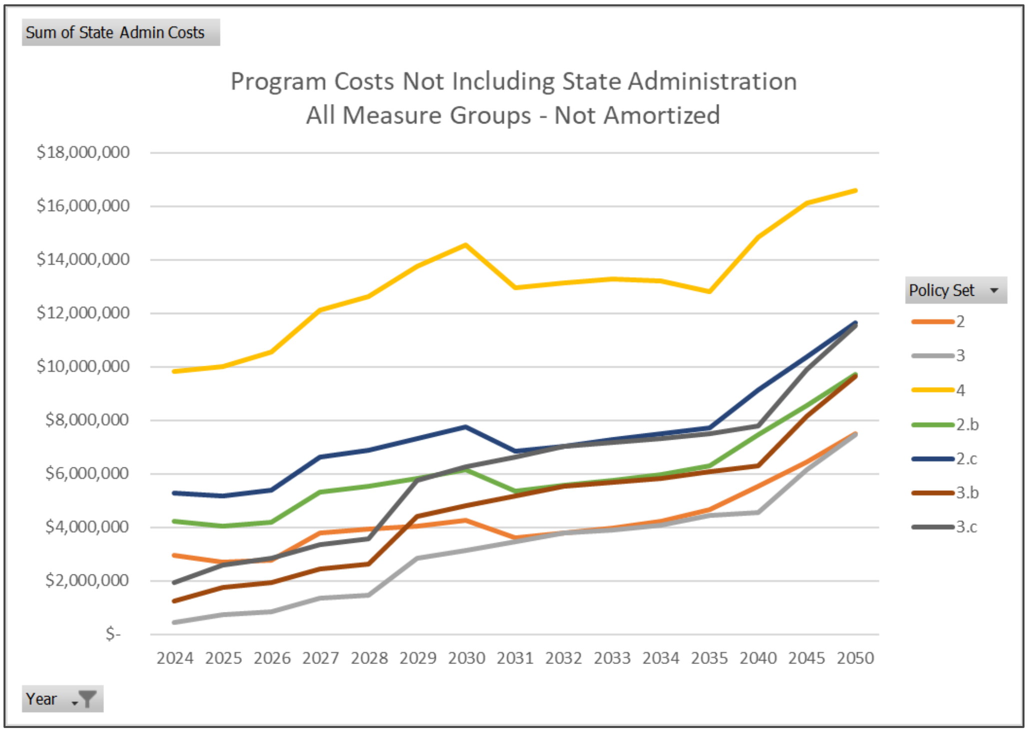


***Figure 18: State Administrative Costs***

The program and administrative cost estimates in the workbook are based on the volume of program activity and measures in each year. This method of estimation may under-estimate start-up costs for new initiatives but may also over-estimate costs in the medium term because it does not capture potential economies of scale, the potential benefits of market transformation for key technologies and/or program and technology innovations that can occur as markets and program delivery matures.

We conducted interviews with specialists currently working on the development and implementation of a cap and invest policy and building performance standards to inform and cross check the results of the program and administrative cost workbook calculations.[27] Staffing and program cost estimations based on these interviews resulted in values of $10 to $60 million above the BAU scenario, which are somewhat lower than the estimates from our workbook analysis. At the same time, the interviewees indicated that program administrative and development costs are a) likely to exceed initial estimates, and b) highly dependent upon

[27] Interviews conducted with Luke Martland and Claire Boyd-White on Washington State Cap and Invest Initiative experience, and with Rajiv Ravulapati of the Institute for Market Transformation on Building Performance Standard design and compliance in several jurisdictions.

the ability to collaborate and coordinate with other jurisdictions. This is particularly true for a state like Vermont with a smaller energy economy.

## E) Fuel Cost and Rate Impacts

The fossil fuel workbook assesses impacts of the selected policy sets on fuel prices and rates for each of the three major fossil fuels targeted for GHG emission reductions: gas, fuel oil and propane. The electricity workbook assesses rate impacts for the electric sector to account for significant changes in consumption likely to result from building electrification. The estimates of fuel price or rate impacts are based solely on estimated program costs and forecast changes in fuel volumes. This simplification will not address, for example, secondary effects resulting from price driven changes in demand for each fuel.

These workbooks take LEAP outputs that translate the number of measures by type in each year, and the incentive and other program costs required for each policy scenario's measure adoption rates and emission reductions. The LEAP model outputs provide the total volumes by fuel type for the BAU and policy set scenarios.

These workbooks also take the program and administrative cost results for each scenario. Costs are allocated to each sector – residential, commercial, and industrial – based on each sector's annual share of fuel sales under each scenario, measured in million British Thermal Units (MMBTu).

Table 12 and Figures 19 and 20 illustrate the outputs of the fuel and rate impact workbooks, illustrating the estimated increase in residential heating oil prices.

| Sector | Year | Fuel | Units | BAU Scenario Average Rate | Average Change in Rates | | |
|---|---|---|---|---|---|---|---|
| | | | | | 2. 2030 Economy-Wide | 3. RCI Proportional | 4.Regulatory Bundle |
| Residential | 2023 | Heating Oil | $/gal | $3.74 | $0.00 | $0.00 | $0.00 |
| Residential | 2024 | Heating Oil | $/gal | $3.58 | $0.04 | $0.01 | $0.02 |
| Residential | 2025 | Heating Oil | $/gal | $3.38 | $0.06 | $0.01 | $0.03 |
| Residential | 2026 | Heating Oil | $/gal | $3.32 | $0.09 | $0.01 | $0.04 |
| Residential | 2027 | Heating Oil | $/gal | $3.26 | $0.13 | $0.03 | $0.07 |
| Residential | 2028 | Heating Oil | $/gal | $3.22 | $0.16 | $0.03 | $0.09 |
| Residential | 2029 | Heating Oil | $/gal | $3.25 | $0.20 | $0.05 | $0.11 |
| Residential | 2030 | Heating Oil | $/gal | $3.30 | $0.25 | $0.09 | $0.15 |
| Residential | 2031 | Heating Oil | $/gal | $3.33 | $0.32 | $0.12 | $0.20 |
| Residential | 2032 | Heating Oil | $/gal | $3.34 | $0.41 | $0.16 | $0.26 |
| Residential | 2033 | Heating Oil | $/gal | $3.37 | $0.49 | $0.20 | $0.32 |
| Residential | 2034 | Heating Oil | $/gal | $3.38 | $0.59 | $0.25 | $0.39 |
| Residential | 2035 | Heating Oil | $/gal | $3.40 | $0.63 | $0.35 | $0.34 |
| Residential | 2040 | Heating Oil | $/gal | $3.46 | $1.13 | $0.86 | $0.58 |
| Residential | 2045 | Heating Oil | $/gal | $3.52 | $1.41 | $1.34 | $0.63 |
| Residential | 2050 | Heating Oil | $/gal | $3.58 | $1.30 | $1.54 | $0.46 |

*Table 12: Residential Heating Oil Price Impacts*

The fuel oil price impacts in Table 12 are based on amortized program costs.

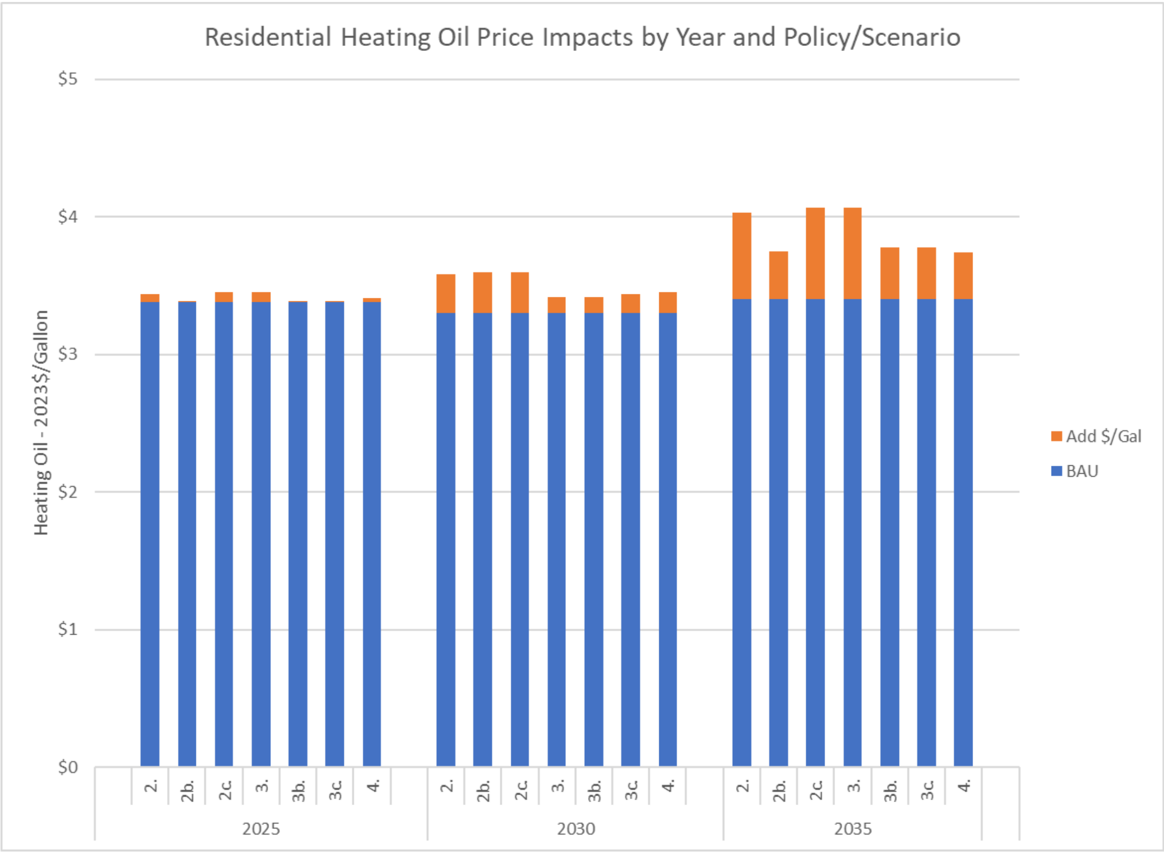


***Figure 19: Residential Fuel Oil Price Impacts with Amortized Program Costs***

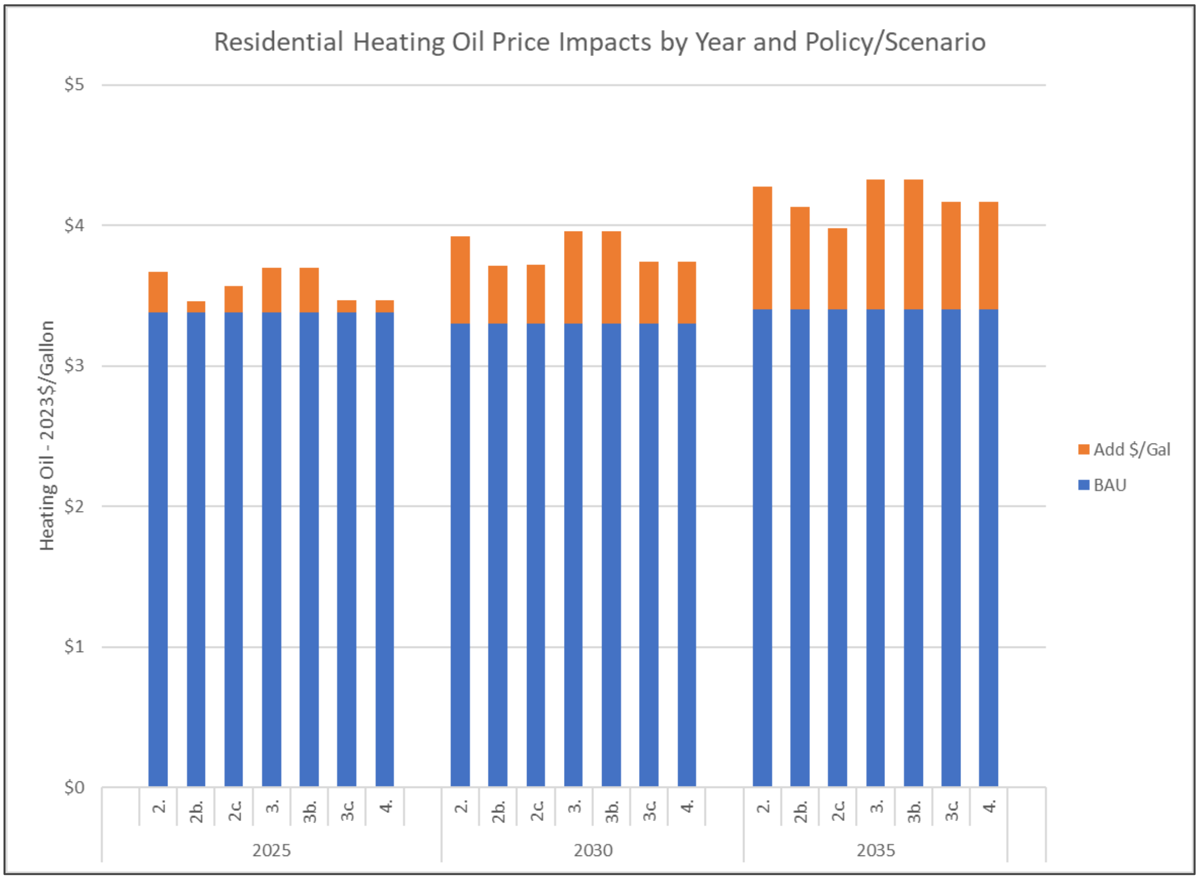


***Figure 20: Residential Fuel Oil Price Impacts with Unamortized Program Costs***

These figures present a baseline forecast of fuel prices without price increases resulting from thermal sector climate policies as well as the expected impact on prices from such policies. Note that the baseline price is forecast to be considerably lower than prices in the most recent Vermont winter of 2022-2023 during which the average residential fuel oil price was $4.73 per gallon and the average propane price was $3.46 per gallon.[28]

[28] "U.S. Energy Information Administration, Vermont Weekly Oil and Propane Prices: average of weekly values from October 2022 through March 2023. (https://www.eia.gov/dnav/pet/PET_PRI_WFR_DCUS_SVT_W.html).

# V. Discussion of Key Questions

This section discusses key questions related to the design, development and implementation of the policies modeled in this study. The modeling results are best considered as providing structured and detailed information to assist with policy and program design, development, and implementation. They are less useful as predictions of outcomes or the means to such outcomes. As the saying goes, "*All models are wrong, some are useful*".

## A) Equity and Just Transitions

Key questions related to the equity and just transition impacts of the policies include:

- Which of the programmatic approaches would require policy interventions, including financial subsidies, to ensure equitable distribution of costs and benefits to consumers?
- How do these interventions impact the overall cost and cost effectiveness of the programmatic approach or policy?

The policy analyses in this study all have substantial participation, emissions reductions, incentives, and program costs from lower income households. Figure 21 illustrates the total incentives supporting adoption of measures by households with incomes less than 120% of the statewide median income. Figure 22 illustrates the total measure incentives indicating that on average across all the policies, close to 80% of the total measure incentives are directed to help low- and moderate- income households reduce their energy burden and lower emissions. The share of total incentives going to low-income households for each policy by year is summarized in Appendix F, Table 30.

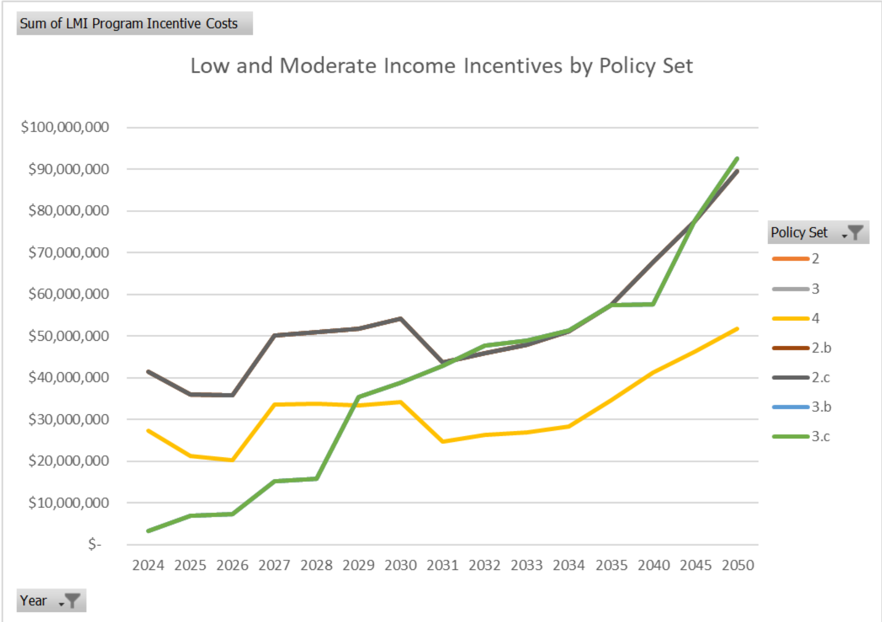


*Figure 21: Low- and Moderate- Income Incentives*

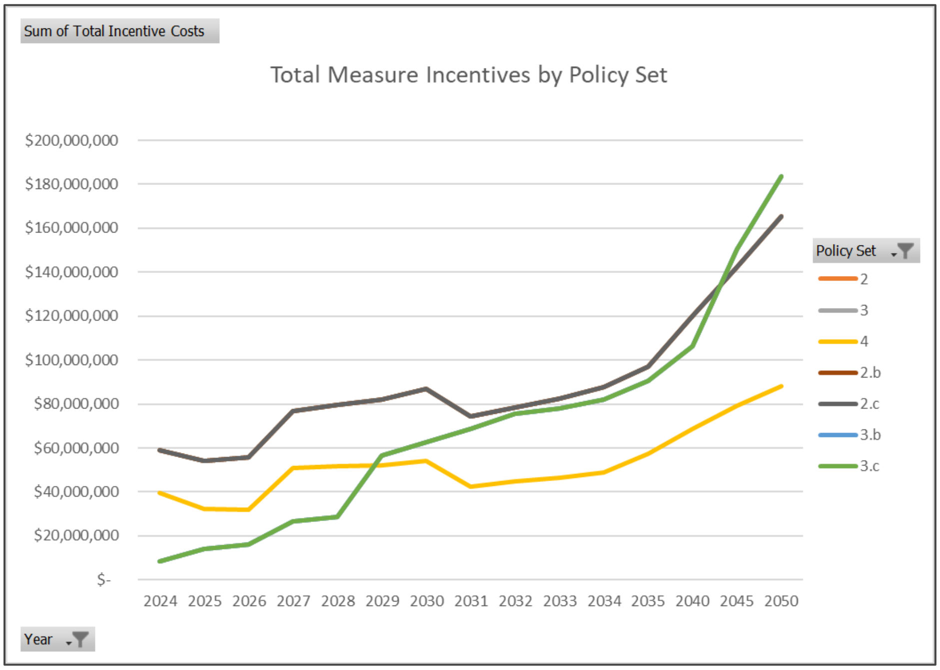


*Figure 22: Total Measure Incentives*

Providing a 100% incentive for decarbonization measures for low-income households and a 75% incentive for moderate-income households is an expensive proposition, and a major driver to the program cost results in this study. However, it is not reasonable to expect low- and moderate-income households will be able or willing to make investments to reduce their emissions without a high level of incentive support. If LMI households do not receive sufficient incentive support, it will be difficult to meet the GWSA requirements. The incentives therefore serve to drive the necessary participation, but also are critical to making sure benefits are realized by Vermonters who are economically disadvantaged.

These incentives and the more efficient and cleaner decarbonization measures will help to lower the annual energy operating costs for participating households while reducing risks and impacts from poor building shell thermal performance and moisture control. Our study uses the damage based social cost of carbon from the Pathways Report as a proxy for avoided economic and social damages associated with fossil fuel use.

The regulatory bundle policy has lower total program and administrative costs than the other Climate Initiative 2030 scenarios, due to having fewer residential sector emissions reduction measures and incentives for low-income households.

- How are the costs and savings of the different programmatic approaches expected to be distributed across Vermont household categories (e.g., urban v. rural, by income level, and if possible, multi-family vs single-family households, as well as specific consideration of the commercial/industrial impact)?
- If savings and costs are anticipated to be uneven, what modifications would help ensure a more balanced approach?

Across our analyses the main driver for the type of decarbonization measure and for the distribution of the costs and benefits is the initial fuel. Across housing stock, tenancy, and urban versus rural populations, our modeling and analysis reflects participation that is proportional to the population demographics. While the modeling reflects differences in energy demand, the size of building, and costs for measures between new construction, existing, and retrofitted (weatherized) homes, the modeling and policies do not target particular building types or sub-populations (with the exception, as noted earlier, of low- and moderate-income households).

The balanced approach in the modeling, based on the population, housing, and fuel use characteristics, helps to underscore the importance of more granular program delivery or design modifications needed to reach harder to serve market segments. Our analysis did not attempt to model an unbalanced versus balanced approaches nor to provide quantitative results for such an outcome. If, as an alternative approach, thermal sector decarbonization efforts focused predominantly on helping fuel oil and propane customers transition, relative to their share of the population, and less so on gas customers, relative to their share of the population, it could be possible to achieve needed emission reductions with lower costs and greater savings (since the economics of switching to clean heat from gas are less attractive than from fuel oil or propane).

- What steps can be taken to encourage early adopters?
- What measures will be needed to support individuals who have yet to make the transition?

Education, outreach, and project-by-project level support will be needed to help consumers have the information and support necessary to facilitate a transition on a time frame that works for them. There are often non-economic factors, such as busy lives, limited information, lack of available and trusted workforce, supply chain issues, and non-energy priorities that prevent consumers from adopting decarbonization measures.

Portions of the resource acquisition and state administration costs discussed in Section IV. C above should be used to create customer support materials, both general and at the project-by-project level. Consistent state-wide thematic messaging should be used, along with the ability to target messaging and information to specific sub-populations. Market incentive levels in the analysis decline somewhat over time. However, to encourage late adopters, it may be necessary to maintain incentive levels even as markets become transformed. As reflected in our study's fuel and rate impact model analysis, for customers that choose to or are not able to implement decarbonization measures, increasing fuel prices (associated with recovery of programmatic costs) will steadily increase the economic motivation for them to switch from fossil fuels. Our study does not address the economic potential stranded cost and equity issues that are the subject of several "Future of Gas" proceedings and studies currently underway in other jurisdictions.

## B) Timing of Building Sector Requirements

- How, if at all, would the least cost approach differ for achieving the 2050 RCI sector GHG emissions target if the approach was not constrained by meeting the 2030 emissions reduction requirement?

Failing to meet the legal obligation of the GWSA by 2030 for the RCI sector reduces program and state administration costs through 2034. Delaying implementation may also reduce or avoid near term pressures related to equipment supply chain, workforce availability and development, delivery bottlenecks, and administrative capabilities.

As mentioned above in the Section IV A) on the analytic results and approach, the scenario modeling for this study matched RCI sector reductions as closely as possible to proportional sectoral requirements, but under the priority constraint of meeting the economy-wide reductions. In doing so, we did not modify the scenarios or measures in the non-RCI sectors. To meet the economy-wide reduction requirements, the RCI sector under this approach "over-complies" with the GWSA 2030 requirement based on strict sector proportionality.

Expanding on this result, if the RCI sector is only required to meet its proportional 40% reductions from 2018 emissions levels, the required emissions in the 2030 are 1,728 thousand metric tonnes of CO2e.

## C) Supporting Policies and Implementation

- What are the critical near-term and longer-term supporting policies (e.g., residential electrical service upgrades, grid infrastructure) that are integral to the successful implementation of each of the programmatic approaches?
- What are the estimated total gross and net costs to fully implement these supporting policies statewide?
- What are the impacts of not fully implementing critical supporting policies on overall cost effectiveness of each of the programmatic approaches in the RCI sector?

Meeting the emissions reduction requirements of the GWSA relies heavily on electrification in the building and transportation sectors. Electric technologies are more efficient than combustion-based technologies across the sectors, and so the total increase in electricity consumption is moderated. The estimated increase in electricity final demand for the scenarios is illustrated in Figure 23.

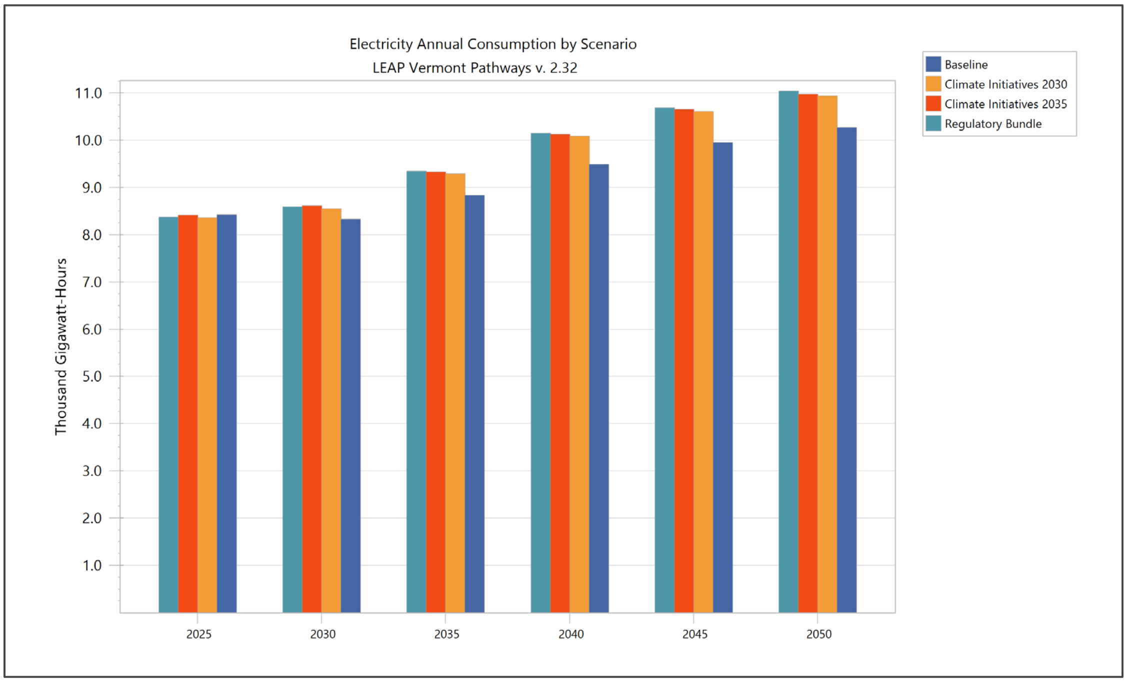


*Figure 23: Annual Final Demand Electric Consumption by Scenario*

Similarly, system-wide peak electric power requirements are projected to increase in the BAU scenario and across the scenarios as illustrated in Figure 24.

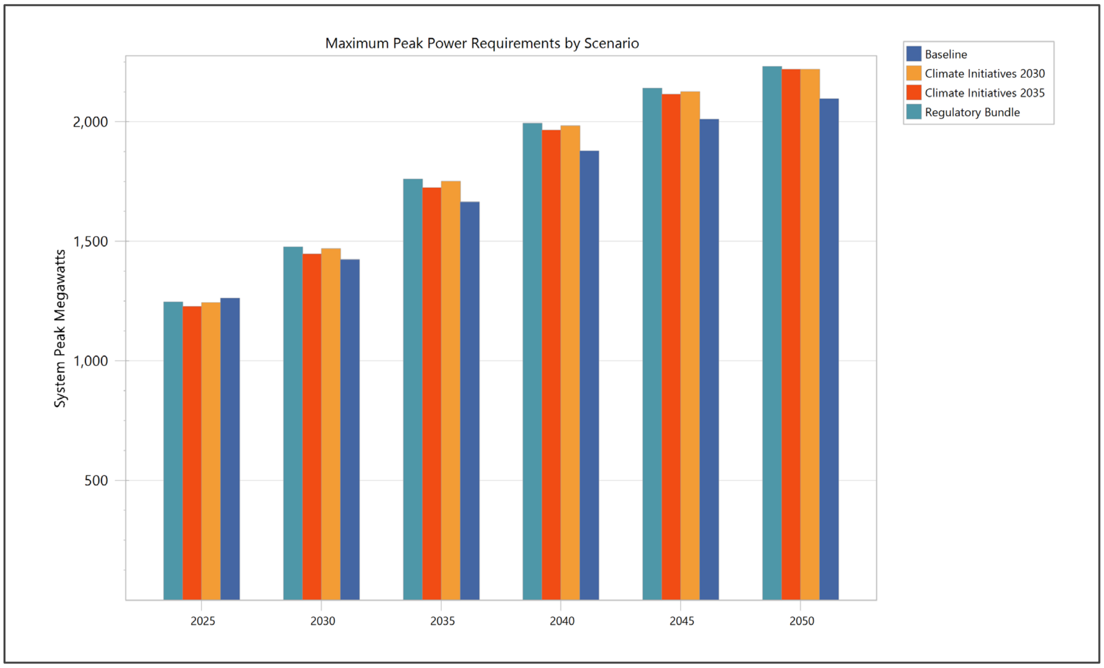


*Figure 24: System Wide Peak Electric Demand*

Our analyses and scenario modeling provide helpful, but only very high-level, indicators for more detailed planning and policy development concerning grid infrastructure improvements. The scenario analyses assume that 75% of electric vehicle battery charging is managed so that it reduces system peak impacts. Our analysis does not address the opportunity or impacts of flexible load management, storage, and rate design to minimize the increased electric peak impacts of building electrification.

Our estimated costs for electrification technologies assume that a portion of households will require electric panel service upgrades. There are also transmission and distribution costs of $84/kW-yr for increasing peak demand in the transformation module.

Given the anticipated increase in electrification and the associated grid improvement planning, a structured benefit cost framework permitting comparison of both traditional transmission and distribution investments and non-wire alternatives (such as battery storage and distributed generation) should be developed. This is best done through a stakeholder process that includes both utility and non-utility perspectives.

The implications of not addressing the grid improvement planning needs could include reduced grid resilience and reliability, bottlenecks on the grid that impede adoption of electrification measures, higher system costs, and higher electric rates for consumers.

- What information is needed to inform, manage, design, and implement each programmatic approach?
- What gaps exist in the information that is currently available?
- What program design decisions need to be made up front to best understand impacts of the program?

Vermont has a strong track-record of energy program design, planning, regulatory and administrative oversight, and delivery. This is a significant asset when considering the challenges of programmatic development and implementation necessary to meet the GWSA requirements. The scale, depth, and pace of the required adoption of decarbonization measures far exceeds historic levels. While Vermont has made good initial progress towards a transformed energy economy, particularly in end-use efficiency and a decarbonized electric grid, meeting the GWSA mandates requires fundamentally transforming most of the energy use in the RCI and transportation sectors.

Key factors that will need to be addressed during programmatic development include:

a. **Workforce requirements and potential**. Delivery of results requires an expanded and enhanced workforce across most, if not all, segments of the supply chain. This is not limited strictly to the delivery of equipment and services (such as cold climate heat pumps or weatherization), but also to planning, grid-engineering, regulation, program management and over-sight, finance, information technology, data security, and communications. Across the whole system, new staffing will be needed to increase and sustain the pace of transitions. How to best identify, attract, develop and retain this multi-faceted workforce will be an ongoing area of need for up-to-date information, strategic planning, and implementation.

b. **Inclusive, and efficient regulatory and planning.** Program implementation will require engagement with stakeholders, impacted industries and communities and other stakeholders. These all require time and information sharing. Meeting the required pace of programmatic implementation, however, cuts the other direction, potentially limiting the time and availability information for decision making. Progress depends on balancing these factors – and planning and regulatory functions that do not get bogged down but use adaptive and collaborative planning, management, and oversight to continuously revisit, revise and improve results.

c. **Coordination with other markets and jurisdictions.** The ability to coordinate initiatives with other jurisdictions can lead to significant cost savings for program management and administrative costs. It may also reduce costs for delivered measures due to great economies of scale. Vermont is a relatively small market. Aligning programmatic and policy initiatives with other markets and jurisdictions could increase the potential to influence and benefit from broader markets and new technology developments. Information sharing and coordination with other jurisdictions may or may not be helpful. At the same time, coordination and collaboration with jurisdictions outside of Vermont risks slowing implementation, may take more time, and could require additional financial and personnel resources.

d. **Consumer behavior and equity.** Information leading to better understanding of consumer behavior and the levels and types of financial and non-financial support consumers require to transition is critical to program implementation and success. It also has significant implications for program costs and equity. Again, Vermont has substantial experience and assets to draw upon in this regard, but expanded and enhanced analytics, decision modeling, messaging, support services, and market channels will be needed.

e. **Support for impacted businesses and individuals.** Transitioning an energy system away from fossil fuels and their associated economic and environmental costs provides a great opportunity for new businesses and for consumers to benefit from more efficient systems and technologies. There will, however, also inevitably be businesses and or consumers who are negatively impacted through the transition. In part, the potential negative impacts help to speed the transition through market and regulatory signals, and it would be ill-advised to design the potential motivating features of negative impacts completely out of the system. In other words, if you design programs or policies to completely shield all customers from all potential negative impacts, they will have less impetus to make changes. Information on the scale and type of support needed to constructively mitigate or alleviate negative impacts, while maintaining encouragement for transition will help to maintain progress on emission reductions, while providing an appropriately designed safety-net.

# VI. Conclusions

This study indicates multiple policy options can meet GWSA requirements. The analyses and results also indicate that within each policy, multiple adoption profiles can meet requirements. The modeling and results are not prescriptive or predictive. For each of the policy sets there are other possible mixes of measures and measure adoption rates that can meet the GWSA requirements. At the same time several common structural themes for reducing emissions, economy-wide and for the RCI sector, are apparent. Key findings and conclusions from our work are:

- It has been understood for quite some time that meeting Vermont's GWSA requirements will depend fundamentally on three complementary activities, a) reduced demand through more efficient buildings, equipment and management, b) a supply of decarbonized electricity matched to loads, and c) electrification of building and transportation end uses. Results of this study have now made clear the following about the impacts and net societal costs and benefits of doing so.

- Our societal benefit cost results indicate economy-wide the GWSA compliant scenarios entail additional net social costs of $568 million to $1.485 billion. In 2021 Vermont's total energy expenditures were $2.814 billion[29] putting the net costs for meeting the economy-wide emissions reduction requirements in the range of 0.9% to 2.4% of the present value of annual energy expenditures over the study horizon.[30]

- If the RCI sector is responsible for only meeting its 40% proportional emissions reductions from 2018 historic levels, then the Climate Initiative 2035 scenarios are sufficient to meet the 2030 requirements. Meeting the economy-wide 2030 GWSA requirement if the RCI sector adopts the Climate Initiative 2035 profile requires an additional 300 thousand metric tonnes of CO2e reductions from other sectors. Such reductions cannot be assumed without additional policies and programs to ensure attainment.

- The societal cost benefit results indicate the regulatory bundle has the lowest net cost, of $568 million over the study horizon. This is the result of attaining a higher level of emissions reductions from the commercial and industrial sectors, and less from the residential sector. Therefore, the societal cost findings for this bundle have less to do with the relative costs of regulation versus other approaches and more to do with assumptions of who will participate in and who will respond to this modeled approach. If the other scenarios also placed a greater emphasis on reductions from the commercial and industrial sector, their net costs would be reduced and more aligned with the regulatory bundle result.

- The regulatory bundle scenario relies more on compliance enforcement and less on incentives to catalyze transitions. It has higher state administrative costs and lower program and incentive costs. The practicality and acceptability of relying on more of a compliance and enforcement-based approach in comparison to incentive driven approaches is an important qualitative factor to consider.

- The expansion of existing programs and initiatives is estimated to have lower program and administrative costs than a clean heat standard and the cap and invest initiative. This is because there are fewer requirements for the development of new programs and

[29] Energy Information Administration, Vermont State Energy Profile, August 2023 update: https://www.eia.gov/state/data.php/notes-sources.cfm?sid=VT

[30] Annual Expenditures of $2.8 billion x 30 years discounted at 2% = $63.02 billion. $568Mn/$63.02Bn = 0.9%, and $1.49Bn/$64.5Bn = 2.36%.

administrative structures and functions. The variation between the program and administrative costs for these initiatives is relatively small in comparison to the overall investments and benefits.

- Our study and research highlight important potential differences in costs and benefits, the timing of measure adoption, and implementation issues between policies. It does not support the conclusion that one policy is definitively superior to the other options for reducing emissions from the RCI sector.

- The study highlights many common implementation, design, and delivery challenges related to the scale and pace of development required to meet the GWSA. This holds true regardless of the policy choice. Even the BAU scenario embodies emission reductions and adoption of measures that are much faster and deeper than historic levels.

- The design of policies and programmatic initiatives to meet the GWSA is a historic opportunity to address equity impacts of energy use. For this study, our analysis assumes incentive levels for low-income households cover 100% of the measure costs. This means adopting more efficient and cleaner technologies can reduce the energy burden for economically disadvantaged households. The levels of participation and incentive levels for low-income households are significant drivers of the program and administrative costs. This level of investment is likely necessary to support a just, equitable, and sustainable transition. Without enabling participation from low-income households, attaining the GWSA requirements will be difficult if not impossible, and would not address the important equity and justice policy objectives.

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## B. Qualitative Assessment – Criteria and Results

The qualitative assessment of policy options is presented in detail in the separate task report available on the Vermont Climate Council's website.[31]

## C. LEAP Model Documentation and Detailed Outputs

### LEAP Model Description, Inputs and Assumptions

The Vermont energy systems model is constructed using the Low Emissions Analysis Platform, or LEAP, developed by the Stockholm Environment Institute[32]. For this analysis, the project team updated the energy model constructed originally for Vermont's Climate Action Plan and Comprehensive Energy Plan. Important details of the model's construction, methodology and main data sources can be found in the 2022 Vermont Pathways Analysis Report[33], as well as Appendix D of the state's 2022 Comprehensive Energy Plan[34]. Beginning with this model, the project team made a number of changes and updates to reflect additional historical data not available during the model's original construction, corrections to previous historical assumptions, and updated assumptions to be integrated with the model's BAU scenario or modeling of individual mitigation options. These changes are described in an attachment to this appendix, available here:

Attachment C1: Descriptions of Individual Mitigation Options has been provided to the state team.

In addition, the LEAP model itself (version 3.27) has been provided to the state team.

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[31] https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/Task%202%20Policy%20Options%20and%20Qualitative%20Assessment%203-16-23.pdf

[32] Heaps, C.G., 2022. LEAP: The Low Emissions Analysis Platform. [Software version: 2020.1.91] Stockholm Environment Institute. Somerville, MA, USA. https://leap.sei.org

[33] EFG and Cadmus. Vermont Pathways Analysis Report 2.0, February 11, 2022. Prepared for the Vermont Agency of Natural Resources, https://climatechange.vermont.gov/sites/climatecouncilsandbox/files/2022-03/Pathways%20Analysis%20Report_Version%202.0.pdf.

[34] SEI and NESCAUM. Analysis of Greenhouse Gas Emission Reduction Pathways for Vermont. January 13, 2022. Prepared for the Vermont Public Service Department, https://publicservice.vermont.gov/sites/dps/files/documents/CEP_AppendixD_LEAPModelingReport.pdf.

The model includes built-in documentation about data sources and assumptions, visible through the LEAP "Notes" feature located at each branch inside the model. Supplementary or intermediate calculations, many of which are conducted using Microsoft Excel, are also included inside the model itself and are visible to users after the model is opened on a computer running LEAP. No special license is required to open and view the model, but users must download and install an appropriate version of LEAP to do so. The model was constructed and tested using LEAP version 2020.1.0.91 and NEMO version 1.9.0.

### Selected Modeling Outputs

Select modeling outputs for Appendix C were provided to the state team as an Excel file titled, "final_charts_for_report_11-15-2023."

## D. Customer Perspective Workbook and Results

The customer economics workbook assesses investments in decarbonization measures such as heat pumps, weatherization, and advanced wood heating systems for the most important GHG-reducing measures incorporated into the LEAP model.

We begin with the energy consumption and the annual cost of a fossil fuel measure in each scenario. Utilizing the efficiency of both the fossil fuel and decarbonization measures, we calculate the energy consumed by the decarbonization measure after the switch. We can then calculate the annual cost of the decarbonization measure, and then the change in annual costs as a result of the switch to the decarbonization measures.

We also incorporate the capital costs of both the fossil fuel and decarbonization measures. By incorporating the measure life of the decarbonization measure and a real discount rate of 5%, we can calculate the annualized incremental capital cost of the switch to the fossil decarbonization measure.

We then incorporate the incentives and tax credits available for the decarbonization measure, aligned with the program and admin costs workbook. We can then calculate the annualized incremental capital costs of the decarbonization measures for both LMI and market rate households. By incorporating the change in annual costs and capital costs from a switch from a fossil fuel to a decarbonization measure, we are able to calculate the net change in annual costs for LMI and market rate households.

The result is a calculation of the net change in annual costs for LMI and market rate households for each policy set in 2025 and 2030 for electrification measures, advanced wood heat measures, and weatherization. The workbook identifies cases in which customer costs are reduced for a decarbonization measure and those for which customer costs are increased.

## E. Fuel and Rate and Bill Impacts Modeling and Results

The fossil fuel workbook assesses impacts of the selected policy sets on fuel prices and rates for each of the three major fossil fuels targeted for GHG emission reductions: gas, fuel oil and propane. The electricity workbook assesses rate impacts for the electric sector to account for significant changes in consumption likely to result from building electrification. The estimates of fuel price or rate impacts are based solely on estimated program costs and forecast changes in fuel volumes. This simplification will not address, for example, secondary effects resulting from price driven changes in demand for each fuel.

These workbooks take LEAP outputs that translate the number of measures by type in each year, and the incentive and other program costs required for each policy scenario's measure adoption rates and emission reductions. The LEAP model outputs provide the total volumes by fuel type for the BAU and policy set scenarios.

These workbooks also take the program and administrative cost results for each scenario. Costs are allocated to each sector – residential, commercial, and industrial – based on each sector's annual share of fuel sales under each scenario, measured in (one million British thermal unit) MMBTu.

Charges for utility-delivered energy are expressed in average cost per unit of energy (UE) consumed for customer class *i*. That is:

$$Revenue_{i0} = FixedCharges_{i0} + VariableChargePer\ UE_{i0} \times UE\ Sales_{i0}$$

***where:***

$$VariableChargePer\ UE_{i0} = \frac{VariableCharges_{i0}}{UE\ Sales_{i0}}$$

And UE equals kWh for electricity and MCF for natural gas

Variable charges include combined energy revenues for each customer class. Customer classes were defined as:

- Residential customers
- Commercial customers
- Industrial customers

LEAP modeled electricity forecasts for transportation in addition to the three customer classes listed above. Passenger car electricity forecasts were treated as residential while light, medium, and heavy-duty vehicle electricity forecasts were treated as commercial.

The base-case forecast fixed and variable charges over the study period to estimate retail rates in the absence of future policy scenarios. The forecasted charges (fixed and variable) in any year *y* were held constant in real terms:

$$Revenue_y = FixedCharges_y + \ (VariableChargesPer\ UE_y \times \ UE\ Sales_y)$$

***where:*** $kWhSales_y$ represents each EEU's forecasted sales in year *y in* the absence of future DSM programs.

Electric rate impacts are a function of increased sales volumes driven by electrification in the buildings and transportation sectors, as well as increased costs for meeting electric sector demands. When added costs increase more quickly than the rate base, electric rates will go up. For electric rates, the additional costs use the 2022-2023 avoided costs approved by the Vermont DPS and treat those as additional incurred costs when retail sales forecasts increase. The analysis also applied an avoided transmission and distribution cost of $84.02 /kW/year at the meter and treated as an incurred cost for each additional peak kW forecast under each of the policy scenarios.

Increased costs for natural gas service are derived from EEU costs and savings that the PUC approved for 2018. The rate impact analysis applied avoided costs without social costs of carbon and externalities.

Propane and fuel oil are assumed to not include fixed customer charges and are structured to recover all costs through variable volumetric charges. At a high level, estimates of annual impacts for these fuels are driven by annual estimated program costs spread across remaining sales of each delivered fuel (fossil fuel and biofuel).

Base-year natural gas rates are derived from rate class-specific daily access charges, natural gas charges, distribution charges, and assistance program fees issued May 2023. Links to all files downloaded and sources for residential and G-class (G1-G4) rates are provided in the Fuel Price

Analysis workbook. Fixed customer charges were weighted by fiscal year 2022 customer counts and volumetric charges were weighted by fiscal year 2022 revenues for each class. Customer counts and revenues were provided by Vermont Gas to Cadmus as part of the 2022 Energy Efficiency Potential Assessment for the Vermont Department of Public Service.

BAU scenario propane and heating oil prices were taken from the LEAP model, derived from EIA Vermont Weekly Heating Oil and Propane Prices in 2023.

Changes from the base year for natural gas, propane, and heating oil were based on year-over-year percent changes observed in the Annual Energy Outlook 2023 price forecasts.

## Fossil Fuel Results

| Sector | Year | Fuel | Units | BAU Scenario Average Rate | Average Change in Rates | | |
|---|---|---|---|---|---|---|---|
| | | | | | 2. 2030 Economy-Wide | 3. RCI Proportional | 4.Regulatory Bundle |
| Residential | 2023 | Natural Gas | $/MCF | $14.70 | $0.23 | -$0.02 | $0.21 |
| Residential | 2024 | Natural Gas | $/MCF | $13.90 | $0.72 | $0.04 | $0.43 |
| Residential | 2025 | Natural Gas | $/MCF | $13.92 | $1.03 | $0.08 | $0.63 |
| Residential | 2026 | Natural Gas | $/MCF | $14.11 | $1.38 | $0.11 | $0.82 |
| Residential | 2027 | Natural Gas | $/MCF | $14.29 | $1.90 | $0.34 | $1.19 |
| Residential | 2028 | Natural Gas | $/MCF | $14.53 | $2.40 | $0.39 | $1.51 |
| Residential | 2029 | Natural Gas | $/MCF | $14.88 | $2.95 | $0.75 | $1.86 |
| Residential | 2030 | Natural Gas | $/MCF | $15.31 | $3.70 | $1.26 | $2.37 |
| Residential | 2031 | Natural Gas | $/MCF | $15.64 | $4.69 | $1.65 | $3.08 |
| Residential | 2032 | Natural Gas | $/MCF | $15.93 | $5.84 | $2.22 | $3.94 |
| Residential | 2033 | Natural Gas | $/MCF | $16.46 | $7.18 | $2.87 | $4.94 |
| Residential | 2034 | Natural Gas | $/MCF | $16.80 | $8.57 | $3.64 | $5.95 |
| Residential | 2035 | Natural Gas | $/MCF | $17.11 | $2.26 | $1.02 | $1.76 |
| Residential | 2040 | Natural Gas | $/MCF | $18.44 | $4.71 | $2.45 | $3.35 |
| Residential | 2045 | Natural Gas | $/MCF | $19.37 | $8.29 | $4.72 | $5.30 |
| Residential | 2050 | Natural Gas | $/MCF | $19.67 | $12.86 | $8.40 | $7.13 |

*Table 13: Residential Natural Gas Rate Forecasts by Scenario*

Natural gas prices for residential customers increase steadily over time under each of the three scenarios. The 2030 Economy-wide scenario has the greatest increase by 2034, $8.57/MCF, a 51% increase. The increase is driven by a combination of program costs incurred and a smaller rate base to spread the costs over as natural gas consumption decreases, overall. Residential natural gas sales under the three scenarios are projected to decrease by as much as 80% of 2023 sales by 2050. The RCI proportional scenario does not see increases of the same magnitude because natural gas sales forecasts decrease more slowly than the 2030 scenario.

| Sector | Year | Fuel | Units | BAU Scenario Average Rate | Average Change in Propane Prices | | |
|---|---|---|---|---|---|---|---|
| | | | | | 2. 2030 Economy-Wide | 3. RCI Proportional | 4.Regulatory Bundle |
| Residential | 2023 | Propane | $/gal | $3.24 | $0.00 | $0.00 | $0.00 |
| Residential | 2024 | Propane | $/gal | $3.32 | $0.04 | $0.01 | $0.02 |
| Residential | 2025 | Propane | $/gal | $3.42 | $0.06 | $0.01 | $0.03 |
| Residential | 2026 | Propane | $/gal | $3.50 | $0.09 | $0.01 | $0.04 |
| Residential | 2027 | Propane | $/gal | $3.57 | $0.13 | $0.03 | $0.07 |
| Residential | 2028 | Propane | $/gal | $3.66 | $0.16 | $0.03 | $0.09 |
| Residential | 2029 | Propane | $/gal | $3.72 | $0.20 | $0.05 | $0.11 |
| Residential | 2030 | Propane | $/gal | $3.79 | $0.25 | $0.09 | $0.15 |
| Residential | 2031 | Propane | $/gal | $3.84 | $0.32 | $0.12 | $0.20 |
| Residential | 2032 | Propane | $/gal | $3.91 | $0.41 | $0.16 | $0.26 |
| Residential | 2033 | Propane | $/gal | $3.96 | $0.49 | $0.20 | $0.32 |
| Residential | 2034 | Propane | $/gal | $4.00 | $0.59 | $0.25 | $0.39 |
| Residential | 2035 | Propane | $/gal | $4.04 | $0.63 | $0.35 | $0.34 |
| Residential | 2040 | Propane | $/gal | $4.25 | $1.13 | $0.86 | $0.58 |
| Residential | 2045 | Propane | $/gal | $4.40 | $1.41 | $1.34 | $0.63 |
| Residential | 2050 | Propane | $/gal | $4.55 | $1.30 | $1.54 | $0.46 |

*Table 14: Residential Propane Price Forecasts by Scenario*

Propane prices for residential customers increase steadily through 2034 under each of the three scenarios. The 2030 Economy-wide scenario has the greatest increase by 2034, $0.59/gal, a 15% increase. The increase is driven by a combination of program costs incurred through 2035. Unlike natural gas, the analysis assumes no fixed costs for propane. Therefore, prices of propane do not increase as usage decreases.

| Sector | Year | Fuel | Units | BAU Scenario Average Rate | Average Change in Rates | | |
|---|---|---|---|---|---|---|---|
| | | | | | 2. 2030 Economy-Wide | 3. RCI Proportional | 4.Regulatory Bundle |
| Residential | 2023 | Heating Oil | $/gal | $3.74 | $0.00 | $0.00 | $0.00 |
| Residential | 2024 | Heating Oil | $/gal | $3.58 | $0.04 | $0.01 | $0.02 |
| Residential | 2025 | Heating Oil | $/gal | $3.38 | $0.06 | $0.01 | $0.03 |
| Residential | 2026 | Heating Oil | $/gal | $3.32 | $0.09 | $0.01 | $0.04 |
| Residential | 2027 | Heating Oil | $/gal | $3.26 | $0.13 | $0.03 | $0.07 |
| Residential | 2028 | Heating Oil | $/gal | $3.22 | $0.16 | $0.03 | $0.09 |
| Residential | 2029 | Heating Oil | $/gal | $3.25 | $0.20 | $0.05 | $0.11 |
| Residential | 2030 | Heating Oil | $/gal | $3.30 | $0.25 | $0.09 | $0.15 |
| Residential | 2031 | Heating Oil | $/gal | $3.33 | $0.32 | $0.12 | $0.20 |
| Residential | 2032 | Heating Oil | $/gal | $3.34 | $0.41 | $0.16 | $0.26 |
| Residential | 2033 | Heating Oil | $/gal | $3.37 | $0.49 | $0.20 | $0.32 |
| Residential | 2034 | Heating Oil | $/gal | $3.38 | $0.59 | $0.25 | $0.39 |
| Residential | 2035 | Heating Oil | $/gal | $3.40 | $0.63 | $0.35 | $0.34 |
| Residential | 2040 | Heating Oil | $/gal | $3.46 | $1.13 | $0.86 | $0.58 |
| Residential | 2045 | Heating Oil | $/gal | $3.52 | $1.41 | $1.34 | $0.63 |
| Residential | 2050 | Heating Oil | $/gal | $3.58 | $1.30 | $1.54 | $0.46 |

*Table 15: Residential Heating Oil Price Forecasts by Scenario*

Heating oil prices for residential customers increase steadily through 2034 under each of the three scenarios. The 2030 Economy-wide scenario has the greatest increase by 2034, $0.59/gal, a 17% increase. The increase is driven by a combination of program costs incurred through 2035. Unlike natural gas, the analysis assumes no fixed costs for heating oil. Therefore, prices of heating oil do not increase as usage decreases.

| Sector | Year | Fuel | Units | BAU Scenario | Average Change in Rates | | |
|---|---|---|---|---|---|---|---|
| | | | | | 2. 2030 Economy-Wide | 3. RCI Proportional | 4.Regulatory Bundle |
| Commercial | 2023 | Natural Gas | $/MCF | $10.68 | $0.08 | -$0.02 | $0.12 |
| Commercial | 2024 | Natural Gas | $/MCF | $9.61 | $0.52 | $0.06 | $0.28 |
| Commercial | 2025 | Natural Gas | $/MCF | $9.35 | $0.76 | $0.12 | $0.40 |
| Commercial | 2026 | Natural Gas | $/MCF | $9.23 | $1.00 | $0.14 | $0.49 |
| Commercial | 2027 | Natural Gas | $/MCF | $9.08 | $1.38 | $0.31 | $0.72 |
| Commercial | 2028 | Natural Gas | $/MCF | $9.02 | $1.71 | $0.29 | $0.86 |
| Commercial | 2029 | Natural Gas | $/MCF | $9.14 | $2.08 | $0.56 | $1.03 |
| Commercial | 2030 | Natural Gas | $/MCF | $9.27 | $2.61 | $0.95 | $1.33 |
| Commercial | 2031 | Natural Gas | $/MCF | $9.22 | $3.34 | $1.22 | $1.80 |
| Commercial | 2032 | Natural Gas | $/MCF | $9.31 | $4.24 | $1.65 | $2.45 |
| Commercial | 2033 | Natural Gas | $/MCF | $9.40 | $5.20 | $2.12 | $3.16 |
| Commercial | 2034 | Natural Gas | $/MCF | $9.45 | $6.23 | $2.65 | $3.86 |
| Commercial | 2035 | Natural Gas | $/MCF | $9.50 | -$0.47 | -$0.23 | -$0.67 |
| Commercial | 2040 | Natural Gas | $/MCF | $9.66 | -$0.78 | -$0.55 | -$1.19 |
| Commercial | 2045 | Natural Gas | $/MCF | $9.86 | -$1.22 | -$1.03 | -$2.00 |
| Commercial | 2050 | Natural Gas | $/MCF | $9.82 | -$2.35 | -$2.47 | -$3.78 |

***Table 16: Commercial Natural Gas Rate Forecasts by Scenario***

Natural gas prices for commercial customers increase steadily through 2034 under each of the three scenarios. The 2030 Economy-wide scenario has the greatest increase by2034, $6.23/MCF, a 66% increase. The increase is driven by a combination of program costs incurred and a smaller rate base to spread the costs over as natural gas consumption decreases, overall.

However, rates are projected to decrease relative to the BAU scenario between 2035 and 2050. Commercial natural gas sales are projected to decrease by as much as 64% relative to 2023 sales by 2050, so the commercial rate base does not decrease as much as the residential rate base, which sees increased rates through 2050. Additionally, variable costs account for a smaller share of rates for commercial customers than for residential customers, so there are fewer fixed costs to recover for commercial customers, putting less upward pressure on rates.

| Sector | Year | Fuel | Units | BAU Scenario | Average Change in Rates | | |
|---|---|---|---|---|---|---|---|
| | | | | | 2. 2030 Economy-Wide | 3. RCI Proportional | 4.Regulatory Bundle |
| Commercial | 2023 | Propane | $/gal | $3.24 | $0.00 | $0.00 | $0.00 |
| Commercial | 2024 | Propane | $/gal | $3.32 | $0.04 | $0.01 | $0.02 |
| Commercial | 2025 | Propane | $/gal | $3.42 | $0.06 | $0.01 | $0.03 |
| Commercial | 2026 | Propane | $/gal | $3.50 | $0.09 | $0.01 | $0.04 |
| Commercial | 2027 | Propane | $/gal | $3.57 | $0.13 | $0.03 | $0.07 |
| Commercial | 2028 | Propane | $/gal | $3.66 | $0.16 | $0.03 | $0.09 |
| Commercial | 2029 | Propane | $/gal | $3.72 | $0.20 | $0.05 | $0.11 |
| Commercial | 2030 | Propane | $/gal | $3.79 | $0.25 | $0.09 | $0.15 |
| Commercial | 2031 | Propane | $/gal | $3.84 | $0.32 | $0.12 | $0.20 |
| Commercial | 2032 | Propane | $/gal | $3.91 | $0.41 | $0.16 | $0.26 |
| Commercial | 2033 | Propane | $/gal | $3.96 | $0.49 | $0.20 | $0.33 |
| Commercial | 2034 | Propane | $/gal | $4.00 | $0.59 | $0.25 | $0.39 |
| Commercial | 2035 | Propane | $/gal | $4.04 | $0.63 | $0.35 | $0.35 |
| Commercial | 2040 | Propane | $/gal | $4.25 | $1.06 | $0.87 | $0.63 |
| Commercial | 2045 | Propane | $/gal | $4.40 | $1.29 | $1.43 | $0.83 |
| Commercial | 2050 | Propane | $/gal | $4.55 | $1.29 | $1.92 | $0.81 |

***Table 17: Commercial Propane Price Forecasts by Scenario***

Propane prices for commercial customers increase steadily through 2034 under each of the three scenarios. The 2030 Economy-wide scenario has the greatest increase by 2034, $0.59/gal, a 15% increase. The increase is driven by a combination of program costs incurred through 2035. Unlike natural gas, the analysis assumes no fixed costs for propane. Therefore, propane prices do not increase as usage decreases.

| Sector | Year | Fuel | Units | BAU Scenario | Average Change in Rates | | |
|---|---|---|---|---|---|---|---|
| | | | | | 2. 2030 Economy-Wide | 3. RCI Proportional | 4.Regulatory Bundle |
| Commercial | 2023 | Heating Oil | $/gal | $3.74 | $0.00 | $0.00 | $0.00 |
| Commercial | 2024 | Heating Oil | $/gal | $3.58 | $0.04 | $0.01 | $0.02 |
| Commercial | 2025 | Heating Oil | $/gal | $3.38 | $0.06 | $0.01 | $0.03 |
| Commercial | 2026 | Heating Oil | $/gal | $3.32 | $0.09 | $0.01 | $0.04 |
| Commercial | 2027 | Heating Oil | $/gal | $3.26 | $0.13 | $0.03 | $0.07 |
| Commercial | 2028 | Heating Oil | $/gal | $3.22 | $0.16 | $0.03 | $0.09 |
| Commercial | 2029 | Heating Oil | $/gal | $3.25 | $0.20 | $0.05 | $0.11 |
| Commercial | 2030 | Heating Oil | $/gal | $3.30 | $0.25 | $0.09 | $0.14 |
| Commercial | 2031 | Heating Oil | $/gal | $3.33 | $0.32 | $0.12 | $0.19 |
| Commercial | 2032 | Heating Oil | $/gal | $3.34 | $0.41 | $0.16 | $0.25 |
| Commercial | 2033 | Heating Oil | $/gal | $3.37 | $0.49 | $0.20 | $0.31 |
| Commercial | 2034 | Heating Oil | $/gal | $3.38 | $0.59 | $0.25 | $0.38 |
| Commercial | 2035 | Heating Oil | $/gal | $3.40 | $0.63 | $0.35 | $0..33 |
| Commercial | 2040 | Heating Oil | $/gal | $3.46 | $1.06 | $0.87 | $0.56 |
| Commercial | 2045 | Heating Oil | $/gal | $3.52 | $1.29 | $1.43 | $0.65 |
| Commercial | 2050 | Heating Oil | $/gal | $3.58 | $1.29 | $1.92 | $0.55 |

*Table 18: Commercial Heating Oil Price Forecasts by Scenario*

Heating oil prices for commercial customers increase steadily through 2034 under each of the three scenarios. The 2030 Economy-wide scenario has the greatest increase by 2034, $0.59/gal, a 17% increase. The increase is driven by a combination of program costs incurred through 2035. Unlike natural gas, the analysis assumes no fixed costs for heating oil. Therefore, prices of heating oil do not increase as usage decreases.

| Sector | Year | Fuel | Units | BAU Scenario | Average Change in Rates | | |
|---|---|---|---|---|---|---|---|
| | | | | | 2. 2030 Economy-Wide | 3. RCI Proportional | 4.Regulatory Bundle |
| Industrial | 2023 | Natural Gas | $/MCF | $10.07 | $0.11 | $0.05 | $0.11 |
| Industrial | 2024 | Natural Gas | $/MCF | $8.99 | $0.50 | $0.08 | $0.23 |
| Industrial | 2025 | Natural Gas | $/MCF | $8.73 | $0.70 | $0.11 | $0.33 |
| Industrial | 2026 | Natural Gas | $/MCF | $8.61 | $0.91 | $0.11 | $0.40 |
| Industrial | 2027 | Natural Gas | $/MCF | $8.45 | $1.27 | $0.25 | $0.61 |
| Industrial | 2028 | Natural Gas | $/MCF | $8.38 | $1.58 | $0.21 | $0.74 |
| Industrial | 2029 | Natural Gas | $/MCF | $8.49 | $1.92 | $0.47 | $0.90 |
| Industrial | 2030 | Natural Gas | $/MCF | $8.61 | $2.43 | $0.86 | $1.19 |
| Industrial | 2031 | Natural Gas | $/MCF | $8.55 | $3.11 | $1.09 | $1.62 |
| Industrial | 2032 | Natural Gas | $/MCF | $8.63 | $3.97 | $1.49 | $2.24 |
| Industrial | 2033 | Natural Gas | $/MCF | $8.71 | $4.89 | $1.92 | $2.88 |
| Industrial | 2034 | Natural Gas | $/MCF | $8.75 | $5.87 | $2.43 | $3.53 |
| Industrial | 2035 | Natural Gas | $/MCF | $8.79 | -$0.89 | -$0.46 | -$1.02 |
| Industrial | 2040 | Natural Gas | $/MCF | $8.92 | -$1.62 | -$1.15 | -$2.07 |
| Industrial | 2045 | Natural Gas | $/MCF | $9.12 | -$2.81 | -$2.37 | -$4.25 |
| Industrial | 2050 | Natural Gas | $/MCF | $9.08 | -$5.70 | -$5.70 | -$13.14 |

*Table 19: Industrial Natural Gas Rate Forecasts by Scenario*

Natural gas prices for industrial customers increase steadily through 2034 under each of the three scenarios. The 2030 Economy-wide scenario has the greatest increase by 2050, $5.87/MCF, a 67% increase. The increase is driven by a combination of program costs incurred and a smaller rate base to spread the costs over as natural gas consumption decreases.

However, rates are projected to decrease relative to the BAU scenario between 2035 and 2050. Industrial natural gas sales are projected to decrease by as much as 58% relative to 2023 sales by 2050, so the industrial rate base does not decrease as much as the residential rate base, which sees increased rates through 2050. Additionally, fixed costs are very low for industrial customers, accounting for less than 1% of rates, so there are fewer fixed costs to recover for industrial customers, putting less upward pressure on rates.

## Electricity Results

Program costs for each of the policy scenarios considered were not borne by electricity rates. Changes in electric rates under each scenario are the result of added generation costs, as well as added transmission and distribution costs, both for energy and peak demand.

Additionally, changes in retail sales forecasts given the level of fossil fuel displacement under each of the policy scenarios largely resulted in decreased rates, as costs are spread over a larger rate base, but increased overall customer bills because of increased electricity usage per-customer.

| Sector | Year | Fuel | Units | BAU Scenario | Average Change in Rates: Climate Initiatives 2030 | Climate Initiatives 2035 | Regulatory Bundle |
|---|---|---|---|---|---|---|---|
| Residential | 2023 | Electricity | $/kWh | $0.192 | ($0.001) | ($0.000) | ($0.001) |
| Residential | 2024 | Electricity | $/kWh | $0.188 | ($0.001) | ($0.000) | ($0.001) |
| Residential | 2025 | Electricity | $/kWh | $0.188 | ($0.001) | ($0.000) | ($0.001) |
| Residential | 2026 | Electricity | $/kWh | $0.187 | ($0.001) | ($0.000) | ($0.001) |
| Residential | 2027 | Electricity | $/kWh | $0.188 | ($0.001) | ($0.001) | ($0.001) |
| Residential | 2028 | Electricity | $/kWh | $0.188 | ($0.002) | ($0.001) | ($0.001) |
| Residential | 2029 | Electricity | $/kWh | $0.187 | ($0.002) | ($0.001) | ($0.001) |
| Residential | 2030 | Electricity | $/kWh | $0.187 | ($0.002) | ($0.001) | ($0.001) |
| Residential | 2031 | Electricity | $/kWh | $0.188 | ($0.002) | ($0.001) | ($0.001) |
| Residential | 2032 | Electricity | $/kWh | $0.188 | ($0.002) | ($0.001) | ($0.001) |
| Residential | 2033 | Electricity | $/kWh | $0.189 | ($0.001) | ($0.001) | ($0.001) |
| Residential | 2034 | Electricity | $/kWh | $0.189 | ($0.001) | ($0.000) | ($0.001) |
| Residential | 2035 | Electricity | $/kWh | $0.187 | ($0.001) | ($0.000) | ($0.001) |
| Residential | 2040 | Electricity | $/kWh | $0.183 | ($0.001) | $0.000 | $0.000 |
| Residential | 2045 | Electricity | $/kWh | $0.181 | $0.000 | $0.001 | $0.001 |
| Residential | 2050 | Electricity | $/kWh | $0.178 | $0.001 | $0.001 | $0.001 |

***Table 20: Residential Customer Rate Forecast by Scenario***

Overall, residential rates decreased slightly through 2035, relative to the BAU scenario rate forecasts. The increase in the rate base was greater than the increased generation and T&D costs to deliver the added retail sales. The LEAP model did forecast a modest decline in retail sales after 2035, which resulted in modest rate increases after 2035 under each of the policy scenarios.

| Sector | Year | Fuel | Average Annual BAU Scenario Bill | Average Change in Annual Bill | | |
|---|---|---|---|---|---|---|
| | | | | Climate Initiatives 2030 | Climate Initiatives 2035 | Regulatory Bundle |
| Residential | 2023 | Electricity | $1,267.41 | $1.54 | $0.79 | $1.39 |
| Residential | 2024 | Electricity | $1,254.01 | $2.10 | $0.85 | $1.87 |
| Residential | 2025 | Electricity | $1,254.58 | $2.50 | $0.82 | $2.18 |
| Residential | 2026 | Electricity | $1,268.30 | $2.96 | $0.82 | $2.53 |
| Residential | 2027 | Electricity | $1,288.01 | $3.32 | $1.20 | $2.78 |
| Residential | 2028 | Electricity | $1,316.39 | $3.67 | $1.55 | $3.01 |
| Residential | 2029 | Electricity | $1,351.09 | $4.02 | $1.82 | $3.19 |
| Residential | 2030 | Electricity | $1,384.67 | $4.57 | $2.09 | $3.49 |
| Residential | 2031 | Electricity | $1,429.71 | $4.68 | $2.08 | $3.45 |
| Residential | 2032 | Electricity | $1,473.10 | $4.81 | $1.99 | $3.33 |
| Residential | 2033 | Electricity | $1,522.27 | $4.65 | $1.74 | $3.05 |
| Residential | 2034 | Electricity | $1,560.13 | $4.71 | $1.48 | $2.82 |
| Residential | 2035 | Electricity | $1,591.43 | $4.62 | $1.09 | $2.47 |
| Residential | 2040 | Electricity | $1,741.06 | $2.39 | ($1.59) | ($0.70) |
| Residential | 2045 | Electricity | $1,820.42 | ($0.67) | ($4.33) | ($4.27) |
| Residential | 2050 | Electricity | $1,862.78 | ($3.91) | ($5.69) | ($8.00) |

***Table 21: Residential Customer Electricity Bill Forecasts by Scenario***

While rates are projected to decrease slightly for residential customers under each of the policy scenarios, customer bills are forecast to increase slightly as electricity displaces natural gas and other fossil fuels. It is important to note that the bill increases are averaged across all customers, rather than specifically isolating loads within homes that adopt electrification measures.

| Sector | Year | Fuel | Units | BAU Scenario | Average Change in Rates | | |
|---|---|---|---|---|---|---|---|
| | | | | | Climate Initiatives 2030 | Climate Initiatives 2035 | Regulatory Bundle |
| Commercial | 2023 | Electricity | $/kWh | $0.164 | ($0.004) | ($0.002) | ($0.005) |
| Commercial | 2024 | Electricity | $/kWh | $0.160 | ($0.007) | ($0.004) | ($0.007) |
| Commercial | 2025 | Electricity | $/kWh | $0.159 | ($0.010) | ($0.007) | ($0.011) |
| Commercial | 2026 | Electricity | $/kWh | $0.159 | ($0.013) | ($0.009) | ($0.013) |
| Commercial | 2027 | Electricity | $/kWh | $0.159 | ($0.015) | ($0.012) | ($0.016) |
| Commercial | 2028 | Electricity | $/kWh | $0.159 | ($0.017) | ($0.014) | ($0.018) |
| Commercial | 2029 | Electricity | $/kWh | $0.158 | ($0.018) | ($0.015) | ($0.019) |
| Commercial | 2030 | Electricity | $/kWh | $0.158 | ($0.018) | ($0.015) | ($0.019) |
| Commercial | 2031 | Electricity | $/kWh | $0.159 | ($0.019) | ($0.016) | ($0.020) |
| Commercial | 2032 | Electricity | $/kWh | $0.158 | ($0.019) | ($0.016) | ($0.020) |
| Commercial | 2033 | Electricity | $/kWh | $0.159 | ($0.020) | ($0.017) | ($0.021) |
| Commercial | 2034 | Electricity | $/kWh | $0.159 | ($0.020) | ($0.017) | ($0.021) |
| Commercial | 2035 | Electricity | $/kWh | $0.157 | ($0.019) | ($0.017) | ($0.020) |
| Commercial | 2040 | Electricity | $/kWh | $0.153 | ($0.018) | ($0.017) | ($0.019) |
| Commercial | 2045 | Electricity | $/kWh | $0.150 | ($0.017) | ($0.017) | ($0.018) |
| Commercial | 2050 | Electricity | $/kWh | $0.147 | ($0.017) | ($0.017) | ($0.018) |

*Table 22: Commercial Customer Rate Forecast by Scenario*

Overall, commercial rates decreased slightly through all years, relative to the BAU scenario rate forecasts. The increase in the rate base is projected to be greater than the increased generation and T&D costs to deliver the added retail sales.

| Sector | Year | Fuel | Average Annual BAU Scenario Bill | Average Change in Annual Bill | | |
|---|---|---|---|---|---|---|
| | | | | Climate Initiatives 2030 | Climate Initiatives 2035 | Regulatory Bundle |
| Commercial | 2023 | Electricity | $5,128.42 | $48.28 | $27.67 | $54.32 |
| Commercial | 2024 | Electricity | $4,986.04 | $88.17 | $56.69 | $97.14 |
| Commercial | 2025 | Electricity | $4,979.31 | $129.51 | $89.40 | $140.80 |
| Commercial | 2026 | Electricity | $5,008.62 | $179.59 | $130.31 | $193.43 |
| Commercial | 2027 | Electricity | $5,098.16 | $218.29 | $171.37 | $234.32 |
| Commercial | 2028 | Electricity | $5,237.67 | $266.55 | $212.90 | $284.91 |
| Commercial | 2029 | Electricity | $5,396.20 | $317.21 | $256.14 | $338.29 |
| Commercial | 2030 | Electricity | $5,594.00 | $376.87 | $314.44 | $401.48 |
| Commercial | 2031 | Electricity | $5,828.34 | $413.97 | $346.14 | $440.81 |
| Commercial | 2032 | Electricity | $6,029.03 | $458.33 | $384.12 | $487.93 |
| Commercial | 2033 | Electricity | $6,290.10 | $485.47 | $408.18 | $516.76 |
| Commercial | 2034 | Electricity | $6,488.05 | $533.34 | $456.43 | $567.72 |
| Commercial | 2035 | Electricity | $6,625.47 | $575.00 | $501.42 | $611.79 |
| Commercial | 2040 | Electricity | $7,134.50 | $652.74 | $612.14 | $695.54 |
| Commercial | 2045 | Electricity | $6,997.04 | $679.35 | $664.70 | $727.85 |
| Commercial | 2050 | Electricity | $6,633.47 | $682.78 | $695.01 | $727.27 |

*Table 23: Commercial Customer Electricity Bill Forecasts by Scenario*

While rates are projected to decrease slightly for commercial customers under each of the policy scenarios, customer bills are forecast to increase as electricity displaces natural gas and other fossil fuels. It is important to note that the bill increases are averaged across all customers, rather than specifically isolating loads within properties and businesses that adopt electrification measures.

| Sector | Year | Fuel | Units | BAU Scenario | Average Change in Rates | | |
|---|---|---|---|---|---|---|---|
| | | | | | Climate Initiatives 2030 | Climate Initiatives 2035 | Regulatory Bundle |
| Industrial | 2023 | Electricity | $/kWh | $0.074 | $0.000 | $0.000 | $0.000 |
| Industrial | 2024 | Electricity | $/kWh | $0.072 | $0.000 | $0.000 | $0.000 |
| Industrial | 2025 | Electricity | $/kWh | $0.071 | ($0.000) | ($0.000) | $0.000 |
| Industrial | 2026 | Electricity | $/kWh | $0.070 | $0.000 | $0.000 | $0.000 |
| Industrial | 2027 | Electricity | $/kWh | $0.070 | $0.000 | $0.000 | $0.000 |
| Industrial | 2028 | Electricity | $/kWh | $0.071 | $0.000 | $0.000 | $0.000 |
| Industrial | 2029 | Electricity | $/kWh | $0.071 | $0.000 | $0.000 | $0.000 |
| Industrial | 2030 | Electricity | $/kWh | $0.071 | $0.000 | $0.000 | $0.000 |
| Industrial | 2031 | Electricity | $/kWh | $0.071 | ($0.000) | ($0.000) | $0.000 |
| Industrial | 2032 | Electricity | $/kWh | $0.071 | ($0.000) | ($0.000) | $0.000 |
| Industrial | 2033 | Electricity | $/kWh | $0.071 | $0.000 | $0.000 | $0.000 |
| Industrial | 2034 | Electricity | $/kWh | $0.071 | $0.000 | $0.000 | $0.000 |
| Industrial | 2035 | Electricity | $/kWh | $0.071 | $0.000 | $0.000 | $0.000 |
| Industrial | 2040 | Electricity | $/kWh | $0.069 | ($0.000) | ($0.000) | $0.000 |
| Industrial | 2045 | Electricity | $/kWh | $0.068 | $0.000 | $0.000 | $0.000 |
| Industrial | 2050 | Electricity | $/kWh | $0.067 | $0.000 | $0.000 | $0.000 |

*Table 24: Industrial Customer Rate Forecast by Scenario*

Overall, industrial rate impacts are negligible through all years, relative to the BAU scenario rate forecasts. Electricity sales forecasts for industrial customers do not differ substantially between the BAU scenario and any of the policy scenarios. Therefore, there are negligible additional costs, and the rate base remains largely unchanged among industrial customers.

| Sector | Year | Fuel | Average Annual BAU Scenario Bill | Average Change in Annual Bill | | |
|---|---|---|---|---|---|---|
| | | | | Climate Initiatives 2030 | Climate Initiatives 2035 | Regulatory Bundle |
| Industrial | 2023 | Electricity | $419,853.34 | ($0.00) | ($0.00) | $0.00 |
| Industrial | 2024 | Electricity | $404,834.53 | ($0.00) | ($0.00) | $0.00 |
| Industrial | 2025 | Electricity | $398,133.19 | $0.00 | $0.00 | $0.00 |
| Industrial | 2026 | Electricity | $391,458.76 | ($0.00) | ($0.00) | $0.00 |
| Industrial | 2027 | Electricity | $389,071.19 | ($0.00) | ($0.00) | $0.00 |
| Industrial | 2028 | Electricity | $387,832.64 | ($0.00) | ($0.00) | $0.00 |
| Industrial | 2029 | Electricity | $385,859.20 | ($0.00) | ($0.00) | $0.00 |
| Industrial | 2030 | Electricity | $383,234.51 | ($0.00) | ($0.00) | $0.00 |
| Industrial | 2031 | Electricity | $381,632.13 | $0.00 | $0.00 | $0.00 |
| Industrial | 2032 | Electricity | $379,068.97 | $0.00 | $0.00 | $0.00 |
| Industrial | 2033 | Electricity | $377,146.12 | ($0.00) | ($0.00) | $0.00 |
| Industrial | 2034 | Electricity | $374,753.75 | ($0.00) | ($0.00) | $0.00 |
| Industrial | 2035 | Electricity | $368,421.11 | ($0.00) | ($0.00) | $0.00 |
| Industrial | 2040 | Electricity | $364,806.98 | $0.00 | $0.00 | $0.00 |
| Industrial | 2045 | Electricity | $363,701.75 | ($0.00) | ($0.00) | $0.00 |
| Industrial | 2050 | Electricity | $368,016.17 | ($0.00) | ($0.00) | $0.00 |

*Table 25: Industrial Customer Electricity Bill Forecasts by Scenario*

Similar to the forecast changes in electricity rates for industrial customers, customer bills show negligible differences from the BAU scenario. Per-customer usage is not expected to change substantially under any of the policy scenarios.

## F. Program and Administrative Cost Workbook

The third complementary workbook estimates the cost of state (or obligated fossil fuel company) costs for accelerating investment in GHG-reducing measures. This includes estimate of (1) customer incentives (rebates, tax incentives, etc.); (2) program marketing and other administrative costs; and (3) state administrative costs associated with oversight and evaluation (e.g., of measure emission reduction assumptions for a Clean Heat Standard credit values) of each policy.

Sources of data include reporting and select interviews or surveys with existing Vermont program administrators, literature reviews, and select interviews and or surveys with administrators in other jurisdictions, and contractor expertise. Federal dollars (from the Inflation Reduction Act and Infrastructure Investment and Jobs Act) are expected to also be available for customer incentives and the analyses will reflect these as separate from state or program funds.

Table summarizes the measures included in the program and administrative cost workbook.

| Measures | | | | |
|---|---|---|---|---|
| Residential | Heating Equipment | SF ASHP 2 Head | Units | SF 2 Head Ductless HP |
| | | MF ASHP 2 Head | Units | MF 2 Head Ductless HP |
| | | SF ASHP Central | Units | SF Centrally-Ducted Cold Climate Heat Pump |
| | | MF ASHP Central | Units | MF Centrally-Ducted Cold Climate Heat Pump |
| | | SF ASHP HE | Units | SF Ductless Heat Pump |
| | | MF ASHP HE | Units | MF Ductless Heat Pump |
| | | SF GSHP HE | Units | SF Ground Source Heat Pump |
| | | MF GSHP HE | Units | MF Ground Source Heat Pump |
| | | SF ATW HP | Units | SF Air to Water Heat Pump |
| | | APB | Units | Advanced Pellet Boilers |
| | | PSt HE | Units | Pellet Stoves High Efficiency |
| | | PSt Ty | Units | Pellet Stove Typical |
| | | WS HE | Units | Wood Stove High Efficiency |
| | | WS Ty | Units | Wood Stove Typical |
| | Wx | SF Wx | Units | SF Weatherization |
| | | MF Wx 2-4 | Units | MF Weatherization 2-4 untis |
| | | MF Wx 5+ | Units | MF Weatherization 5+ units |
| | | MH Wx | Units | Mobile Home Weatherization |
| | H2O | HPWH HE | Units | Heat Pump Water Heater High Efficiency |
| | | HPWH Ty | Units | Heat Pump Water Heater Typical |
| | Cooking | ECook | Units | Electric Cooking |
| | RE Fuels | RNG | MMBtus | RNG |
| | | BioD | MMBtus | Biodiesel |
| | | BioCHPDH | MMBtus | Bio CHP/District Heat |
| Comm. | Reductions | Com Red | MTCO2e | |
| Ind. | Reductions | Ind Red | MTCO2e | |

***Table 26: Measures in Program and Administrative Cost Workbook***



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Key assumptions in the program and administrative cost workbook are summarized in Table 27.

| | Baseline | Climate Initiatives 2030 | | | Climate Initiatives 2035 | | | Reg. Bundle |
|---|---|---|---|---|---|---|---|---|
| ASSUMPTIONS THAT DO NOT VARY ACROSS N | 1.a | 2.a | 2.b | 2.c | 3.a | 3.b | 3.c | 4 |
| LMI Incentive % of Installed Cost: | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Share of measures taking tax credits | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% |
| Residential Incentive as Share of Resource Acc | 70% | 70% | 70% | 70% | 70% | 70% | 70% | 70% |
| C/I Incentive Share of Resource Acquisition | 52% | 52% | 52% | 52% | 52% | 52% | 52% | 52% |
| Program Admin Cost as Share of Resource Acc | 17.15% | 17.15% | 20.58% | 20.58% | 17.15% | 20.58% | 20.58% | 17.15% |
| State Admin as Share of Program Costs (incen | 3.04% | 3.04% | 3.49% | 3.95% | 3.04% | 3.49% | 3.95% | 7.00% |

***Table 27: Program and Administrative Cost Workbook Key Assumptions***

<u>Table 15 Notes</u>: **Row 1:** Program design assumption, **Row 2:** Based on IRS data of average tax burden for 50 percentile of VT households of $15,800 and 80% uptake on tax credits by HHs w sufficient tax burdens. Not expected to change with Policy or program design. **Row 3:** Due to LMI component, incentives assumed to be higher share than portfolio average. **Row 4:** Portfolio average, based on Efficiency Vermont, 2022 Demand Resource Plan filing. **Row 5:** Portfolio average, based on EVT, DRP filing, Estimated increase for policies 2 and 3 b and c based on new tracking, verification, and reporting. **Row 6:** Portfolio average, based on EVT, DRP filing, increase based on additional tracking and verification, and compliance enforcement for policy set 4.

**Market and Low- and Moderate-Income Incentives**: Across the policy options we assume that incentives cover 100% of the measure costs for households below 80% of the statewide median income, and 75% of the installed cost for households with income between 80% and 120% of the state median income. Market incentives vary by measure based on recent program data and are anticipated to remain constant to ensure the participation of "late-adopters". Incentive levels by measure are summarized in Tables 28 and 29.

| | Market Incentives - Percent of Installed Cost | Incentive Profile % | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Incentive Reduction Profile | | 100% | 100% | 90% | 90% | 80% | 80% | 75% | 75% | 75% | 70% | 60% | 60% | 50% | 0% | 0% | 0% |
| Starting Le | Sector | Measure | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2040 | 2045 | 2050 |
| 12% | Residential | SF ASHP 2 Head | 12% | 12% | 10% | 10% | 9% | 9% | 9% | 9% | 9% | 8% | 7% | 7% | 6% | 0% | 0% | 0% |
| 12% | Residential | MF ASHP 2 Head | 12% | 12% | 10% | 10% | 9% | 9% | 9% | 9% | 9% | 8% | 7% | 7% | 6% | 0% | 0% | 0% |
| 17% | Residential | SF ASHP Central | 17% | 17% | 15% | 15% | 14% | 14% | 13% | 13% | 13% | 12% | 10% | 10% | 9% | 0% | 0% | 0% |
| 17% | Residential | MF ASHP Central | 17% | 17% | 15% | 15% | 14% | 14% | 13% | 13% | 13% | 12% | 10% | 10% | 9% | 0% | 0% | 0% |
| 10% | Residential | SF ASHP HE | 10% | 10% | 9% | 9% | 8% | 8% | 8% | 8% | 8% | 7% | 6% | 6% | 5% | 0% | 0% | 0% |
| 10% | Residential | MF ASHP HE | 10% | 10% | 9% | 9% | 8% | 8% | 8% | 8% | 8% | 7% | 6% | 6% | 5% | 0% | 0% | 0% |
| 25% | Residential | SF GSHP HE | 25% | 25% | 23% | 23% | 20% | 20% | 19% | 19% | 19% | 18% | 15% | 15% | 13% | 0% | 0% | 0% |
| 25% | Residential | MF GSHP HE | 25% | 25% | 23% | 23% | 20% | 20% | 19% | 19% | 19% | 18% | 15% | 15% | 13% | 0% | 0% | 0% |
| 30% | Residential | SF ATW HP | 30% | 30% | 27% | 27% | 24% | 24% | 23% | 23% | 23% | 21% | 18% | 18% | 15% | 0% | 0% | 0% |
| 30% | Residential | APB | 30% | 30% | 27% | 27% | 24% | 24% | 23% | 23% | 23% | 21% | 18% | 18% | 15% | 0% | 0% | 0% |
| 9% | Residential | PSt HE | 9% | 9% | 8% | 8% | 7% | 7% | 7% | 7% | 7% | 6% | 5% | 5% | 5% | 0% | 0% | 0% |
| 9% | Residential | PSt Ty | 9% | 9% | 8% | 8% | 7% | 7% | 7% | 7% | 7% | 6% | 5% | 5% | 5% | 0% | 0% | 0% |
| 12% | Residential | WS HE | 12% | 12% | 11% | 11% | 10% | 10% | 9% | 9% | 9% | 8% | 7% | 7% | 6% | 0% | 0% | 0% |
| 12% | Residential | WS Ty | 12% | 12% | 11% | 11% | 10% | 10% | 9% | 9% | 9% | 8% | 7% | 7% | 6% | 0% | 0% | 0% |
| 16% | Residential | MF Wx 2-4 | 16% | 16% | 14% | 14% | 13% | 13% | 12% | 12% | 12% | 11% | 10% | 10% | 8% | 0% | 0% | 0% |
| 35% | Residential | MF Wx 5+ | 35% | 35% | 32% | 32% | 28% | 28% | 26% | 26% | 26% | 25% | 21% | 21% | 18% | 0% | 0% | 0% |
| 42% | Residential | MH Wx | 42% | 42% | 38% | 38% | 34% | 34% | 32% | 32% | 32% | 29% | 25% | 25% | 21% | 0% | 0% | 0% |
| 45% | Residential | SF Wx | 45% | 45% | 41% | 41% | 36% | 36% | 34% | 34% | 34% | 32% | 27% | 27% | 23% | 0% | 0% | 0% |
| 20% | Residential | HPWH HE | 20% | 20% | 18% | 18% | 16% | 16% | 15% | 15% | 15% | 14% | 12% | 12% | 10% | 0% | 0% | 0% |
| 20% | Residential | HPWH TY | 20% | 20% | 18% | 18% | 16% | 16% | 15% | 15% | 15% | 14% | 12% | 12% | 10% | 0% | 0% | 0% |
| 10% | Residential | ECook | 10% | 10% | 9% | 9% | 8% | 8% | 8% | 8% | 8% | 7% | 6% | 6% | 5% | 0% | 0% | 0% |
| 10% | Residential | RNG | 10% | 10% | 9% | 9% | 8% | 8% | 8% | 8% | 8% | 7% | 6% | 6% | 5% | 0% | 0% | 0% |
| 10% | Residential | BioD | 10% | 10% | 9% | 9% | 8% | 8% | 8% | 8% | 8% | 7% | 6% | 6% | 5% | 0% | 0% | 0% |
| 10% | Residential | BioCHPDH | 10% | 10% | 9% | 9% | 8% | 8% | 8% | 8% | 8% | 7% | 6% | 6% | 5% | 0% | 0% | 0% |
| 10% | Commercial | Com Red | 10% | 10% | 9% | 9% | 8% | 8% | 8% | 8% | 8% | 7% | 6% | 6% | 5% | 0% | 0% | 0% |
| 10% | Industrial | Ind Red | 10% | 10% | 9% | 9% | 8% | 8% | 8% | 8% | 8% | 7% | 6% | 6% | 5% | 0% | 0% | 0% |

***Table 28: Program Market Incentive Levels***

**Heat Pumps**

| Measure | Measure Cost | Initial Incentive % | Incentive $ | Tax Incentive % of post rebate cost | Tax Incentive $ | Customer Cost |
|---|---|---|---|---|---|---|
| ASHP 2 Head | $ 7,000 | 12% | $ 805 | 30% | $ 1,859 | $ 4,337 |
| ASHP Central | $ 8,500 | 17% | $ 1,445 | 30% | $ 2,000 | $ 5,055 |
| ASHP Single Head | $ 4,620 | 10% | $ 462 | 30% | $ 1,247 | $ 2,911 |
| ATW HP | $ 10,199 | 30% | $ 3,060 | 30% | $ 2,000 | $ 5,139 |
| GSHP | $ 30,000 | 25% | $ 7,500 | 30% | $ 2,000 | $ 20,500 |

**Advanced Wood Heat**

| Measure | Measure Cost | Initial Incentive % | Incentive $ | Tax Incentive % of post rebate cost | Tax Incentive $ | Customer Cost |
|---|---|---|---|---|---|---|
| APB | $ 20,000 | 30% | $ 6,000 | 30% | $ 2,000 | $ 12,000 |
| PSt HE | $ 4,400 | 9% | $ 396 | 30% | $ 1,201 | $ 2,803 |
| PSt Ty | $ 4,400 | 9% | $ 396 | 30% | $ 1,201 | $ 2,803 |
| WS HE | $ 3,319 | 12% | $ 398 | 30% | $ 876 | $ 2,045 |
| WS Ty | $ 3,319 | 12% | $ 398 | 30% | $ 876 | $ 2,045 |

**Weatherization Market and Tax Incentives**

| Measure | Measure Cost | Initial Incentive % | Incentive $ | Tax Incentive % of post rebate cost | Tax Incentive $ | Customer Cost |
|---|---|---|---|---|---|---|
| SF Wx | $ 8,743 | 45% | $ 3,934 | 30% | $ 1,200 | $ 3,609 |
| MF Wx 2-4 | $ 6,001 | 16% | $ 960 | 30% | $ 1,200 | $ 3,841 |
| MF Wx 5+ | $ 3,000 | 35% | $ 1,050 | 30% | $ 585 | $ 1,365 |
| MH Wx | $ 9,300 | 42% | $ 3,906 | 30% | $ 1,200 | $ 4,194 |

**Heat Pump Water Heaters**

| Measure | Measure Cost | Initial Incentive % | Incentive $ | Tax Incentive % of post rebate cost | Tax Incentive $ | Customer Cost |
|---|---|---|---|---|---|---|
| HPWH HE | $ 2,075 | 29% | $ 602 | 30% | $ 442 | $ 1,031 |
| HPWH TY | $ 2,075 | 15% | $ 311 | 30% | $ 529 | $ 1,235 |

**Electric Cooking**

| Measure | Measure Cost | Initial Incentive % | Incentive $ | Tax Incentive % of post rebate cost | Tax Incentive $ | Customer Cost |
|---|---|---|---|---|---|---|
| Ecook | $ 1,098 | 10% | $ 110 | 30% | $ 296 | $ 692 |

**Biofuels**

| Measure | Measure Cost | Initial Incentive % | Incentive $ | Tax Incentive % of post rebate cost | Tax Incentive $ | Customer Cost |
|---|---|---|---|---|---|---|
| RNG | $ 20 | 10% | $ 2 | 0% | $ - | $ 18 |
| BioD | $ 43 | 10% | $ 4 | 0% | $ - | $ 39 |
| BioCHPDH | $ 11 | 10% | $ 1 | 0% | $ - | $ 9 |

**Commercial Industrial Reductions**

| Measure | Measure Cost | Initial Incentive % | Incentive $ | Tax Incentive % of post rebate cost | Tax Incentive $ | Customer Cost |
|---|---|---|---|---|---|---|
| Com Red | $ 100 | 10% | $ 10 | 30% | $ 27 | $ 63 |
| Ind Red | $ 100 | 10% | $ 10 | 30% | $ 27 | $ 63 |

***Table 29: Measure Costs, Initial Market Rate Incentives and Tax Incentives by Measure Group[35]***

[35] Estimated costs for Weatherization are for customers with >120% of median income and are roughly 20% lower than estimated costs for low-income weatherization with an average of $10,689.

Across the policy options and years our analysis results in most program incentives going to households below 120% of the state median income. Table 30 illustrates the share of each year's total program incentives that are supporting low- and moderate- income households.

| Low and Moderate Income Incentives as Share of Total Program Incentives by Year | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2030 Initiatives** | **2024** | **2025** | **2026** | **2027** | **2028** | **2029** | **2030** | **2031** | **2032** | **2033** | **2034** | **2035** | **2040** | **2045** | **2050** |
| 2. Expansion w Surcharge | 70% | 67% | 64% | 65% | 64% | 63% | 62% | 59% | 58% | 58% | 58% | 59% | 57% | 55% | 54% |
| 2.b Clean Heat Standard | 70% | 67% | 64% | 65% | 64% | 63% | 62% | 59% | 58% | 58% | 58% | 59% | 57% | 55% | 54% |
| 2.c Cap and Invest | 70% | 67% | 64% | 65% | 64% | 63% | 62% | 59% | 58% | 58% | 58% | 59% | 57% | 55% | 54% |
| 4. Regulatory Bundle | 69% | 66% | 64% | 66% | 65% | 64% | 63% | 58% | 59% | 58% | 58% | 60% | 60% | 58% | 59% |
| | | | | | | | | | | | | | | | |
| **2035 Initiatives** | **2024** | **2025** | **2026** | **2027** | **2028** | **2029** | **2030** | **2031** | **2032** | **2033** | **2034** | **2035** | **2040** | **2045** | **2050** |
| 3. Expansion w Surcharge | 39% | 48% | 46% | 57% | 55% | 63% | 62% | 62% | 63% | 63% | 63% | 63% | 54% | 52% | 50% |
| 3.b Clean Heat Standard | 39% | 48% | 46% | 57% | 55% | 63% | 62% | 62% | 63% | 63% | 63% | 63% | 54% | 52% | 50% |
| 3.c Cap and Invest | 39% | 48% | 46% | 57% | 55% | 63% | 62% | 62% | 63% | 63% | 63% | 63% | 54% | 52% | 50% |

***Table 30: Share of Total Measure Incentives Supporting Low- and Moderate-Income Households***

The program and administrative cost workbook also estimates the annual level of federal tax incentives associated with the adoption of measures.

| Federal Tax Incentives, LEAP 3.23 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Summary** | | | | | | | | | | | |
| **Federal Tax Incentives (Table Col. AC)** | | | | | | | | | | | |
| | **2024** | **2025** | **2026** | **2027** | **2028** | **2029** | **2030** | **2031** | **2032** | **2033** | **2034** |
| **2030 Initiatives** | | | | | | | | | | | |
| 2. Expansion w Surcharge | $ 7,962,401 | $ 6,647,544 | $ 6,506,341 | $ 9,513,506 | $ 9,642,270 | $ 9,788,000 | $ 10,287,528 | $ 7,776,688 | $ 7,917,275 | $ 8,080,774 | $ 8,144,501 |
| 2.b Clean Heat Standard | $ 7,962,401 | $ 6,647,544 | $ 6,506,341 | $ 9,513,506 | $ 9,642,270 | $ 9,788,000 | $ 10,287,528 | $ 7,776,688 | $ 7,917,275 | $ 8,080,774 | $ 8,144,501 |
| 2.c Cap and Invest | $ 7,962,401 | $ 6,647,544 | $ 6,506,341 | $ 9,513,506 | $ 9,642,270 | $ 9,788,000 | $ 10,287,528 | $ 7,776,688 | $ 7,917,275 | $ 8,080,774 | $ 8,144,501 |
| 4. Regulatory Bundle | $ 5,230,052 | $ 3,730,588 | $ 3,398,654 | $ 6,212,073 | $ 6,151,056 | $ 6,008,566 | $ 6,162,037 | $ 3,817,325 | $ 3,742,519 | $ 3,681,393 | $ 3,498,426 |
| | | | | | | | | | | | |
| **2035 Initiatives** | | | | | | | | | | | |
| 3. Expansion w Surcharge | $ 526,217 | $ 1,276,681 | $ 1,370,597 | $ 2,711,194 | $ 2,855,553 | $ 7,168,791 | $ 7,754,763 | $ 8,664,672 | $ 9,545,767 | $ 9,614,333 | $ 9,978,548 |
| 3.b Clean Heat Standard | $ 526,217 | $ 1,276,681 | $ 1,370,597 | $ 2,711,194 | $ 2,855,553 | $ 7,168,791 | $ 7,754,763 | $ 8,664,672 | $ 9,545,767 | $ 9,614,333 | $ 9,978,548 |
| 3.c Cap and Invest | $ 526,217 | $ 1,276,681 | $ 1,370,597 | $ 2,711,194 | $ 2,855,553 | $ 7,168,791 | $ 7,754,763 | $ 8,664,672 | $ 9,545,767 | $ 9,614,333 | $ 9,978,548 |

***Table 31: Federal Tax Incentives by Scenario***

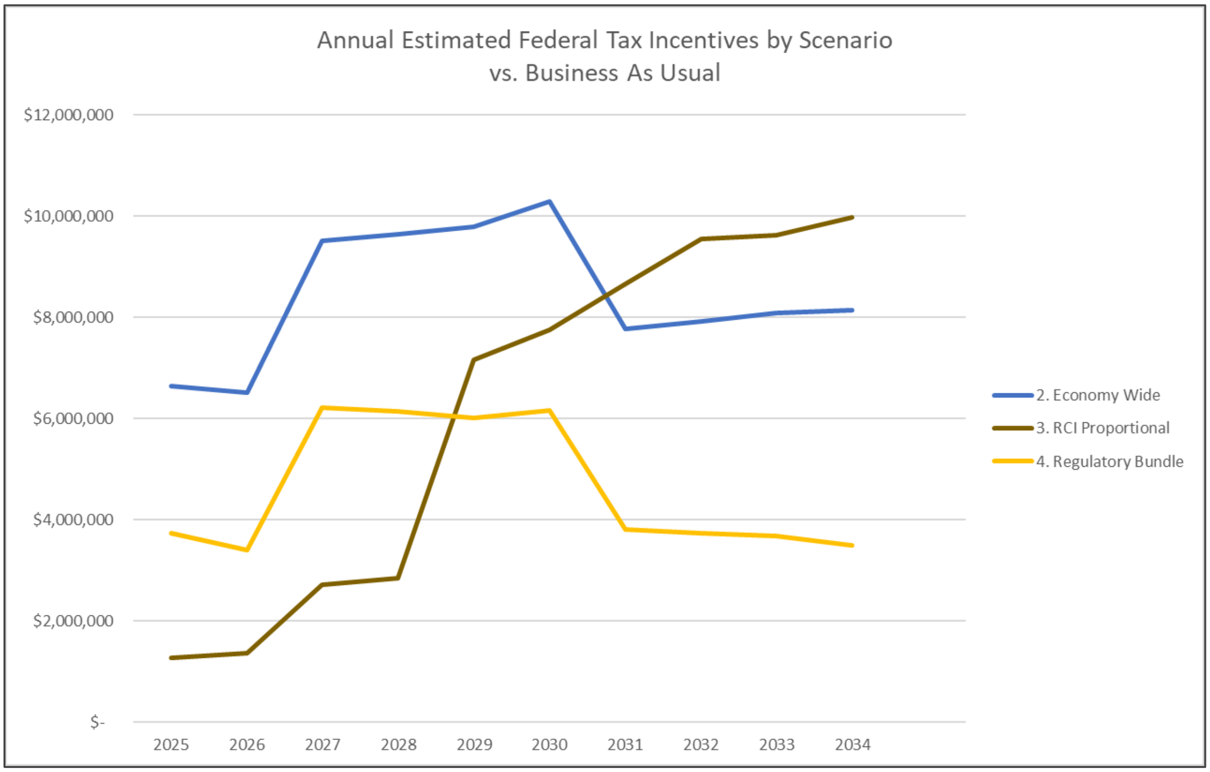


*Figure 25: Federal Tax Incentives*