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A Review of Home Heating Energy Efficiency in Vermont

PRESENTED TO THE VERMONT SENATE COMMITTEE ON NATURAL RESOURCES AND ENERGY

Senator Anne Watson, Chair

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ACRONYMS AND ABBREVIATIONS

ACRONYM	FULL NAME	ACRONYM	FULL NAME
BED	Burlington Electric Department	LIHEAP	Low Income Home Energy Assistance Program
CAP	Climate Action Plan	OEO	Office of Economic Opportunity
CEP	Comprehensive Energy Plan	PADD	Petroleum Administration for Defense Districts
CHS	Clean Heat Standard	PSD	Department of Public Service
CO2	Carbon Dioxide	PUC	Public Utility Commission
DCF	Department of Children and Families	QPIs	Quantified Performance Indicators
DOE	Department of Energy	RDIs	Residential Direct Installs
EEC	Energy Efficiency Charge	RES	Renewable Energy Standard
EEUs	Energy Efficiency Utilities	RGGI	Regional Greenhouse Gas Initiative
EVT	Efficiency Vermont	TEBC	Thermal Efficiency Benefit Charge
GHG	Greenhouse gas	VCC	Vermont Climate Council
GMP	Green Mountain Power	VGS	Vermont Gas Systems
GWSA	Global Warming Solutions Act	VHFA	Vermont Housing Finance Agency
HESP	Home Energy Savings Program	WAP	Weatherization Assistance Program
HHS	Department of Health and Human Services	WRAP	Weatherization Repayment Assistance Program
ISO-NE	Independent System Operator New England		

EXECUTIVE SUMMARY

Vermont's Global Warming Solutions Act sets significant emissions reduction mandates by 2025, 2030, and 2050. Reducing emissions in Vermont's thermal sector is one component for reaching these goals. We consider the impacts of household adoption of weatherization, cold climate heat pumps, biofuels, and natural gas on Vermont's climate goals. We identify an Energy Efficiency Gap in the thermal sector occurring primarily due to costs of greenhouse gas (GHG) emissions on the environment, and possible barriers to adopting energy efficiency technologies.

This report evaluates options for Vermont's energy efficiency policies in the residential thermal sector, focusing on cost-effectiveness, climate goals, and equity across homeowner incomes. The report examines existing proposals and possible alternative solutions, including:

1. Clean Heat Standard
2. Fuel Tax Increase
3. Thermal Efficiency Benefit Charge
4. Biofuels Blending Requirement
5. Low-Interest Financing Programs
6. Energy Efficiency Utilities (EEU) Modifications

Through a mixed methods approach—expert interviews, literature review, case study, and data analysis—we identified low-interest financing and EEU modifications as the policies that best meet the specified criteria. Table 1 shows a simplified version of the analysis for each policy across each criterion.

Table 1: Summary of Policy Proposals

POLICY PROPOSAL	POLICY EVALUATION CRITERIA		
	COST-EFFECTIVENESS	PROGRESS TOWARDS GOALS	EQUITY
Clean Heat Standard	✕	✓	✕
Fuel Tax Increase	–	✓	✕
Thermal Efficiency Benefit Charge	–	✓	✕
Biofuels Blending Requirement	–	✓	–
Low-interest Financing Programs	✓	✓	✓
EEU Modifications	✓	✓	✓

Note: Check means the policy meets the criteria; X means the policy does not meet the criteria; and – means the policy is neutral, it could or could not meet the criteria.

To maximize the success of any policy, we identify three structural challenges that will need to be addressed: 1) trade workforce development, 2) grid infrastructure and resilience, and 3) community engagement.

1 INTRODUCTION

Vermont's Global Warming Solutions Act sets significant emissions reduction mandates by 2025, 2030, and 2050. Reducing emissions in Vermont's thermal sector is one component for reaching these goals. In this report, we analyze the impacts of household adoption of weatherization, cold climate heat pumps, biofuels, and natural gas on Vermont's climate goals and evaluate options for Vermont's energy efficiency policies in the residential thermal sector, focusing on cost-effectiveness, progress toward climate goals, and equity across homeowner incomes.

This section explores Vermont's current climate and energy goals, regulatory environment, and equity landscape. These factors are critical to understanding how energy efficiency policies and technologies function within Vermont.

1.1 Climate and Energy Goals

1.1.1 Global Warming Solutions Act

In 2020, the Vermont Legislature passed the Global Warming Solutions Act (GWSA), creating a set of binding emissions reduction requirements.[1] The Act mandates that Vermont's emissions fall 26 percent below 2005 levels by 2025, 40 percent of 1990 levels by 2030, and 80 percent of 1990 levels by 2050 in accordance with the climate targets of the Paris Climate Agreement.[2] Figure 1 shows Vermont's historic and target emissions levels.[3] The GWSA also established the Vermont Climate Council (VCC), a body responsible for developing and maintaining a Climate Action Plan (CAP).[4]

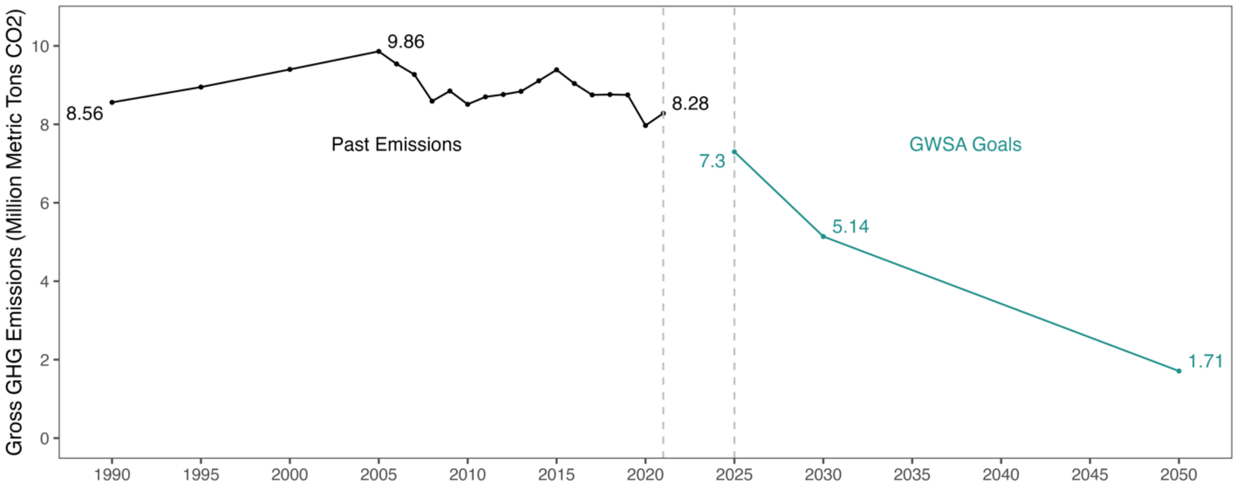

Figure 1: Past Emissions and Global Warming Solutions Act Emissions Goals, 1990-2050
Source: Vermont Agency of Natural Resources[5]

1.1.2 Climate Action Plan

In December 2021, the VCC adopted Vermont's Initial CAP.[6] Overall, the Plan includes 234 climate change mitigation, adaptation, or resilience strategies,[7] resulting in 29 CAP-related bills passed by the

Vermont Legislature.[8] The CAP identifies the transportation and residential thermal sectors as the highest carbon dioxide (CO2) emitters. By 2030, the CAP has set targets for the numbers of cold-climate heat pumps (169,472), heat pump water heaters (136,558), Electric Vehicles (125,744), and homes weatherized (120,000) to reduce thermal and transportation emissions.[9] As of 2023, the Conservation Law Foundation estimates that Vermont is not on track to meet these goals.[10]

By July 1, 2025, the VCC is mandated to update the CAP.[11] Work began in January 2024, with a draft expected by March 2025.[12] The December 2024 updates reflect recommendations from four subcommittees: Cross Cutting Pathways, Agriculture and Ecosystems, Rural Resilience & Adaptation, and Cross Sector Mitigation.[13] The VCC has proposed 55 priority actions, including passing a modified Clean Heat Standard (CHS), increasing electric capacity, improving resilience-building initiatives, developing a larger climate workforce, and expanding education in schools and communities.[14]

1.1.3 Comprehensive Energy Plan

In 2022, the Department of Public Service (PSD) released its Comprehensive Energy Plan (CEP). The CEP's goals and initiatives prioritize energy adequacy, reliability, security, and affordability.[15] The Plan builds upon requirements outlined in the 2011 and 2016 CEP to set new energy need goals. The Department also emphasizes the importance of ensuring a just and equitable energy transition to meet the needs of all Vermont citizens, communities, and institutions. The CEP therefore focuses on two themes—equitable solutions and grid evolution—within the three primary energy sectors: transportation, thermal, and electricity. Some of the CEP's strategies include expanding weatherization programs, encouraging heat pumps and biofuel alternatives, strengthening building energy standards, and considering a Clean Heat Standard.[16]

The CEP aligns with the goals set forth by the Global Warming Solutions Act. While the CEP and Climate Action Plan were developed simultaneously, they serve distinct purposes. The CEP focuses on implementing statutory energy policy.[17] The CAP focuses on climate change strategies for GHG mitigation, sequestration, and adaptation.[18] Figure 2 demonstrates the policy areas of overlap as determined by the VCC and PSD. Generally, the CEP's energy systems planning is outside the scope of the CAP.[19]

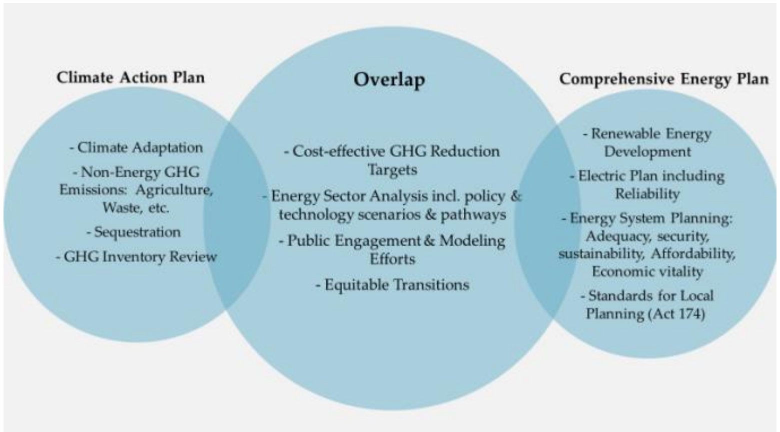

Figure 2: Climate Action Plan and Comprehensive Energy Plan
Source: 2022 Vermont Comprehensive Energy Plan[20]

1.2 Overview of Current Regulatory Framework

1.2.1 Public Utility Commission (PUC) and Energy Efficiency Utilities (EEUs)

The Public Utility Commission (PUC) is a Vermont government agency composed of a three-member quasi-judicial commission that regulates public utilities.[21] They regulate the siting, or the process of determining the locations, for electric and natural gas infrastructure across the state.[22] Additionally, the PUC oversees the rates, quality of service, and overall financial management of Vermont's public utilities, including cable television, electric, energy efficiency, gas, telecommunications, large wastewater companies, and water.[23] For brevity and relevance, this report will focus on the PUC's oversight of Vermont's Energy Efficiency Utilities (EEUs), a combination of private and public entities.

In 1999, the Vermont Legislature created EEUs to provide energy efficiency services to the state. There are three EEUs, mixed private and public entities, in Vermont: Efficiency Vermont (EVT), Vermont Gas Systems (VGS), and the City of Burlington Electric Department (BED). EVT provides energy efficiency services across the state, including rebates, energy assessments, financing, revocation and construction, project support, education and events, and income-based assistance.[24] VGS provides natural gas energy efficiency services within its coverage territory, including rebates, financing, energy audits, and weatherization assistance.[25] BED provides energy efficiency services solely to the City of Burlington, with the goal of becoming a Net Zero Energy city by 2030.[26]

EEUs get their funding through four primary mechanisms: three public sources — the Energy Efficiency Charge (EEC), the Regional Greenhouse Gas Initiative (RGGI), and Renewable Energy Standard (RES) Tier III investments — and one private source, the Forward Capacity Market.[27] Each are described below:

1. The EEC: The primary funding mechanism for Vermont's EEUs via a surcharge directly on customers' energy bills based on kilowatt hours used.[28]
2. The RGGI: A system of carbon cap and trade that requires fossil fuel-powered electric generation plants with the capacity for 25 or greater megawatts to obtain annual allowances for each ton of carbon that they emit.[29]
3. The Forward Capacity Market: Payments received by EVT and BED from Independent System Operator New England (ISO-NE) for reducing electricity demand during peak periods.[30]
4. Tier III of the RES: Distribution utilities invest in EEU rebate programs to meet the required fossil savings goals.[31]

1.2.2 Weatherization Assistance Program (WAP)

Since the 1980s, Vermont's Weather Assistance Program (WAP) has provided income-eligible Vermonters with no-cost whole-home weatherization upgrades.[32] To qualify for WAP, Vermont residents must meet income eligibility requirements.[33] The Department of Children and Families (DCF) administers the program through its Office of Economic Opportunity (OEO). The OEO has five partner organizations that implement WAP across the State.[34]

In 2024, WAP completed weatherization projects at 1,211 homes, a 72-unit increase (or 5.9 percent increase) from the number of completed projects in 2023.[35] Each household received an average investment of $11,958, leading to an average energy savings of 28.8 percent. Weatherization projects prevented 2,387.29 tons of CO_2 from entering the atmosphere.

The WAP is funded primarily through a state fuel tax and also via federal funds from the Department of Energy (DOE) and the Department of Health and Human Services (HHS).[36] The state fuel tax is stratified into three separate rates. For heating oil, propane, kerosene, and other dyed diesel fuel, the rate is $0.02 per gallon.[37] The natural gas and coal rate is 0.75 percent of the retail sales.[38] For electricity, the rate is 0.5 percent of the retail sales.[39] HHS funding for energy assistance comes from the Low Income Home Energy Assistance Program (LIHEAP), providing funds for weatherization assistance, up to 15 percent of total LIHEAP funds.[40] DOE funding comes from the federal Weatherization Assistance Program in the form of state grants.[41] The Trump administration's position on weatherization—advocating for the elimination of federal funding for the Weatherization Assistance Program—signals potential cuts to key funding sources.[42]

1.3 Energy Burden

As energy costs continue to rise, many Americans are choosing between buying food or paying their energy bills.[43] In 2023, the average Vermonter spent $7,071 on energy costs, a 17 percent increase from 2019.[44] The percentage of household income spent on energy costs, or the "energy burden", is the most commonly used expenditure-based metric.[45] To be considered high energy burden, a household must have an energy burden of 6 percent or greater.[46] To be considered severely energy-burdened, a household must have an energy burden of over 10 percent. Several key factors contribute to higher levels of energy burden, including geography, housing characteristics, socio-economic status, energy prices and policies, and behavioral factors (Table 2). The median energy burden in the U.S. is 5.6 percent, including transportation fuel.[47] Among certain demographics, the median energy burden is disproportionately higher than the national average, especially for low-income, Black, Hispanic, and rural households.[48] Older housing stock often has poor insulation, outdated heating and cooling systems, and inefficient appliances, which contribute to higher energy burden.[49]

Table 2: Factors Impacting the Energy Burden

LOCATION AND GEOGRAPHY	HOUSING CHARACTERISTICS	SOCIO-ECONOMIC SITUATION	ENERGY PRICES AND POLICIES	BEHAVIORAL FACTORS
Rural, urban, remote community, Native American, island territory Climate Population density Urban layout (affecting access to jobs and efficient appliances)	Characteristics of the building (manufactured, multi-family, or single-family) Rental and public housing Type of appliances used Type of thermostat: WiFi, smart, programmable, touchscreen	Income Ethnicity and race Immigrant vs native-born Number of occupants, children, elderly, and handicapped	Energy prices and rate designs Energy mix and access to natural gas Availability and effectiveness of low-income energy programs and appliances	Lack of knowledge Misplaced incentives/ principal-agent problems (especially in multi-family homes) Lifestyle cultural factors Lack of control over energy bills High non-monetary costs

Source: Brown et al, 2020[50]

The average Vermonter has an energy burden of 11 percent (electricity, heating, and transportation).[51] The average thermal energy burden is 3.6 percent – $2,447 in annual spending.[52] In Vermont, towns in the Northeast and along the Green Mountains face some of the highest thermal burdens, whereas the Champlain Valley has some of the lowest burdens.[53] Figure 3 shows the distribution of thermal energy burden across the state. Communities with lower energy burdens have higher adoption rates of heating technologies (cold climate heat pumps and weatherization) that can reduce thermal burden, indicating that those who could benefit the most from these technologies are not installing them.[54]

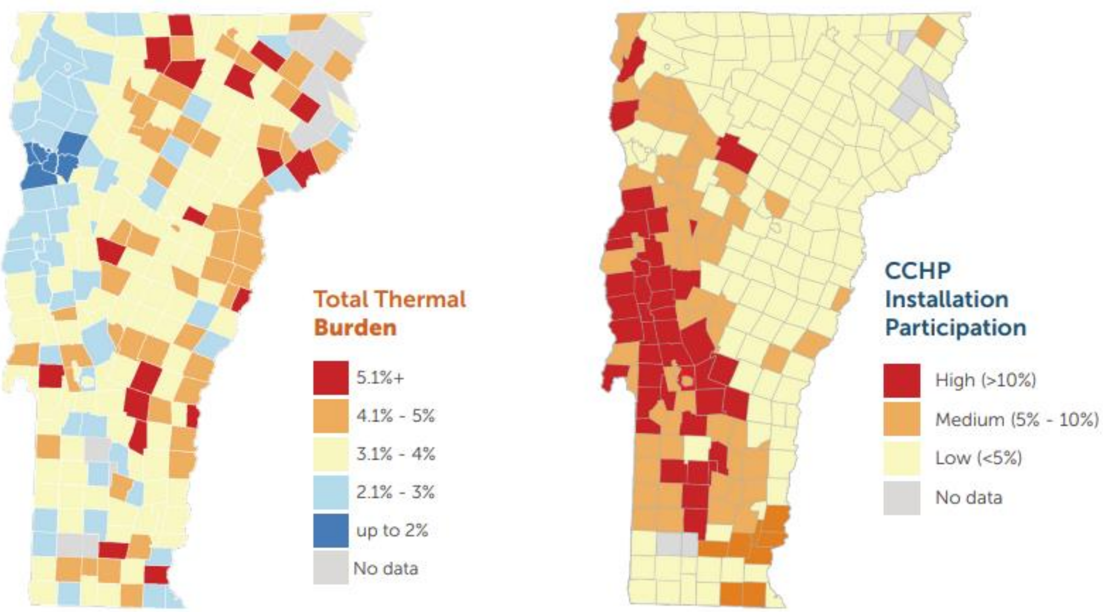

Figure 3: Thermal Energy Burden by Town and Per Capita Installations of Cold Climate Heat Pumps by Town
Source: 2023 Vermont Energy Burden Report[55]

2 PROBLEM STATEMENT

Vermont has limited economic resources to meet its ambitious climate and energy goals outlined in the Global Warming Solutions Act (GWSA) and Comprehensive Energy Plan. The GWSA recognizes human-caused greenhouse gas emissions as the driver of the climate crisis and calls for Vermont to accelerate solutions to address it.[56] The GWSA describes the necessity of immediate action since delays risk economic damage to Vermont.[57]

Currently, Vermont has been proactive in taking action with policies promoting energy efficiency in the residential thermal sector through the Energy Efficiency Utilities (EEUs)—Efficiency Vermont (EVT), Burlington Electric Department (BED), and Vermont Gas Systems (VGS)—and other programs such as the Weatherization Assistance Program (WAP). Our research focuses on how to most efficiently meet these goals, specifically asking: **what policies would be most cost-effective and equitable for achieving progress towards Vermont's climate and goals in the thermal sector?**

Some policies for reducing greenhouse gas emissions can be cost-prohibitive to the state government or consumers. Policies may require large government expenditures to be effective, which requires increased taxes, or they may tax consumers indirectly by raising prices on essential goods. In either case, due to resource limitations at the governmental and household levels, Vermont would benefit from policies which are cost-effective for achieving energy and environment goals since they would minimize taxes or price increases.

Equity has been and continues to be a focus of the Vermont General Assembly in energy efficiency policy. For example, the Affordable Heat Act includes provisions requiring the PUC to design the program equitably and consult with an Equity Advisory Group.[58] Some energy policies can have regressive outcomes, adding strain on low-income households. Currently, low-income households have the highest energy burden, and regressive energy policies would increase their burden. To avoid increasing the burden on the most burdened households, the implemented policies would need to forefront equity as a built-in consideration and focus on providing benefits to low- and moderate-income households.

This report considers the benefits and drawbacks of numerous policy options to improve the cost-effectiveness and energy equity impacts of Vermont's thermal energy policy.

3 POLICY EVALUATION CRITERIA AND METHODOLGY

3.1 Policy Evaluation Criteria

After reviewing recent legislation and discourse regarding the residential thermal energy sector in Vermont, including the Affordable Heat Act, and interviewing 11 experts on Vermont energy, we collected the following frequently mentioned criteria for evaluating whether a policy is a good fit for Vermont.[59]

1. Cost-effectiveness
2. Progress made toward climate and energy goals
3. Equitable distribution of energy burden focusing on low- and moderate-income households

The cost-effectiveness of a policy will be evaluated through an analysis of its financial impact on Vermonters in their role as taxpayers and consumers.

- To consider cost-effectiveness of a policy, the cost needs to be considered. The cost of a policy is measured through price increases for Vermont consumers and expenditures by the state or local government, for which the cost is passed on to Vermonters through the need for increased tax revenue. Measuring both taxes and prices ensures a holistic consideration of a policy's impact on Vermonters.
- A policy is considered cost-effective if it costs less to accomplish the same goals relative to other policies. The social cost-effectiveness of a policy is typically measured in the literature as welfare gains, indicating increases in the efficiency of resource usage in the economy. A factor that may affect welfare gains is the amount of excess subsidy. Subsidies are considered excess when they are provided to promote a choice, such as buying a heat pump, even though many individuals may have made the same choice without the subsidy.

The impact on progress towards climate and energy goals will be measured through the expected amount of carbon emissions abated, accomplishing the key requirement of the GWSA.

Finally, the equity of a policy will be understood through an analysis of the impact on households of various income levels.

- A policy is considered equitable if it is progressive or reduces the energy burden for low- and moderate-income households.
- A policy is considered inequitable if it is regressive or places an additional energy burden on households who can least afford it.

3.2 Methodology

We employed a four-pronged mixed methods approach to analyze the impacts of the Clean Heat Standard and other alternative energy policies on Vermont's GHG goals and economy.

3.2.1 Literature Review

First, a comprehensive review of existing literature was conducted to understand the existing climate and energy landscape, energy upgrade technologies, and the Energy Efficiency Gap. Utilizing academic studies in addition to government and organization reports, we examine technologies used to enhance residential efficiency and the energy efficiency adoption and equity gaps. Furthermore, we build upon information to inform the analysis of proposed and alternative energy solutions as well as structural challenges that implementation of these policies might face.

3.2.2 Expert Interviews

Expert interviews informed our assessments of the Clean Heat Standard and its potential alternatives. We also used interviews to further investigate Vermont's energy landscape on EEUs, energy efficiency technologies, weatherization, and energy equity. We targeted five primary types of individuals and organizations to ensure representation from a variety of energy perspectives: EEU employees, state officials, nonprofit leaders, energy equity experts, and economists. EEU employees are experts on energy efficiency technologies, electrification initiatives, and the broader energy policy landscape in Vermont. State officials and nonprofit leaders provided insight into the impacts and feasibility of proposed and alternative energy policies as well as on-the-ground perspectives of how Vermont residents interact with existing programs. Energy equity experts elaborated on the role of the energy burden, the consequences of inequitable energy policy, and possible strategies to ensure that future energy policies are equitable. Economists offered perspectives on the energy market and consumer implications of potential energy policy implementation. We targeted individuals within these areas for interviews as they have the most knowledge of the current Vermont energy and policy landscapes. The Acknowledgments section contains a list of interviewees.

3.2.3 Data Analysis

We conducted three sets of calculations to analyze the Vermont energy system.

1. Using the 2023 American Community Survey (ACS), 2020 Census, and heat pump data from the Energy Action Network, we analyzed the influence of income on town-level heat pump adoption in Vermont (Section 5.2.2).
2. Utilizing Vermont Department of Taxes data on fuel tax revenues, we estimated the amount of additional returns the State would yield based on increasing the tax rate (Section 6.2.2).
3. Combining Vermont Department of Taxes data on fuel tax revenue with biofuel CO2 reduction data from the National Renewable Energy Laboratory and EIA CO2 emissions by fuel source data, we modeled the CO2 abatement from varying levels of biofuel blending (Section 6.3.3).

3.2.4 Maine Case Study

We conducted a case study to examine Maine's energy efficiency programs, particularly Efficiency Maine. Both states share challenges and characteristics, such as their cold climates, rural populations (61.4 percent of Mainers and 64.9 percent of Vermonters live in rural areas), and aging housing stock (with approximately 25 percent of homes in Maine and Vermont built before 1940).[60] [61] [62] Maine, like Vermont, has also set ambitious GHG emissions reduction targets—45 percent by 2030 and at least 80 percent by 2050.[63] The methodology for this case study involved a comprehensive literature review, including Efficiency Maine's reports, evaluations of its programs, and external articles. We focused on three key programs:

- The Home Energy Savings Program (HESP) heat pump usage and customer feedback data (Section 4.2.5 and Section 8.3)
- The Residential Direct Install (RDI) program (Section 7.1.5)

- The Distributed Energy Resource Management Systems (Section 8.2.4)

4 ENERGY UPGRADE TECHNOLOGIES

In this section, we provide background information on four home heating energy upgrades households may consider in Vermont.

4.1 Weatherization

4.1.1 What is the Home Weatherization Process?

According to one expert interview, home weatherization to reduce energy usage involves two main components: 1) air sealing and 2) insulation.[64]

1. Air sealing is the process of filling leaks in a home preventing the movement of hot air to the outside and cold air to the inside. Before air sealing, a building auditor tests how leaky the home is using a blower door, a diagnostic test that identifies leak locations and the current airtightness of the home. Leakage typically occurs in attics, basements, and openings (doors/windows).
2. After air sealing, insulation is installed in the walls to decrease the heat transfer through the walls. In weatherization retrofits, insulation typically involves blown-in cellulose insulation or blown-in fiberglass insulation for mobile homes. For weatherization to be effective, insulation must be done after air sealing since it is difficult to do air sealing after insulation has been pumped in.

From a labor perspective, an expert reported that working on weatherization projects is less desirable than working on new construction projects since weatherization requires people to work in walls and nooks of buildings constructed decades or even centuries ago.[65] The concentration of work in the attic and basement—two areas with the most extreme temperatures on hot and cold days—also makes weatherization work less desirable.[66]

Weatherizing a home is a time-intensive process for households, support staff, and contractors. Homeowners must submit forms for the WAP and have multiple meetings with the efficiency coach, building auditor, and quality control inspector for testing and evaluation. One interviewee reported spending, on average, 105 hours of labor per job, including travel time.[67]

4.1.2 Average Weatherization Job Costs Nearly $12,000 in Vermont and Reduces Heating Energy Consumption by Almost 30%

The WAP provides information on the cost and savings of weatherization. Across all funding sources, WAP projects are capped at $15,866.[68] In 2024, the average per household investment was $11,958, and the average energy savings per household was 28.7 percent per year.[69] However, some contractors have reported higher average costs per job, nearing the $15,866 limit.[70]

4.1.3 Weatherization is Needed in All Homes, Particularly Older and Mobile Homes

Weatherization provides significant energy efficiency improvements for all non-weatherized homes. However, older and mobile homes have worse air leakage and more insulation issues than newer buildings, making weatherization important. Older homes are more common in Vermont as 25 percent of buildings were constructed before 1940 (Figure 4), in contrast to the national average of 12 percent.[71] The WAP currently services many mobile homes, representing around 30-40 percent of the share of WAP jobs, according to a weatherization expert.[72]

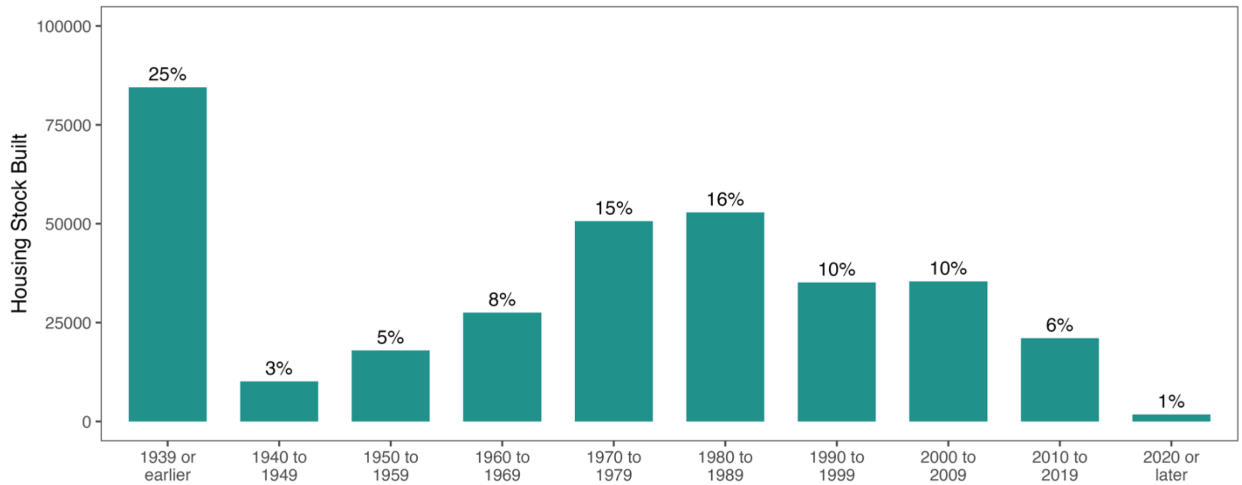

Figure 4: Housing Stock by Year of Structure Built, Vermont
Source: HousingData.org[73]

4.2 Cold-climate Heat Pumps

4.2.1 How do Heat Pumps Work?

Heat pumps are dual heating and cooling systems that transfer heat energy from inside the home to the outside. Figure 5 outlines the operation of a heat pump.

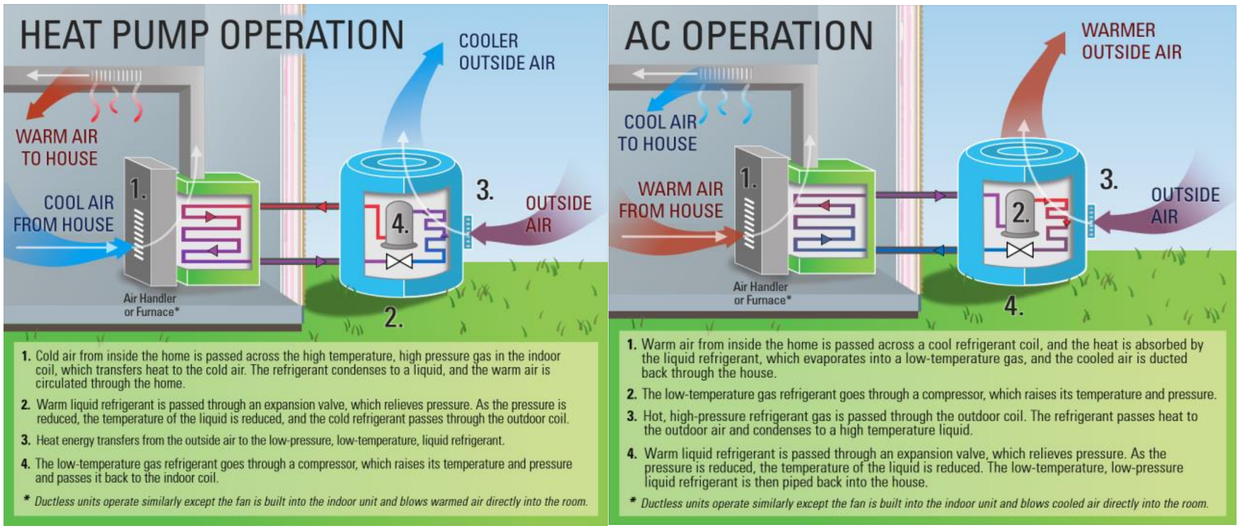

Figure 5: Heat Pump Operation Diagrams
Source: EPA[74]

The heat pumps described above are air-source heat pumps because they draw heat energy from the outdoor air. Heat pumps may also draw heat energy from the ground (ground-source heat pumps or geothermal heat pumps) and water (water-source heat pumps). Air-source heat pumps are the cheapest to install and account for most installations, and thus, they will be the focus of our analysis.[75]

Heat pumps can be ducted or ductless mini-splits. Ducted heat pumps serve the whole home through a duct system, while ductless mini-splits are units heating only a specific room. Heat pumps may also be classified as minimum efficiency, medium efficiency, and high efficiency. Only high-efficiency cold-climate heat pumps work in cold weather, providing a standard of 65°F indoors when it is 5°F outside.

4.2.2 Average Whole-Home Heat Pump Installation Costs Over $15,000 in Vermont

The reported cost of an air-source heat pump installation ranges from $3,000 to $11,000, and the cost of ductless mini-splits ranges from $1,500 to $8,000.[76] However, actual installation costs in Vermont have been reported to be at times higher than these ranges at times. According to an expert on heat pumps in Vermont, installations cost $5,000-7,000 for single-zone ductless heat pumps, $8,000-12,000 for multi-zone ductless heat pumps, and $15,000-20,000 for ducted whole-home heat pumps.[77]

4.2.3 Heat Pump Savings Outweigh Costs

A physics-based study by the National Renewable Energy Laboratory found that heat pump installations are financially advantageous and provide households with positive present value.[78] The long-run savings from heat pumps offset the short-run upfront cost for households currently heating with fuel oil, propane, and electric induction. Notably, this is not true for households currently heating with natural gas because natural gas is cheaper than fuel oil, propane, and electric induction heating.

According to the study, 83 percent of homes in the Northeast currently using fuel oil or propane and 81 percent of homes currently using electric induction would have a positive net present value if they adopted a high-efficiency cold-climate heat pump, as shown in Figure 6. A positive net present value indicates that it would be financially advantageous to the household to finance a heat pump even after factoring in the costs of a typical home equity loan.[79] In other words, the energy bill savings over the lifetime of the heat pump (16 years) are greater than the cost of financing the heat pump.[80]

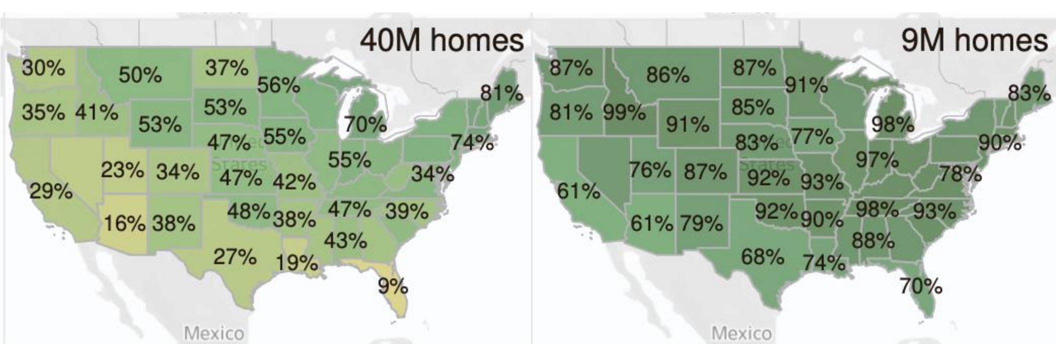

Figure 6: Percentage positive net present value by state or region, with $2,000 incentive. Disaggregated by current fuel type, electricity (left), and fuel oil and propane (right). Model scenario of homes currently with AC.
Source: Wilson et al.[81]

BOX 1: PRESENT VALUE AND DISCOUNT RATE

Present value is the current value of future earnings. It is determined by discounting future earnings by a discount rate, typically tied to the interest rate. For example, if an individual could earn a rate of return of five percent interest per year by purchasing a Treasury Bill, $105 of energy savings one year from today has the present value of $100. The discount rate would be five percent.

The above scenario includes homes currently with air conditioning and a $2,000 federal incentive. Without the $2,000 federal incentive, the percentage of households with a positive net present value decreases slightly to 74 and 75 percent, respectively.[82] For homes without air conditioning, the percent of households with positive net present value decreases to 63 and 46 percent.[83]

Similarly, the Vermont Pathways report, developed using the Vermont LEAP model, supports the financial advantage of heat pump installation. According to the model, heat pumps and heat pump water heaters have a substantial negative marginal abatement cost (net cost savings) in the medium (5 years) and long run (25 years).

4.2.4 Heat Pumps More Efficient in Weatherized Homes

Experts on heat pump installation have emphasized the importance of weatherizing before installing heat pumps. A weatherized home stays warmer and requires a less powerful heat pump. Heat pumps in non-weatherized homes need to be far larger in heating capacity, increasing the upfront and energy costs of the heat pump. This extra capacity also becomes unnecessary if the home is later weatherized. Oversized heat pumps may also exhibit short-cycling behavior, drastically reducing their efficiency.[84] The most efficient heat pumps are single-zone, one-indoor, one-outdoor units designed to meet 99 percent of a home's theoretical peak heating load.[85] Furthermore, a heat pump's lifespan may be reduced if it is constantly running to heat a leaky home, as prolonged operation time increases wear and tear on the machinery.[86]

4.2.5 Furnaces Provide Backup Heat for Frigid Days and Power Outages

While the technology of heat pumps has improved in recent decades, most heat pumps lose some efficiency at extreme cold temperatures. Most cold-climate heat pumps continue to operate at temperatures as low as -13°F but start losing efficiency at 5°F since the heating source starts switching from heat pumping to electric induction.[87] The most advanced models can maintain 100 percent efficiency down to -5°F.[88] On the coldest days of the winter, when Vermont reaches minimum temperatures below 5°F,[89] supplementing heat pumps with furnace heat is optimal.

In addition, keeping fuel as a backup in case of power outages, especially in rural areas, is necessary for safety. When including severe weather, the average Vermont house loses power 2.25 times per year for an average of 3.6 days.[90]

Heat pumps work best as the primary heat source, with other heating used only as a backup or for small areas. In Maine, a survey of HESP customers found that of customers who bought heat pumps, 19 percent turned their heat pump on and off as needed or shut them down below 20°F in favor of fossil-fuel heating, reducing the heat pump's efficiency and impact.[91] To prevent under-utilization, Efficiency Maine implemented new requirements limiting most of their rebates to whole-home heat pumps accounting for at least 80 percent of a home's heating needs for higher-income households.[92] Although hybrid heat pump-furnace and ductless mini-split setups can cause under-utilization of heat pumps, such hybrid setups maintain safety and provide efficiency gains nonetheless. Heat pumps can be paired with smart thermostats to maximize savings and efficacy.

4.2.6 Heat Pumps Necessary for Cooling as Temperatures Increase

In Vermont, cooling needs are on the rise. As Figure 7 shows, cooling degree days are increasing in the Northeast. While Vermont's cooling needs have been relatively consistent, the state recently experienced an extreme heat wave in 2024, reaching heat indexes above 100°F in some areas.[93] Heat pumps can provide the necessary cooling as temperatures rise and manage extreme heat waves if they become more common.

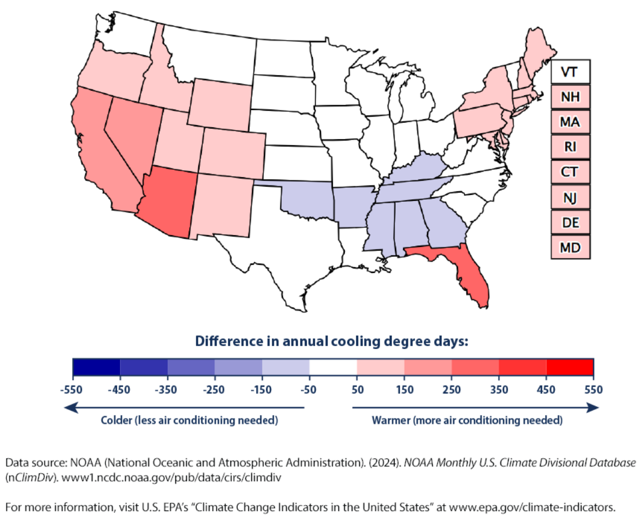

Figure 7: Change in Annual Cooling Degree Days by State, 1960-2023 Versus 1895-1959
Source: EPA 2024[94]

4.3 Biofuels

4.3.1 What are Biofuels?

Biofuels are liquid fuels produced from organic sources.[95] Biofuels have several notable benefits, including lower carbon intensity, energy security, economic development, and infrastructure compatibility.[96] They also have some challenges to widespread use, such as production capacity, technological limitations, and fossil fuel market competition.[97] The most common biofuels are ethanol, biodiesel, and renewable diesel.[98] Biodiesel and renewable diesel can replace heating oil, whereas ethanol is a gasoline substitute (not used for heating), making biodiesel and renewable diesel candidates for heating applications.[99]

4.3.2 Biodiesel Production Process

Biodiesel and renewable diesel are produced from feedstocks such as vegetable oils (soy and canola), used cooking oils, and animal fats.[100] Soybean oil comprises the largest share of feedstock used in biodiesel and renewable diesel production.[101] Biodiesel and renewable diesel originate from the same feedstock and are produced via different processes.

Biodiesel undergoes transesterification, where the feedstock is mixed with methanol and a catalyst to break down the fats and oils, resulting in biodiesel (fatty acid methyl esters - FAME). The transesterification process oxygenates the fuel, making it roughly 11 percent less energy-dense than traditional fuel.[102] Biodiesel also has a higher viscosity than regular fuel and can crystalize at lower temperatures, causing it to gel.[103] As a result, biodiesel is often blended with other fuels in forms such as B5 (5 percent biodiesel) or B20 (20 percent biodiesel).[104]

Renewable diesel is typically produced via hydrotreating, where feedstocks undergo high temperatures and pressure in the presence of hydrogen and another catalyst to remove oxygen, nitrogen, and sulfur from the fuel.[105] Researchers are developing alternative production pathways, including biological sugar upgrading, catalytic conversion of sugars, gasification, pyrolysis, and hydrothermal processing to make renewable diesel, but hydrotreating remains the most common.[106] Each process produces a hydrocarbon fuel chemically identical to petroleum diesel, resulting in a fuel that can directly replace existing fuels without blending.[107]

4.3.3 Biodiesel Production Location

Biodiesel and renewable diesel production are measured on the Petroleum Administration for Defense Districts (PADD) level. Five PADDS comprise the United States: East Coast (PADD 1), Midwest (2), Gulf Coast (3), Rocky Mountain (4), and West Coast, AK, HI (5). There are currently 56 biodiesel production and 22 renewable diesel production plants in the United States.[108] Biodiesel production is more evenly spread across the U.S. than renewable diesel production (Figure 8).[109] Vermont lacks biodiesel and renewable diesel production plants and would have to import these biofuels. Biodiesel would likely be easier to import than renewable diesel as the Northeast has four biodiesel plants and no renewable diesel plants.

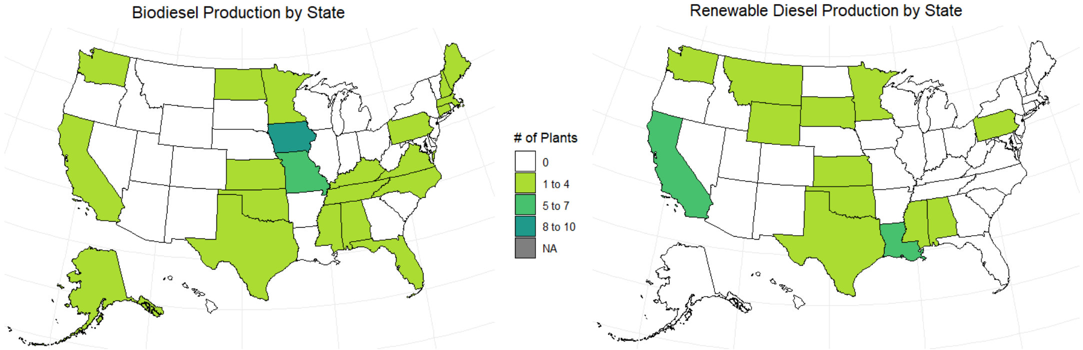

Figure 8: Distribution of Biodiesel and Renewable Diesel Production Plants
Source: Authors' Replication of EIA Data[110]

4.3.4 Biofuels Abate Lifetime Carbon Emissions by 16% for Each Increase of 20% in the Biodiesel Blend

When burning biofuels (renewable diesel and biodiesel), the tailpipe emissions, emissions as a direct result of burning fuel, of harmful pollutants (SO_x, NO_x, PM, CO, and HC) are significantly reduced compared to traditional diesel.[111] However, the CO2 tailpipe emissions are similar to burning fossil fuels.[112] When factoring in the full life cycle of biofuels—including extraction, processing, manufacturing, distribution, use, and disposal—biofuels result in fewer CO2 emissions than traditional diesel.[113]

Both biodiesel and renewable diesel produce significantly lower levels of CO2 than traditional fuels, including diesel, heating oil, and natural gas. Biodiesel CO2 emissions vary based on the blending ratio.[114] Higher concentrations of biodiesel result in increased carbon abatement (Figure 9).[115] 20 percent biodiesel (B20) reduces emissions by 15.66 percent, and B100 reduces emissions by 78.45 percent.[116] Renewable diesel reduces emissions by up to 85 percent and, on average, 68.5 percent.[117] For both fuel types, waste-derived feedstocks (cooking oil and tallow), generally result in lower life-cycle emissions than virgin oilseed (canola and soy).[118]

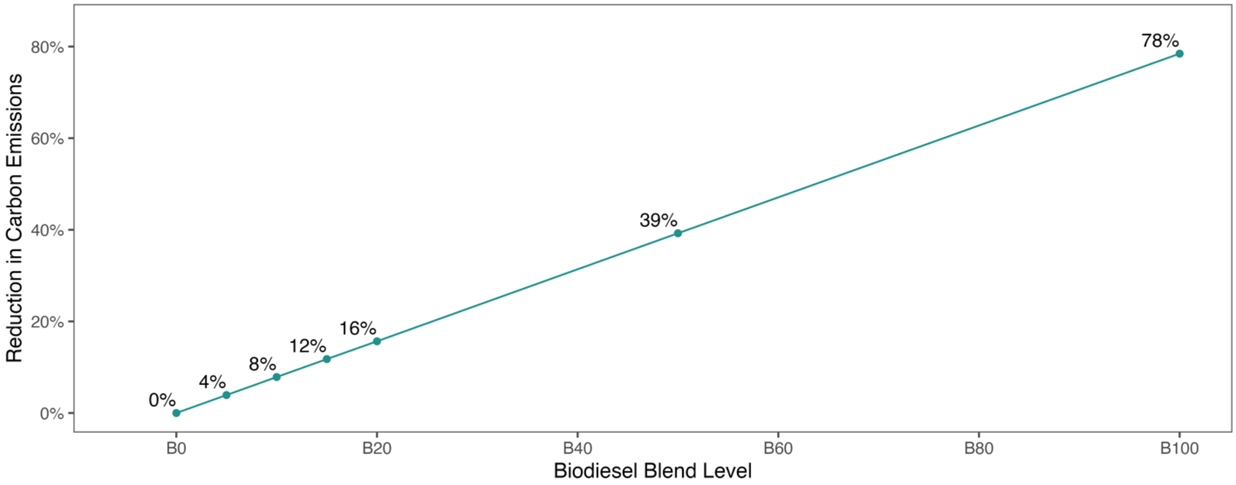

Figure 9: Percent Carbon Emissions Abated at Levels of Biodiesel Blend
Source: National Renewable Energy Laboratory[119]

4.4 Natural Gas

4.4.1 Vermont Gas Systems Pipelines and Coverage Territory

Vermont Gas Systems (VGS) is the sole natural gas distributor in the state serving approximately 55,000 customers.[120] Their coverage territory, shown in yellow in Figure 10 below, spans northwest Vermont from Franklin County to Addison County. The natural gas is imported from Canada—the pipeline's sole source—entering the state at Highgate, Vermont.

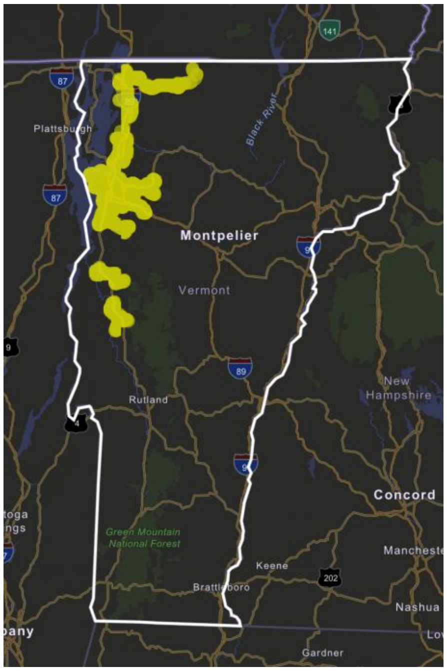

Figure 10: Map of VGS Coverage
Source: VGS Website[121]

VGS's original 1965 pipeline connected natural gas from Highgate to Burlington.[122] Several extensions were proposed between the 1980s and 2000s.[123] Only one extension, Phase 1 of the Addison Rutland Natural Gas Project, was completed in April 2017, extending service to Middlebury, Vergennes, New Haven, and Bristol.[124] Phase 2 of the Addison Rutland Natural Gas Project was meant to connect the pipeline to an International Paper plant in Ticonderoga, New York, with International Paper paying for the infrastructure. However, after cost overruns in Phase 1 of the project, the deal between VGS and International Paper was canceled. VGS has not announced updates on the Phase 3 expansion to Rutland since the opening of Phase I in 2017.[125] In addition to issues with cost overruns, Phase I of the project faced substantial resistance from environmental groups and local stakeholders.[126]

4.4.2 Natural Gas Cleaner than Fuel Oil and Propane, Not as Clean as Biofuel and Heat Pumps

According to the Energy Information Administration, natural gas emits 29 percent less CO2 than fuel oil and 16 percent less CO2 than propane for the same amount of heating.[127] As a result, it is cleaner than fuel oil and propane but is not as clean as high blending levels of biofuel (B40+) and electrification using air-source heat pumps.

As the electric grid transitions from fossil fuels to renewable energy, the carbon abated from electrification using heat pumps—which will increasingly use electricity from renewable sources—will scale up while the emissions from natural gas burned in a home furnace remains unchanged. By 2040, ISO New England forecasts that renewables will make up 56 percent of the grid resource mix, as shown in Figure 11. Combined with other sources of cleaner energy (nuclear, hydro, and imports), a super majority of electricity will be generated with minimal GHG emissions. Consequently, heat pump carbon abatement increases year over year after installation, while natural gas provides fixed benefits, making it less effective over long-time horizons to 2040 and beyond.

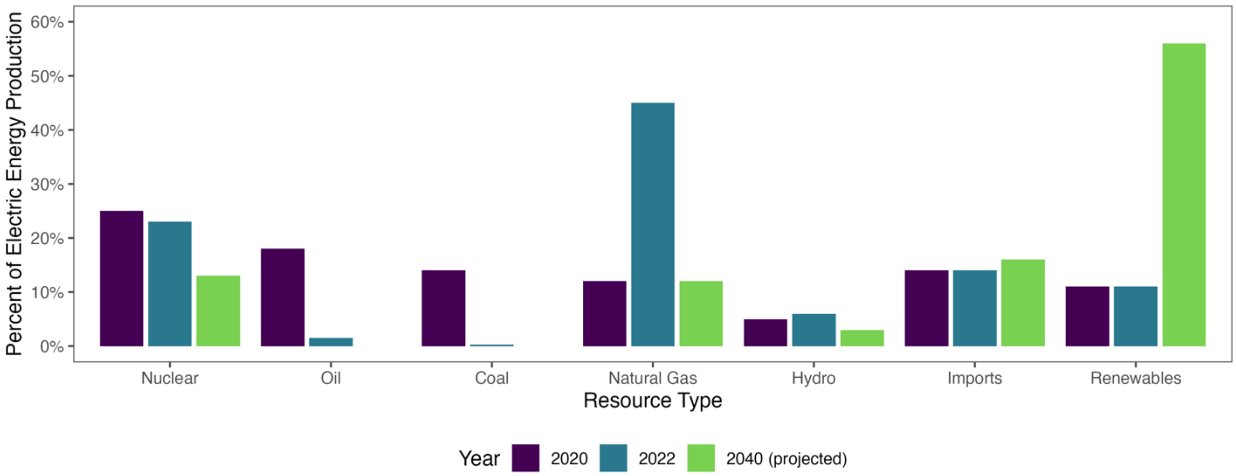

Figure 11: ISO New England Resource Mix, Past, Present, and Projected
Source: ISO New England[128]

4.4.3 Natural Gas Expansion Not Cost-effective, Cheap in Existing Coverage Territory

Natural gas is a cheaper alternative to fuel oil and propane, but natural gas heating is more expensive than the electricity costs of heat pumps.[129] As shown in the left panel of Figure 12, engineering studies find switching to a heat pump from natural gas would yield positive bill savings for 99 percent of New England households. Therefore, for households currently using fuel oil or propane, heat pumps are more financially advantageous than connecting to natural gas. This is especially the case for homes outside of VGS's existing coverage territory since a pipeline extension would be a multi-million-dollar investment. Coupled with the increasing abatement of heat pumps in the long run, expanding natural gas pipelines would not be a long-term cost-effective solution for meeting Vermont's climate goals.

That said, the bill savings are often too small to justify a household's upfront investment. As shown by the right panel of Figure 12, five percent of households would have a positive net present value for switching from natural gas to a heat pump. Experts in Vermont have also supported the finding that most households should expect, at best, to breakeven when switching from natural gas to heat pumps, with some incurring a cost. Thus, households currently on natural gas would require the largest subsidy to make the transition financially viable. Since natural gas is already cleaner than fuel oil, converting these households to heat pumps is the least cost-effective option.

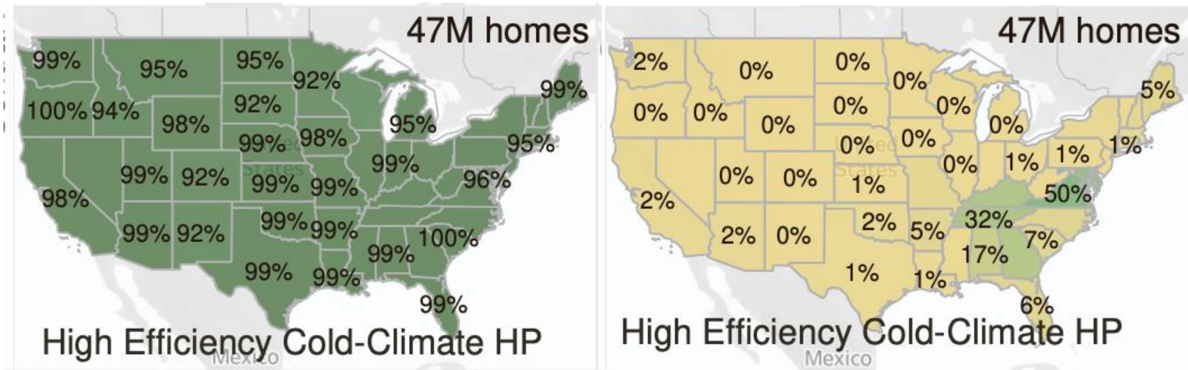

Figure 12: Percent of households currently using natural gas with positive bill savings (left) and positive net present value (right) switching to a high efficiency cold-climate heat pump
Source: Wilson et al. [130]

5 THE ENERGY EFFICIENCY GAP

The Energy Efficiency Gap refers to the long-studied phenomenon of under-adoption of energy efficiency upgrades due to economic and behavioral factors. If the market fails to close the gap, other options—such as government intervention—could be considered. This section analyzes whether such a gap exists in Vermont's housing market, whether there is an equity gap, and the potential causes behind these gaps.

5.1 Is there an Energy Efficiency Adoption Gap?

5.1.1 Housing Market Efficiently Prices Home Energy Upgrades

According to economic theory, individuals make choices based on current and future income and costs. For example, homebuyers tend to favor more energy-efficient homes, viewing lower energy bills as more attractive, which can increase the value of weatherized homes. Thus, weatherized homes with lower heating costs are often priced net higher than non-weatherized homes with greater heating costs. The price premium paid for the more efficient home is forecasted to equal the present value of the expected difference in energy costs. Various studies have utilized this methodology to analyze national housing data.[131]

The price premium for such weatherization/efficiency upgrades ranges from three to five percent of the standard home price.[132] To capture these price premiums in the housing market, energy efficiency needs to be communicated through a standardized rating system. For example, the Residential Energy Services Network offers the Home Energy Rating System, where an accredited rater inspects and tests a home, calculating a score that can be compared between homes.[133] Across a sample of homes throughout the country (including colder climates like the Northeast and Midwest), rated homes sell for an average 2.7 percent higher than unrated homes.

The price premium for heat pumps in particular is 4.3–7.1 percent of the home price, a difference of $10,400–17,000.[134] Notably, heat pump data is concentrated in the Pacific and South Atlantic areas, where adoption rates are higher. Areas with high environmental consciousness, more middle-class households, and mild climates have larger premiums.

Given the price premiums of upwards of $10,000 capturing numerous years of energy bill savings, we conclude that the housing market efficiently prices home energy upgrades, including in Vermont, where there are numerous areas of high environmental consciousness and many middle-class households.[135] However, this analysis is inapplicable to Vermonters who do not intend to move. Although Vermont has the highest proportion of inbound migration in the US,[136] many residents do not sell their homes. Thus, pricing efficiency in the housing market may be irrelevant to their adoption of energy efficiency upgrades.

5.1.2 Energy Efficiency Gap Remains Due to Social Cost of Fossil Fuels

Although the housing market prices home energy upgrades efficiently, we maintain that an Energy Efficiency Gap exists due to negative externalities caused by fossil fuels. A negative externality is a cost to other parties not incurred by the consumer of a certain product. In the case of heating with fossil fuels, the fuel produces greenhouse gas emissions which cause negative externalities to the environment not internalized by the price of the fuel. The social cost of carbon in the US is estimated to be, conservatively, $130 per metric ton of CO2 in 2025,[137] which translates to a $1.32 social cost per gallon of heating oil.[138] Over the lifetime of a heat pump, the social cost of carbon exceeds the price premium.

5.2 Is there an Energy Efficiency Equity Gap?

5.2.1 No Correlation Between Heat Pump Adoption and Household Income, National Study Finds

A study using national data from the 2020 Residential Energy Consumption Survey found no correlation between heat pump adoption and household income.[139] The Energy Information Administration survey collected information on households' primary heating source and income. As shown in Figure 13, heat pump adoption does not increase with income at the national level. However, this finding may not be fully applicable to Vermont. Heat pump data is concentrated in the Pacific and South Atlantic where adoption is high. Only 5 of the 240 surveyed Vermont households indicated that a heat pump was their primary heating source, raising questions about the study's relevance to Vermont. Additionally, the national study found correlations between income and adoption of other more green technologies, such as solar panels and electric vehicles. This trend indicates the existence of an equity gap exists for green technologies, even if it is not directly observed for heat pumps.

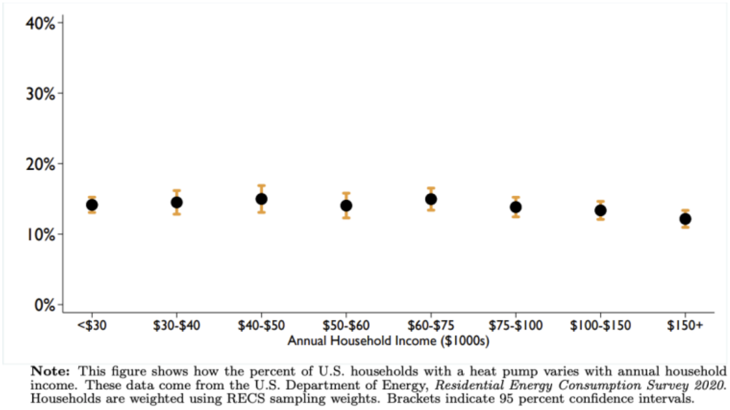

Figure 13: Heat Pump Adoption by Household Income
Source: Davis[140]

5.2.2 Significant Correlation Between Heat Pump Adoption and Median Household Income in Vermont

At the state level, our town (county subdivision) analysis found a statistically significant positive correlation between median household income and the number of heat pumps per housing unit. We present a scatterplot of heat pump adoption and household income at the town level based on linear regression in Figure 14, which shows each $10,000 increase in median household income corresponds to an increase of 2.4 heat pumps per 100 housing units. The relationship is statistically significant ($p<0.001$). The R^2-value (0.13) indicates other factors also impact adoption; the data suggests a clear income-related disparity in heat pump access.

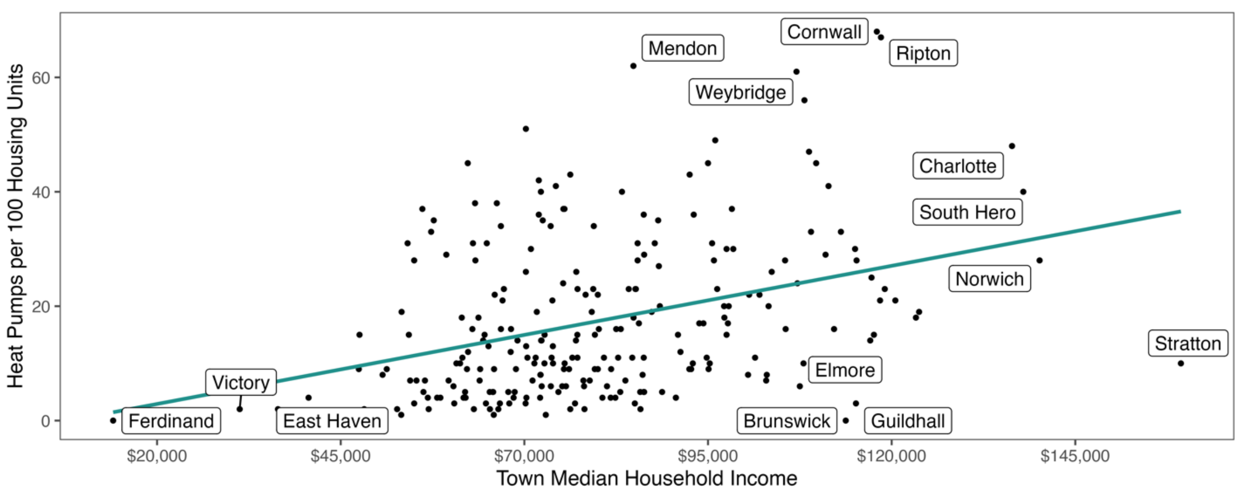

Figure 14: Median Household Income and Heat Pumps Adoption by Town, 2023
Source: Energy Action Network, 2023 American Community Survey, 2020 Census[141]

Notably, additional regression analysis (Table 3, column 2) shows that heat pump adoption is correlated with income but not population density, supporting the findings from the *2023 Vermont Energy Burden Report*.[142] Our analysis does not support the hypothesis that heat pumps are concentrated in urban areas. Our findings in Vermont are consistent with a broader body of research indicating that lower-income households face greater barriers to adopting energy efficiency upgrades, as discussed in the following section.

Table 3: Regression analysis of household income and population density on heat pumps

	Dependent variable:	
	Heat pumps per 100 housing units	
	(1)	(2)
Town median household income (in ten thousands)	2.415*** (0.412)	2.424*** (0.414)
Population density		0.001 (0.002)
Constant	−1.926 (3.415)	−2.072 (3.446)
Observations	241	241
R^2	0.126	0.126
Adjusted R^2	0.122	0.119
Residual Std. Error	13.016 (df = 239)	13.040 (df = 238)
F Statistic	34.304*** (df = 1; 239)	17.153*** (df = 2; 238)

Note: *$p<0.1$; **$p<0.05$; ***$p<0.01$

Source: Authors' calculations using Energy Action Network, American Community Survey 2023, and 2020 Census data[143]

5.3 Barriers to Energy Efficiency Upgrades for Households

5.3.1 The Upfront Cost of Energy Efficiency Upgrades is Significant

Energy efficiency upgrades are costly. The average cost of weatherization jobs for low-income households currently funded by the Vermont Weatherization Assistance Program and other sources is over $15,000. The cost of installing a heat pump varies greatly based on the heating needs, layout of the house, and other case-by-case factors. The reported cost of an air-source heat pump installation ranges from $3,000 to $11,000, and the cost of ductless mini-splits ranges from $1,500 to $8,000.[144] However, the actual cost for installation is typically higher in Vermont than the reported ranges, from $10,000 to $20,000.[145] Furthermore, some homes may require more than one heat pump to provide all the sufficient heat needed, with the average being 1.3 heat pumps per home in Vermont.[146]

5.3.2 High Discount Rate Reduces Energy Efficiency Investments

The discount rate determines how much individuals value future money in the present. In the context of energy efficiency investments, if a household with a higher discount rate is considering an energy efficiency upgrade, they would value future energy bill savings less. As a result, the household would be less likely to proceed with the investment.

In their study, the National Renewable Energy Laboratory used a real discount rate of 3.4 percent per year, a discount rate that—after converting to nominal terms—matches "national average interest rates for home equity loans in the US in 2023."[147] However, the discount rate used by the study may not fully reflect the actual discount rate of many households. A study by Professor Jerry Hausman found a consumer discount rate of about 20 percent per year.[148] Notably, the consumer discount rate increases as income decreases, indicating lower-income households have more financial difficulty adopting energy-efficient appliances.[149] That the consumer discount rate increases as income decreases is logical since lower-income households could be more liquidity-constrained and have higher interest rates.[150] For example, if an individual is revolving credit card debt at a 20 percent interest rate, their best investment is to pay down their credit card debt instead of investing in energy efficiency.[151]

Moreover, there is a difference between household and government discount rates. Typically, households borrow at a higher interest rate than governments, or government-sponsored financial institutions. For example, the Vermont Housing Finance Agency can access multi-purpose capital for below four percent interest when households may need to pay eight percent for a home improvement loan.[152] As a result, an opportunity exists for governments to use their creditworthiness to lower discount rates on energy efficiency savings and bring energy upgrade adoption closer to the socially optimal level, as discussed in 5.1.2. Section 7.1 will discuss a policy solution following this path.

Lastly, the barrier of a high discount rate for energy efficiency investments aligns with our findings from section 5.1.1 in the housing market. Homebuyers are using the discount rate of their mortgage interest rate which is typically lower than interest rates on other loans, such as energy efficiency loans.[153] Homeowners seeking to install energy efficiency technologies face a higher discount rate than homebuyers, and thus value future energy bill savings less than homebuyers, creating an Energy Efficiency Gap.

5.3.4 Lack of Attention and Knowledge are Barriers to Adoption

A lack of attention and knowledge on available upgrades and programs is another barrier to adoption as many households are unable to research the options and commit to the lengthy installation process. A review of the literature on the Energy Efficiency Gap found strong empirical evidence supporting attention and knowledge issues as a factor.[154] The lack of attention and knowledge is consistent with our findings from section 5.1.1 about the housing market. Homebuyers dedicate time to choosing which home to purchase and make time to conduct research on a home's energy appliances.[155] They may even receive guidance from their real estate agent on energy efficiency.[156] The homebuyer also does not need to spend time on the installation process, whereas a homeowner would need to conduct energy audits, communicate with contractors, etc. This points to attention and knowledge being barriers to adoption.

Currently, Vermont's energy efficiency upgrade education is robust, being conducted by the EEUs and other bodies. The utilities provide information through their communication channels, such as customer mailing lists, and energy audits. Occasionally, organizations have engaged in targeted outreach. Contractors communicate with clients about their new systems while working on the job and have engaged in referral outreach methods. Various local organizations have promoted energy upgrades through communication channels and events. However, as reported by our interviewees, it remains difficult to engage people, an issue we discuss further in Section 8.3.

5.3.4 Energy Efficiency Investments May Have a Risk Premium

Risk can be a deterrent to any kind of change, and it is a disincentive for switching to energy efficiency upgrades. There are two types of risk: individual and correlated.

- Individual risk refers to uncorrelated events such as a household's heat pump breaking before its expected lifespan. Since we assume mechanical malfunctions are random and independent of each other—in that one heat pump breaking will not cause other heat pumps to break—heat pump malfunctions are individual risks. The quality of a weatherization job is also an individual risk. For example, air sealing mistakes cause a house to not achieve the savings predicted by the energy audit.
- Correlated risk refers to risks that impact all parties involved at the same time, such as an unexpected change in energy prices. For example, if after switching to a heat pump, the price of electricity doubles, this affects all households using a heat pump as their primary heating source leading to reduced or negative savings for all consumers.

Even if risks are small, the perceived risk of an energy efficiency upgrade—such as installing a heat pump—may be high, leading to higher risk premiums and lower adoption.[157] Studies have shown that risk-averse individuals are less likely to adopt energy-efficient technologies.[158] Risk aversion aligns with our findings from section 5.1.1 in the housing market. Homebuyers purchasing a home with a heat pump can know exactly how much energy bills cost with a heat pump, whereas homeowners would need to follow estimates from an energy audit which come with more uncertainty.

6 REVIEW OF CURRENT PROPOSALS

This section evaluates current policies that have been proposed by the Vermont legislature or the PUC in their most recent report on the Clean Heat Standard.

6.1 Clean Heat Standard (CHS)

6.1.1 What is the Clean Heat Standard?

In 2023, the Vermont Legislature passed the Affordable Heat Act, creating the Clean Heat Standard (CHS) with the aim of reducing greenhouse gas emissions.[159] The CHS requires fossil fuel importers to offset emissions through clean heat credits. Figure 15 visualizes the credit process.[160] These credits can be earned by selling cleaner fuels, funding energy efficiency projects, or purchasing credits from other organizations.[161] The goal of the CHS is to transition Vermont toward lower-carbon heating while maintaining consumer choice and affordability.[162]

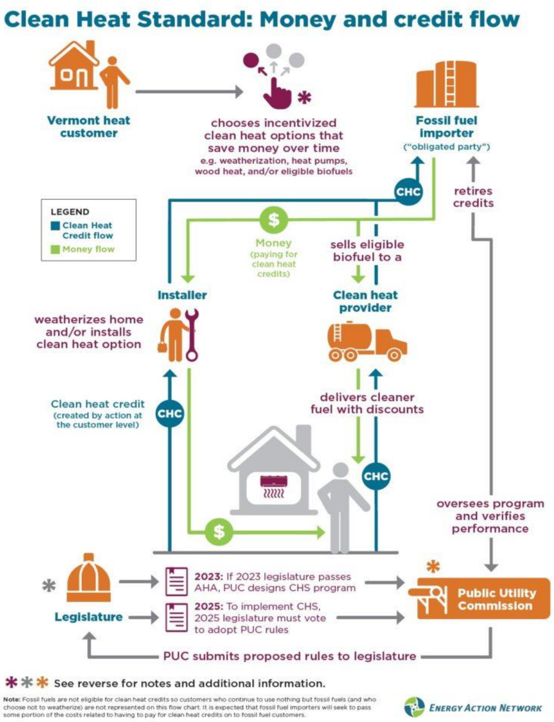

Figure 15: Clean Heat Standard Clean Heat Credit Process
Source: Energy Action Network[163]

Under the draft rules released by the Public Utility Commission (PUC) in January 2025, fuel importers can comply with the CHS by delivering biofuels, renewable natural gas, or heat pumps; supporting weatherization projects; or purchasing clean heat credits.[164] At least 50 percent of all clean heat credits must be directed toward low- to moderate-income households, helping to reduce energy burdens and transition to cost-effective, low-emission heating solutions.[165] Fuel companies that fail to meet targets must pay penalties that are reinvested into additional clean heat initiatives.[166]

While the CHS aims to reduce long-term energy costs, critics warn of higher fuel prices, regulatory challenges, and economic strain on small fuel dealers.[167] In response, a bill has been introduced in the Vermont House of Representatives to repeal the Affordable Heat Act, citing concerns about affordability and implementation challenges.[168] Advocates emphasize that the CHS provides a structured, long-term approach to cutting emissions and that delaying action could result in greater economic and environmental costs in the future.[169]

6.1.2 Clean Heat Standard Increases Cost of Fuel

As part of the Standard, certain entities must be designated as obligated parties in order to participate in the clean heat credit trading system. This process of registration requires much administrative effort, including a significant amount of data processing. Costs are expected to be even higher than predicted due to a lack of compliance or accuracy in the data being processed.[170] The PUC has already spent an "enormous amount of time and resources" processing fuel dealer registration data.[171]

Generating even one credit – one metric ton of CO2 equivalent – for each obligated party is a similarly demanding process.[172] To generate and calculate such a credit, the GHG reduction measure must be registered with location, measure group, type of property, type of measure, and any additional necessary information.[173] Custom credits are possible if a measure does not fit into any pre-existing category, but they require a great deal of information to be registered.[174] In order to be traded or retired, credits must first be verified by the PSD.[175]

To navigate this complex credit-generation process, obligated parties may opt to pay Default Delivery Agents (DDAs) to implement GHG reduction measures and generate credits on their behalf.[176] Establishing a DDA scope of services requires significant upfront costs, including staff time and infrastructure investment.[177] As the bill stands, the only potential funding source would be payments from obligated parties, meaning the DDA would need to collect funds before implementing programs to reduce thermal sector emissions or generate clean heat credits.[178] However, no funding is currently available for these start-up costs.

The total cost of the CHS for the first 10 years of the program is predicted to be $955,923,033.[179] This cost is expected to be passed onto consumers through increases in fuel oil costs. The initial increase in 2026 is expected to be $0.08 per gallon and is projected to rise to $0.58 per gallon in 2035.

The PUC has stated that the costs associated with developing a trading platform for Vermont "far exceed the benefits."[180] Such a system would suit a larger market, but Vermont is a relatively small one.[181] A previous PUC study found that Vermont has the structures needed to meet its GWSA goals with the main challenge instead being adequate funding for programs like weatherization, electrification, and energy efficiency.[182]

6.1.3 Clean Heat Standard Decreases GHG Emissions

The PUC's economic modeling shows a predicted 2.07 million metric tons of in-state incremental CO2 emission reductions because of the Clean Heat Standard during the first ten years of the program. Cumulative emissions abatement is expected to increase as the program grows.[183]

6.1.4 Regressive Fuel Impacts May Harm Low-Income Households

Vulnerable populations often bear disproportionate costs under regressive policies, which impose uniform cost increases regardless of income.[184] This disparity raises concerns about the affordability of energy for vulnerable populations.[185] As the CHS causes fuel prices to increase, regressive cost impacts are a concern.[186] If the cost of heating fuels increases due to compliance requirements, households with limited disposable income may struggle to afford their basic energy needs.[187]

6.1.5 Inequitable Access to Clean Heat Measures

Ensuring that all Vermonters, regardless of income, housing status, or geographic location, have access to clean heat measures is essential to the success of the CHS.[188] Many lower-income households may lack the financial resources to invest in energy-efficient upgrades, even if long-term savings exist.[189] Additionally, rural communities may face challenges due to limited contractor availability, supply chain constraints, and lack of awareness about available programs.[190] Renters often encounter additional barriers due to the "split incentive" problem, wherein landlords may be reluctant to invest in heating upgrades if they do not directly benefit from the resulting energy savings.[191] These challenges can prevent vulnerable populations from fully participating in, and benefiting from, clean heat initiatives.

6.1.6 Local Fuel Dealers May Not Be Able to Implement the Clean Heat Credit System

Local fuel dealers are facing significant challenges regarding their economic viability under the proposed CHS.[192] The anticipated costs and increased administrative burdens associated with compliance pose a threat to the survival of these businesses, making it difficult for them to remain competitive in the market.[193] One expert noted that some local fuel dealers have already begun closing their businesses or retiring early, anticipating the need to hire legal assistance to navigate the complexities of the Clean Heat Standard.[194] These dealers aim to provide their customers with enough time to transition to new providers.[195] The projected distribution of clean heat credits highlights Vermont's reliance on local fuel dealers, who face skepticism about the feasibility of transitioning to clean energy alternatives due to a lack of successful precedents and the challenges of adapting to an evolving regulatory landscape.[196]

6.2 Fuel Tax Increase and Thermal Efficiency Benefit Charge

In the Second Checkback Report on the Clean Heat Standard published on January 15, 2025, the PUC suggested three alternatives to the Clean Heat Standard which, according to the PUC, would be more cost-effective and feasible. The three alternatives are the: 1) increasing the Fuel Tax, 2) implementing a Thermal Efficiency Benefit Charge (TEBC), and 3) implementing a Biofuels Blending Requirement. The following sections will examine the PUC's alternatives according to the policy evaluation criteria.

6.2.1 What is the Fuel Tax? What is the Thermal Efficiency Benefit Charge?

Vermont currently levies a fuel tax on heating oil, propane, kerosene, other dyed diesel fuel, natural gas, coal, and electricity.[197] Table 4 displays the rates of the fuel tax levied on each fuel type and the changes the PUC proposed in their 2021 report on Act 62.

Table 4: Rate of Fuel Tax in 2025 and PUC 2021 Proposal

FUEL TYPE	CURRENT RATE	PUC 2021 PROPOSAL
Heating oil, propane, kerosene, and other dyed diesel fuel delivered in Vermont	\$0.02/gallon	\$0.04/gallon in 2021 \$0.06/gallon in 2023
Natural gas and coal	0.75%	–
Electricity	0.5%	–

Source: Vermont Department of Taxes, Public Utility Commission[198]

The TEBC is another proposed charge on fuel. The TEBC would be collected using the same form/mechanism as the fuel tax. The TEBC would be set by the PUC, similar to how the PUC currently sets the Energy Efficiency Charge (EEC) levied on electricity and natural gas. The TEBC would differ from the fuel tax in that the PUC "could allow fuel dealers that meet certain requirements to provide their own clean heat measures and, therefore, pay a lower TEBC."[199]

6.2.2 Fuel Tax and Thermal Efficiency Benefit Charge Are Effective, but Raise Prices for Consumers

The fuel tax and TEBC are effective at reducing emissions on two fronts:

1. An increased fuel tax or TEBC would increase the price of fuel, disincentivizing fuel consumption.[200] While fuel is not typically considered a price-sensitive good, the permanent nature of a tax increase changes the long-term mental calculation for various agents in the economy.[201] As a result, the consumption of fuel decreases in response to increased taxes.
2. The revenue from the charges can be used in a cross-subsidy to support energy efficiency, which decreases fuel consumption. The funding would go to the Weatherization Assistance Program (WAP) or EEU programs.

Figure 16 shows that the fuel tax generates an average of $4.74 million in revenue per year. In the short run, an increase to $0.04/gallon would double this to $9.47 million, and an increase to $0.06/gallon would triple it to $14.2 million. As households are discouraged from using fuel and switch to other heating sources or reduce consumption, we expect the revenue to decrease in the long run.

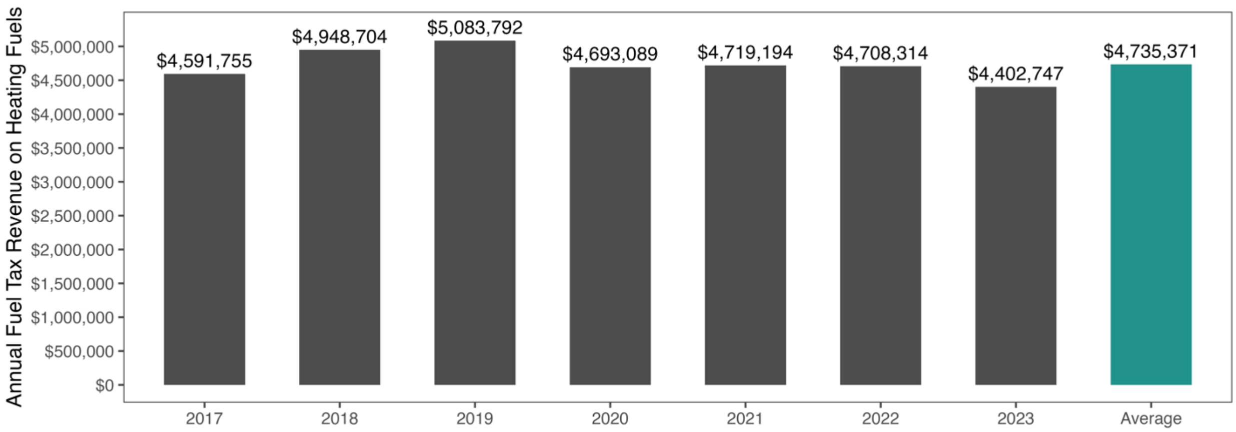

Figure 16: Annual Revenue from Heating Fuels Tax (Heating Oil, Kerosene, Propane, Dyed Diesel)
Source: Vermont Department of Taxes[202]

An increased fuel tax or TEBC would raise the price of fuel for consumers. It is well known that taxes on producers are passed onto consumers. For example, a recent paper suggests that a one cent state tax increase on gasoline and diesel results in an immediate increase of the retail price by 1.22 cents.[203]

When considering the cost-effectiveness of fuel taxes, it is important to assess the welfare gains for each dollar of tax revenue. Taxes would be considered more cost-effective if welfare gains outweigh consumer costs. However, welfare gains are not always large enough to make a carbon tax feasible.[204]

6.2.3 Fuel Tax and Thermal Efficiency Benefit Charge is Regressive

A fuel tax and TEBC present equity concerns since they are regressive. A charge levied on fuel increases the price equally for all consumers, disproportionately impacting low-income households as fuel represents a larger proportion of their income. Assuming an average consumption of 700 gallons of heating oil per year, an increase to $0.04/gallon would amount to an additional $14 per year.[205]

The cross-subsidy of using the fuel tax to fund programs like WAP, which are targeted towards lower income households, improves the equity outcome of the fuel tax. Lower income households are eligible for WAP and can reduce their total fuel consumption through the program which decreases their energy bill even with an extra charge.

However, the households paying more for fuel outnumber the households who can be weatherized by a hundred to one. In 2024, the WAP completed 1,211 projects, whereas an estimated 150,000+ households in Vermont use fuel oil or propane as their primary heating source.[206] Moreover, a shortage of weatherization tradespeople may limit the impact of additional funding for the WAP.

6.3 Biofuels Blending Requirement

6.3.1 Connecticut: A Northeast Model for Biofuel Blending

Four Northeastern states have biofuel blending requirements for heating oil: New York, Rhode Island, Massachusetts, and Connecticut.[207] In 2022, Connecticut passed "An Act Concerning a Low-Carbon Fuel Blend of Heating Oil," a biofuel blending mandate requiring all heating oil in the state to be blended with a specific percentage of biodiesel.[208] The Act creates a five step blending framework: 5 percent biodiesel in 2022, 10 percent in 2025, 15 percent in 2030, 20 percent in 2034, and 50 percent in 2035.[209] Connecticut's Department of Energy and Environmental Protection can suspend the requirement for two reasons: inadequate supply or financial hardship to consumers.[210] From July 2022 to March 2023, Connecticut replaced 36.6 million gallons of heating oil with biodiesel, reducing CO2 emissions by millions of pounds.[211] While Connecticut's requirement does not explicitly mention renewable diesel, its use of "advanced biofuels" leaves room for expansion to renewable diesel.[212] The Vermont Fuel Dealers Association estimates that Vermont could implement a biofuels blending requirement by July 2026.[213]

6.3.2 Biofuels May Be Cost-effective Depending on Price of Imports

Vermont has no oil production due to a lack of reserves and imports its heating oil from external sources.[214] Vermont has low levels of biofuel production, primarily for individual farms, and no large scale biodiesel or renewable diesel production.[215] The opportunity does exist for Vermont farmers to expand production of biofuel feedstocks.[216] However, one expert notes that there has been limited interest in pursuing this type of agriculture as other crop markets are more profitable.[217] As a result, the State would largely rely on imports to supply its needs, and the cost-effectiveness would therefore depend on the market behaviors.[218] As of October 2024, the national average price of B20 biodiesel was $3.53 per gallon; B100 biodiesel was $4.04 per gallon; renewable diesel was $5.05 per gallon; and heating oil was $3.49 per gallon.[219] As B100 biodiesel and renewable diesel production continue to increase, the experts estimate that their prices will decrease.[220] Vermont imports 30 percent of its heating oil from Canada. If energy tariffs are imposed on Canada by the Trump Administration, experts predict that heating fuel prices could increase by $0.25 per gallon.[221] These trends indicate that biofuels may become an increasingly cost-effective option.

6.3.3 Biofuel Blending Requirement Would Reduce GHG Emissions

Biofuels blending requirements have been an important tool for GHG reduction in the European Union since 2005.[222] In the United States, biofuels blending requirements have increased in popularity to reduce state GHG emissions. For every percent increase in biodiesel, there is a 0.78 percent decrease in lifecycle CO2 emissions.[223] Replacing heating oil with renewable diesel reduces emissions by on average 68 percent.[224] If Vermont were to implement a biofuels blending requirement with the same structure as Connecticut, it would abate 4.8 million metric tons of CO2 by 2050 assuming consistent consumption of fuel oil at 2023-2024 levels (Figure 17). As heating becomes electrified in the state, the base scenario emissions are expected to decrease and the amount abated would also decrease.

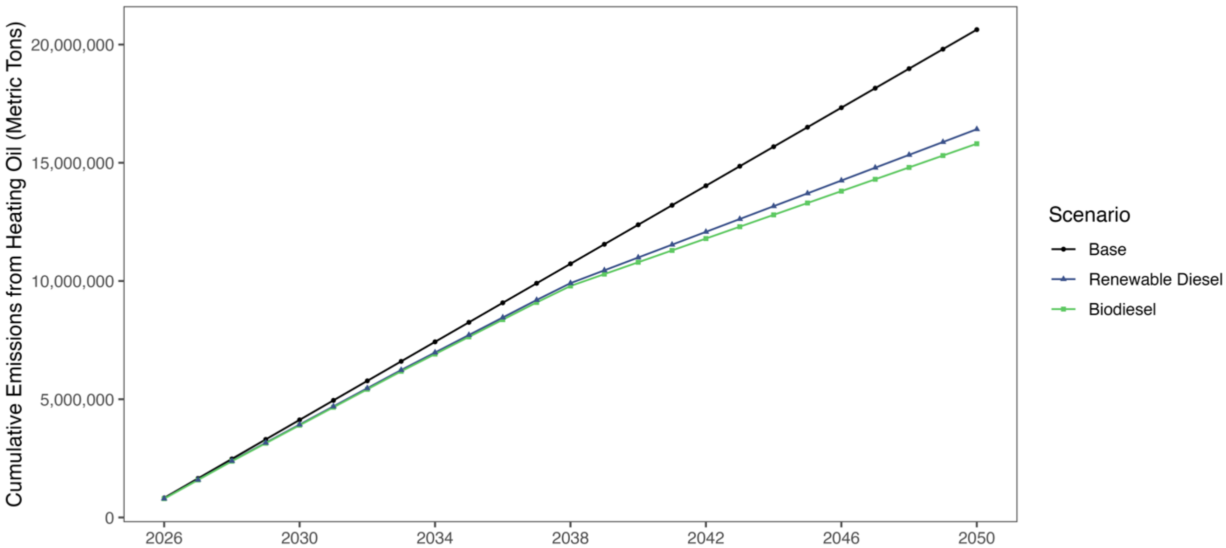

Figure 17: Emissions Abated by Biofuel Blending Requirements, 2026-2050 Forecast
Source: Authors' calculations using Xu et. al and EIA data[225]

6.3.4 Biofuel Blending Requirement Increases Prices, Small Fuel Distributors Could Struggle

Studies have shown that biodiesel mandates have the potential to increase the price of fuel for consumers. Due to supply constraints, when demand for feedstock (soy and canola) increases so does the cost of these products.[226] As a result, biodiesel and renewable diesel production costs companies more. To compensate, producers would likely pass additional costs onto consumers.[227] However, studies from the European Union, a more sophisticated biofuel market, have shown that mandates have no correlation with higher fuel prices.[228]

Small fuel distributors, a significant portion of Vermont fuel dealers, could struggle with a biofuel blending requirement. Small-scale distributors have historically struggled with producing accurate biodiesel blends.[229] Higher compliance costs from obtaining Renewable Identification Numbers also burden smaller dealers.[230] Larger companies benefit from less market concentration, allowing them to spread the cost of biofuel mandates across a larger consumer base and making it harder for smaller businesses to compete.[231]

7 ALTERNATIVE SOLUTIONS

This section discusses two alternative solutions for meeting Vermont's climate and energy goals by expanding and modifying existing Energy Efficiency Utility programs in the residential thermal sector.

7.1 Low-interest Financing Programs

Low-interest financing programs could be a more cost-effective alternative to rebates. This section discusses existing financing programs, evidence of their efficiency and effectiveness, and policies that maximize their benefits. We compare financing programs to rebates since rebates are the primary mechanism currently delivering energy efficiency incentives.

7.1.1 Existing Low-interest Home Improvement Financing Programs

EVT and VGS currently offer a low-interest home improvement financing program with interest rates reducible to 0 percent APR for low- and moderate-income households. Table 5 summarizes the two offerings. BED does not currently offer a program but is considering the option.

Table 5: Overview of EVT and VGS Low-interest Home Improvement Financing Programs

FEATURE	EVT HOME ENERGY LOAN[232]	VGS LOW-INTEREST FINANCING[233]
Minimum interest rate for low- and moderate-income households	0%	0%
Loan term at minimum interest rate	5 years	1 to 5 years
Qualifying projects	Weatherization Cold-climate heat pumps Heat pump water heaters Central wood pellet heating systems Health and safety repairs	Weatherization projects High efficiency natural gas equipment
Maximum loan amount	$25,000	$20,000 for weatherization $15,000 for natural gas equipment
Receive rebate and low-interest loan	Yes	Yes
Partner lenders	EastRise Credit Union Cornerstone Housing Partners	Green Mountain Credit Union

Low-interest financing programs work by using EEU funding to buy-down the interest rate, essentially paying the interest on behalf of the borrower. In 2023, EVT's Home Energy Loan closed 468 loans, including 118 for low-income customers (below 80 percent of area median income) and 168 for moderate-income customers (80–120 percent of area median income). The loans totaled $5,250,628 in value and cost EVT $582,446 in interest rate buy-downs. EVT also held $104,825 in loan-loss reserves. Using an estimate with interest rate buy-downs paid upfront and all loans being 5-year terms at 0 percent interest to the customer, we estimate EVT's partners provided financing to EVT at 4.7 percent interest.[234] EVT is also using a 2 percent default rate which follows standard industry practice.

VGS customers have widely used financing options. According to an expert, around 30 percent of VGS customers purchasing an upgrade through VGS use their low-interest financing program; this is a higher proportion than customers who choose EVT's Home Energy Loan.

In addition, the Vermont Housing Finance Agency (VHFA) partnered with the EEUs starting in 2020 to offer the Weatherization Repayment Assistance Program (WRAP). The program provides long-term two percent interest loans for low- and moderate-income household weatherization projects.[235] As of December 2024, WRAP has worked on 12 projects falling short of its 500 per year target.[236] Barriers to WRAP's success and policies that may increase use of financing programs will be discussed in the next section.

7.1.2 Financing is Cost-effective, Studies Find

Studies show that financing is a cost-effective subsidy design. Implementing a financing program with comparable costs to a rebate has been shown to be more effective than doubling the rebate. Using survey data from 400 respondents asked about purchasing a new energy-efficient refrigerator, Train and Atherton simulated the outcome of five scenarios:[237]

1. The base scenario with a rebate
2. Eliminating the existing rebate
3. Doubling the existing rebate
4. Offering only a loan of 90 percent of the purchase price at two percent interest for five years
5. Offering both the existing rebate and the loan as a second option

Of the scenarios, offering both a rebate and loan (scenario 5) was the most effective at increasing adoption of high efficiency equipment.[238] It was also the scenario with the least excess subsidy, as measured by the individuals who would have purchased the efficient equipment without extra incentives.[239] As shown in Table 6, scenario 5 with both the loan and rebate options maximized purchases of high-efficiency equipment (column B) while minimizing excess subsidy (column C).

Table 6: Simulation Scenarios

SCENARIO	A. LOW-EFFICIENCY PURCHASE, TOTAL	B. HIGH-EFFICIENCY PURCHASE, TOTAL	C. HIGH-EFFICIENCY PURCHASE, EXCESS SUBSIDY	D. HIGH-EFFICIENCY PURCHASE, USING REBATE	E. HIGH-EFFICIENCY PURCHASE, USING LOAN
1. Base with Rebate	46.6%	53.4%	37.9%	15.5%	–
2. No Rebate	56.5%	43.5%	43.5%	–	–
3. Double Rebate	43.1%	56.9%	36.4%	20.6%	–
4. Loan Only, No Rebate	46.6%	53.4%	38.3%	–	15.0%
5. Loan and Rebate	39.3%	60.7%	33.7%	13.7%	13.3%

Source: Kenneth E. Train and Terry Atherton[240]

Energy modeling reports—using the National Energy Modeling System—concluded that zero-interest loans are more cost-effective than rebates.[241] As measured by the welfare gain, zero-interest loans on residential geothermal heat pumps yield an $11.7 billion welfare gain, compared to the $5.1 billion gain of rebates.[242] Zero-interest loans save $36 per ton of CO_2 abated, while subsidies only save $9 per ton.[243] Energy modelling reports support the use of rebates and financing existing in tandem since financing is more cost-effective but has a smaller total impact on CO2 emissions since it is less utilized.[244]

In addition to evidence in Vermont that the current EEU financing programs have been well-received,[245] studies suggest low-interest financing is cost-effective. Particularly, financing offered as a second option to rebates is more cost-effective than rebates alone even if the amount of the rebate is increased. Furthermore, since rebates are less cost-effective than financing, organizations may benefit from prioritizing financing program funding and increasing rebates after all financing needs are met.

7.1.3 Financing More Efficient When Offered in Parallel to Rebates

If the state aims to maximize the cost-effectiveness of energy efficiency subsidies, EEUs could consider offering loans in parallel with rebates. Currently, EVT's Home Energy Loan and VGS's financing are offered in addition to rebates.[246] However, in a parallel arrangement, households that select one subsidy would not receive the other subsidy. The core benefit of this subsidy design is that it reduces excess subsidy provided to households who use both programs. For example, in the current arrangement, one household could receive both the rebate and Home Energy Loan from EVT to install one heat pump. Alternatively, with a parallel arrangement, the same amount of EVT's incentive payments could go to two households installing two heat pumps using either the rebate or Home Energy Loan, resulting in more projects for the same cost to EVT.

Presenting the financing program in parallel with rebates also implies presenting both options upfront to the customer at the point of purchase. Currently, EVT primarily advertises rebates at the point of purchase and financing programs, including the Home Energy Loan and WRAP, are presented as a secondary service or an extra step.[247] In contrast, VGS promotes residential energy rebates and financing together at the point of purchase.[248] Financing programs tend to be more utilized when presented on equal footing with rebates as VGS does, and are less utilized when presented as an extra step. Notably, a WRAP implementation review has identified the complicated enrollment process and uncertainty as a barrier to success.[249]

7.1.4 Financing Increases Energy Efficiency Upgrade Adoption Equitably

Low-interest financing targeted towards low- and moderate-income households is equitable since the benefits are provided on a progressive scale. Furthermore, financing programs resolve two barriers to adoption discussed in section 5.3 that disproportionately affect lower income households.

First, given the high upfront cost of energy efficiency upgrades, financing is necessary for households that do not have the $15,000 on hand to install a heat pump. Given that a majority of households do not have this amount of cash available, they would need to seek financing either through this program or through a private channel with a far higher interest rate.[250]

Second, if income-constrained households have a higher discount rate, financing may be an effective way to incentivize adoption. As Hausman suggests, as income decreases, the discount rate increases.[251]

When the discount rate is greater, consumers discount future savings more, so investment is less valuable.[252] The low-interest financing program decreases the discount rate to the interest rate on the loan, making an investment in the present moment more attractive. For example, a heat pump saves a homeowner $1,000 per year. At Hausman's 20 percent discount rate, the next year's savings would only be valued at $800, and the next year's only $640. However, using a zero percent interest loan (and a discount rate of zero percent), each year's savings are worth $1,000. Over the course of five years, the difference between the present value of the future savings is $2,311 ($5,000 with zero percent discount minus $2,689 with 20 percent discount).

The low-interest financing program has a unique advantage over rebates, since its effects are strongest on lower-income households. These households are most likely to suffer from liquidity constraints.[253] Additionally, their discount rate is higher and so the loan increases the present value of future savings more. In contrast, flat heat pump rebates have been found to have a stronger impact on higher income households.[254] As shown by data analysis of North Carolina heat pumps, households with an income of $50,000-60,000 are affected by the rebate far more than lower income households.[255]

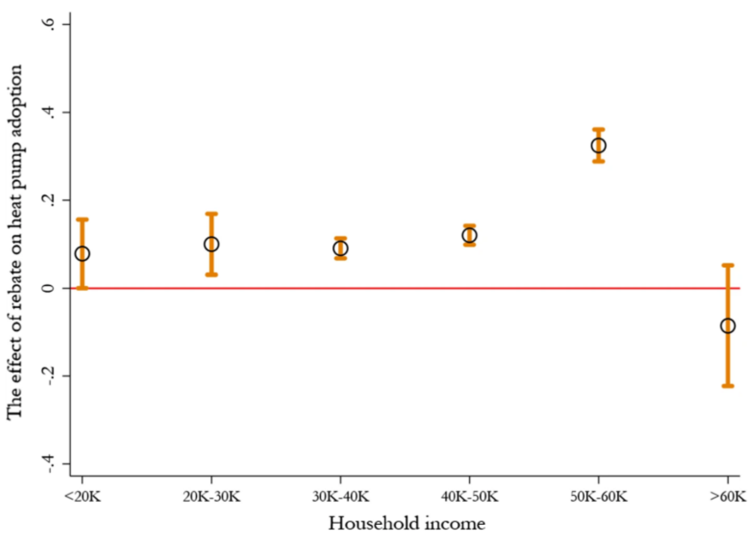

Figure 18: Effect of rebate on heat pump adoption by household income
Source: Shen et al.[256]

7.1.5 Small Upgrades Prompt Households to Complete Larger Projects in Future

The success of the low-interest financing program is determined by its size and cost:

1. The size of the low-interest financing program is determined by the demand for financing and the supply of capital. To expand the size of the program, financing needs to be demanded by households seeking energy upgrades and sufficient capital needs to be supplied to energy efficiency upgrades from private, public, or quasi-public sources.
2. The cost of the low-interest financing program is determined by the interest rate charged by the lender to the EEU for the loan. For example, if EVT receives the loan from the credit union at 4.7 percent interest, EVT must pay a larger interest rate buy-down than if they got the loan to EVT for 3 percent. Lower interest rates require a smaller EEU interest rate buy-down making the loan program cheaper for the EEU.

This section and the following subsections discuss policies for increasing the size and reducing the cost of energy financing programs.

In 2012, Maine introduced the Residential Direct Install (RDI) program as a stepping stone to larger home energy financing efforts.[257] Homeowners received a $600 rebate for completing an energy audit and 6+ hours of air sealing, with an average cost of $850, where homeowners contributed $250.[258] On average, RDI projects reduced air flow by 17 percent and provided 13.5 percent annual net energy savings, cutting about $300 in fuel costs.[259]

The program also allowed homeowners to use RDI measures to meet the 20 percent energy savings threshold for eligibility for a PACE loan.[260] As a result, 20 percent of participants pursued further energy efficiency upgrades, and 50-70 percent of projects by contractors with strong customer service led to larger projects.[261] If Vermont seeks to increase utilization of financing programs for larger energy efficiency upgrades, they could adopt a stepping stone model similar to Maine's program.

7.1.6 Government-sponsored Financing Organizations Lend Cheaper

The EEUs currently partner with credit unions to offer financing programs; however, credit unions lend at higher interest rates than Vermont government-sponsored financing organizations, such as the Vermont Housing Finance Agency (VHFA). EVT's financing program is funded in partnership with EastRise Credit Union and Cornerstone Housing Partners, and VGS's financing program is funded in collaboration with Green Mountain Credit Union. While credit unions are nonprofit organizations who return their net income to their members, their interest rates are, on average, only slightly lower than banks.[262]

The VHFA is a quasi-public organization. The agency is public since it is chartered by the government and mission-driven, but private because it sources a vast majority of capital from private investors by selling bonds and securities. The VHFA primarily provides mortgage financing but is also offering a pilot of the Weatherization Repayment Assistance Program (WRAP) through the EEUs at 2 percent interest.[263]

To reduce the cost of buy-downs of low-interest financing programs, EEUs would benefit from gaining greater access to capital from government-sponsored financial institutions. Government-sponsored institutions can access capital cheaper, through selling highly rated bonds and securities. As such, they are well positioned to provide the cheapest financing to the EEUs. For example, if the VHFA provided funding for EVT's Home Energy Loan at the 2 percent interest rate, instead of the estimated 4.7 percent interest rate offered by EastRise, it would more than halve the cost of the Home Energy Loan for EVT.[264]

Through the process of securitization, government-sponsored financial institutions can also access a larger amount of capital from diverse sources on the open market. Therefore, opportunities exist for the EEUs to work with the VHFA, or other government-sponsored enterprises at the state or federal level to operate expanded and cost-effective low-interest financing programs.

7.1.7 On-bill Loan Repayments for Home Energy Financing

WRAP has piloted on-bill loan repayments; a system of collecting payments on energy loans through the customer's utility bill. The VHFA coordinates with distribution utilities to open an account for each borrower and repayments on loans are collected through the monthly utility bill. On-bill repayments can have numerous benefits:

1. On-bill repayments guarantee that households save on their energy bills from day one by using information from audits. Thus, on-bill repayments more efficiently realize the present value of the future savings avoiding the present bias. Households save money from the start, instead of starting in the negative and breaking even in years.
    a. The WRAP implementation review identifies an inability to achieve the required positive net savings as a barrier to success.[265] Programs which require a positive net present value, such as WRAP, may be more successful funding heat pumps which tend to have a positive net present value for a large proportion of households using fuel oil or propane, which would be reflected in large immediate savings.[266]
2. On-bill repayments provide loans to otherwise liquidity-constrained households. Assessing credit from utility bill repayments avoids checking an individual's FICO score, which has been criticized for its discriminatory effect.[267]
3. On-bill repayments are less stressful for households than another loan to pay. When combined with the utility bill, the repayment reduces the mental and administrative burden of households, resolving an issue that disproportionately impacts lower income individuals.
4. On-bill repayments may reduce the default rate, since households may prioritize paying their utility bills.[268] A reduced default rate reduces loan loss provisions, reducing the cost of the program.

According to an expert on WRAP, setting up on-bill repayments has not created a large administrative burden as distribution utilities are able to open accounts easily after being onboarded. Thus, to achieve these benefits, Vermont could consider making on-bill repayments standard for all EEU loans.

7.2 Modifications to Energy Efficiency Utilities

7.2.1 Vermont's EEUs a Historically Flexible Tool

In 1999, when the PUC created Vermont's EEU system, their mandate was to decrease Vermont's electricity usage by promoting energy efficiency.[269] In 2020, the PUC announced a priority shift to reflect Vermont's climate goals, directing EEUs to incorporate strategic electrification into their services.[270] Recent EEU electrification programs have included heat pump and electric vehicle rebates and commercial electrification programs. Every three years, EEUs create a set of quantified performance indicators (QPIs) that measure their progress toward PUC goals (See Appendix D for full list of 2024-26QPIs).[271] The PUC is then responsible for approving the list of QPIs.[272] Since 2020, QPIs have reflected the change in the PUC's electrification stance.

7.2.2 How Could EEUs be Restructured to More Effectively Reduce GHGs?

Vermont could restructure its EEUs in two ways to make them more effective at reducing GHG emissions: 1) implement an explicit climate mandate and 2) allow project rollover.

Despite progress in incorporating climate objectives, Vermont's Energy Efficiency Utilities (EEUs) remain constrained by structural limitations that hinder their ability to maximize greenhouse gas (GHG) reductions. The Public Utility Commission requires EEUs to report greenhouse gas emissions and has approved carbon dioxide reduction QPIs for EVT and VGS for the 2024-2026 performance period.[273] BED's QPIs do not include specific CO2 reduction goals, but their Net Zero Emission plan reduces CO2 emissions to zero by 2030. Though EEUs have expanded to include climate-related objectives in recent years, they still do not have an official climate mandate.[274] As a result, EEUs have been restricted to approaching GHG emissions reductions from an energy efficiency perspective rather than a whole-climate perspective.[275] For instance, an EEU expert expressed frustration that their utility could not offer more heat pump assistance because heating was not their primary goal.

Following the passage of the RES in 2015, the PUC's decision to shift the EEUs toward strategic electrification provided a framework for altering the EEUs' mandate. The PUC could use the GWSA as a similar impetus for developing and implementing an EEU climate mandate. Currently, VGS and EVT's carbon reduction QPIs are the fifth and sixth highest weighted metrics for each EEU, respectively. A climate mandate could require carbon reduction to be weighed at the same level or higher than customer electricity savings, creating a consistent standard for GHG reduction across Vermont's EEUs. Furthermore, a climate mandate would provide EEU budget flexibility, as they could optimally allocate and expand funding for broader climate focused initiatives such as clean heating without dramatically increasing total budgets. Increasing EEUs' climate capacity could also incentivize further Tier III investment among distribution utilities, as they would have more options.

In conjunction with a climate mandate, the PUC could restructure the way it measures project completion. Under the current structure, projects completed by December 31 count for that year's performance period, whereas projects completed on January 1 count for the next. As a result, EEUs may be incentivized to hold off on projects that are already approved but not completed, as they would exceed that year's requirement without counting toward future goals.[276] This pattern results in fewer GHG emissions reductions in the short-term, given EEUs favor long-term planning strategies. Another pattern experts identified is the increased difficulty of completing efficiency projects. EEUs have been able to meet their goals by targeting the "low hanging fruit" – i.e., households already inclined to undertake these projects – but as more projects reach completion, obtaining the next project becomes marginally harder.[277] If the PUC were to alter project completion criteria to allow for projects exceeding yearly performance quotas to extend into the next performance periods, GHG reduction would be incentivized earlier rather than later and create a buffer for EEUs as they conduct outreach toward more difficult clients. Furthermore, earlier completion of projects would create more capacity for EEUs to take on additional jobs in the next performance period.

7.2.4 EEUs Have Already Demonstrated Their Commitment to Equity

EEUs have been drivers of energy equity throughout the energy transition process. All EEUs have implemented minimum low-income spending requirements.[278] Each EEU has its own set of low-income assistance programs designed to increase equity in their service provision. VGS offers a 20 percent discount on energy bills for qualified customers as well as a Low-Income Weatherization program.[279] BED offers a 12.5 percent discount on energy bills for income-qualified customers and enhanced rebates for low-income households.[280] EVT offers several income-based assistance programs, such as free energy-efficient products and appliances, reduced-cost weatherization services, and low-interest loans to income-qualifying renters and homeowners.[281] EVT is also piloting a window-mounted heat pump program that could improve access to efficient heating for renters.[282]

7.2.5 EEUs are Trusted and Reliable Among Vermonters

EEUs have a high level of trust, brand recognition, and satisfaction across Vermont. Most experts expressed that EEUs were reliable partners in energy efficiency provision. One expert stated, "I do think that, generally, Efficiency Vermont is very user-friendly. It has real name recognition among people. I think Efficiency Vermont is very effective generally in what they do." Another expert stated, "I think the current name recognition, the trust, and the institutional knowledge. I think there is a real structure and setup that people already understand." These sentiments are reflected in EEU satisfaction data. Eighty-seven percent of BED customers are satisfied with their service, and ninety-five percent are satisfied with energy efficiency programs.[283] In 2023, EVT had an 81 percent general customer satisfaction rating.[284]

8 STRUCTURAL CHALLENGES TO ENERGY UPGRADE EXPANSION

In this section, we discuss three structural challenges Vermont would need to overcome to expand energy efficiency infrastructure. For the policies covered in section six and seven to succeed and operate efficiently, these challenges must be addressed.

8.1 Trades Workforce Development

Policies expanding home energy upgrades likely necessitate a scaled-up climate workforce. There are several considerations in the feasibility of this development within Vermont, which we will explore.

The US is facing a national shortage of skilled tradespeople. From 2007 to 2022, as the housing stock increased by 11 percent, full-time skilled trades workers needed to maintain homes decreased by 16 percent.[285] However, Vermont has fared better compared to other states, being one of four states with positive growth (6 percent) in skilled trades workers during this period.[286]

The unemployment rate in Vermont was 2.4 percent in December 2024, lower than the national average of 4.1 percent in the same month and second lowest in the country.[287] Among the 2.4 percent of unemployed people in Vermont, the majority are typically in the process of moving between jobs, and are not looking to change careers to a skilled trade.[288] Thus, there is limited room for Vermont to expand its climate workforce without crowding out other industries.

Many groups have launched initiatives to support the skilled trades development pipeline. The Energy Action Network convenes the Climate Workforce Coalition, an initiative focused on recruiting and retaining skilled climate workers.[289] EVT is launching a Talent Pipeline Management initiative for weatherization and heating upgrades.[290] Addressing the barriers to trades recruitment and retention through various initiatives is crucial for reaching Vermont's climate and energy goals.

8.2 Grid Infrastructure and Resilience

8.2.1 Existing Grid Infrastructure Not Enough to Meet Future Electricity Demand

Nationwide electrification of the transportation and building sectors is poised to significantly increase electricity demand in the coming decades. Studies project that, under high electrification scenarios, U.S. electricity consumption could surge by 52 to 85 percent by 2050.[291] This growth is primarily driven by the adoption of electric vehicles (EVs) and electric heating systems, such as heat pumps.[292] Traditional peak grid loads, the maximum amount of electricity on the grid, have occurred in summer months. Heat pump installation is projected to alter this trend and increase winter grid loads.[293] The integration of these technologies presents challenges for grid infrastructure, operations, and planning, necessitating capacity expansion and the development of strategies to manage increased and shifting loads.[294]

In Vermont, the national electrification trend is expected to continue. ISO New England forecasts a 17 percent increase in regional electricity consumption over the next decade, with Vermont anticipated to add over 120,000 Electric Vehicles by 2033.[295] Additionally, the state is projected to experience a nearly tenfold increase in electric heating system installations during this period.[296]

8.2.2 Using Fossil Fuels to Boost Load Capacity Will Not Meet GHG Goals

Many states, such as North Carolina, Virginia, and Georgia, are increasingly turning to fossil fuels, particularly natural gas, to meet rising electricity demand amid the ongoing electrification of various sectors.[297] Recent analyses indicate that while states are investing in renewable energy, there is a notable trend of proposing new natural gas plants to ensure reliability and meet peak demand.[298] Despite commitments to reduce greenhouse gas emissions, the expansion of gas-fired power generation may continue as a stopgap measure to address immediate grid challenges.[299] Continued investment in fossil fuel infrastructure can lead to "lock-in" effects that impede the shift toward renewable energy.[300] As a result, the reliance on fossil fuels poses significant risks to long-term climate goals.[301]

8.2.3 Vermont is Planning for an Electrified Future

Vermont utilities, such as Vermont Electric Power Company (VELCO), BED, and Green Mountain Power (GMP) are actively planning for increases in electrification.[302] For example, VELCO's transmission plan for 2024 to 2026 includes extensive discussion of flexible load management, battery storage, and distributed energy resources, strategies that enhance the resilience, reliability, and sustainability of the electric grid.[303] GMP's 4 MW lithium-ion project also enhances grid stability and integrates renewable energy sources more effectively.[304] BED is developing load management practices that automatically meet EV and thermal demands.[305]

Vermont plans to boost its solar, hydroelectric, and geothermal energy production. In 2024, the State received nearly $62.5 million to deliver residential solar, but policy, funding, and administrative uncertainties remain under the Trump Administration even amidst the reversal of an initial funding freeze.[306] The state is also investing in smart grid technologies to modernize its electrical infrastructure, including an extensive fiber-optic network for real-time electricity flow monitoring.[307] Vermont is expanding its hydroelectric resources through a power purchase agreement with FirstLight, securing over 54 gigawatt-hours of clean hydropower from the Shepaug Generating Station in Connecticut through 2025.[308] To bolster geothermal capacity, the Vermont Legislature passed S.305, empowering municipalities to develop and operate thermal energy networks without requiring approval from the Public Utility Commission, which facilitates the creation of localized geothermal systems for efficient heating and cooling.[309]

8.2.4 Load Shifting

Distributed Energy Resource Management Systems, or DERMS, are systems where batteries are connected to a center, where decisions are made, often by computers or now AI, to optimize the use of an energy grid. In FY2024, Efficiency Maine worked with Virtual Peaker, a distributed energy resource management system (DERMS), to implement its Load Shifting Initiative.[310] The program launched residential and commercial small battery measures. One hundred thirty-one small batteries and 99 vehicles and chargers were enrolled for the Summer 2024 capacity season, as were two large batteries, Bowdoin College and Portland Jetport.[311] This amount of enrollment exceeded Efficiency Maine's goals for the year.[312] Program result data is not yet available.

8.2.5 Time-of-Use Tariffs Can Reduce Electricity Demand in Peak Periods

Octopus Energy, the United Kingdom's largest energy supplier as of February 2025,[313] implemented a time-of-use tariff designed for heat pumps named *Cosy Octopus*. During off-peak periods from 4 a.m. to 7 a.m. and 1 p.m. to 4 p.m., Octopus reduces the price of electricity by 40 percent. During the peak period from 4 p.m. to 7 p.m., Octopus increases the price of electricity by 60 percent. By reducing demand during peak periods, the *Cosy Octopus* program aims to reduce strain on the grid and generation using fossil fuels. An analysis of *Cosy Octopus*'s 6,631 customers—who opted into the program voluntarily—found the time-of-use tariff halved demand during the evening peak. If Vermont wishes to use demand-side management to reduce peak loads on the electricity grid through the thermal sector, Vermont could consider implementing or modifying existing time-of-use tariffs to be tailored to heat pump usage.

8.3 Community Engagement

Community outreach consists of two main components: providing educational tools on how to use energy programs and technologies effectively and raising awareness about their availability. This is especially important for heat pumps, as misuse and misinformation hinder their impact. One expert highlights that some Vermonters avoid heat pumps altogether due to misconceptions, believing they could not adequately heat their home.[314] These trends mirror broader misconceptions surrounding green technology in Vermont.[315]

Maine's RDI program demonstrated how word-of-mouth can drive participation. After the program stopped advertising, community-driven referrals alone grew sufficient demand.[316] While Vermont lacks specific data on contractor word-of-mouth, experts confirm many contractors are small businesses that have deep ties with local communities, increasing engagement naturally.[317]

Leveraging community trust is key to combating misinformation and increasing participation in Vermont. Local Energy Committee members, Regional Planning Commissions, nonprofits, and town leaders are well-positioned to serve as community advocates.[318] Engaging these groups in policy development and revision not only strengthens public confidence but also ensures programs are transparent, accessible, and responsive to community needs.[319] Furthermore, establishing structured community feedback mechanisms can help ensure that policies reflect community concerns and provide insights for continual program improvement.[320]

9 CONCLUSION

The Global Warming Solutions Act set ambitious greenhouse gas reduction goals for Vermont. As a result, a more sustainable energy system is critical to achieving these goals. Addressing barriers to energy efficiency adoption is one pathway to ensuring Vermont meets its climate commitments while maintaining equity and economic viability.

Weatherization and heat pumps are effective and practical long-term solutions for reducing emissions and improving home energy efficiency. Weatherization lowers heating demand by improving insulation and air sealing, while heat pumps offer a cleaner alternative to fossil fuel heating. Both technologies provide cost savings.

Despite their benefits, there is an Energy Efficiency Gap that leads to under-adoption of these technologies. Market inefficiencies, behavioral biases, and financial barriers prevent many households from making cost-effective energy upgrades.

This report has evaluated six policies using the following criteria:

1) Cost-effectiveness
2) Progress made toward climate and energy goals
3) Equitable distribution of energy burden focusing on low- and moderate-income households

Our main findings are outlined below and summarized in Table 7.

Table 7: Summary of Policy Proposals

POLICY PROPOSAL	POLICY EVALUATION CRITERIA		
	COST-EFFECTIVENESS	PROGRESS TOWARDS GOALS	EQUITY
Clean Heat Standard	✕	✓	✕
Fuel Tax Increase	–	✓	✕
Thermal Efficiency Benefit Charge	–	✓	✕
Biofuels Blending Requirement	–	✓	–
Low-interest Financing Programs	✓	✓	✓
EEU Modifications	✓	✓	✓

Note: Check means the policy meets the criteria; X means the policy does not meet the criteria; and – means the policy is neutral, it could or could not meet the criteria.

Clean Heat Standard (CHS)

Requires fuel distributors to offset emissions through clean heat credits

1) Cost-effectiveness (✕): The CHS is estimated to raise the price of fuel by $0.08 per gallon in 2026 and $0.58 per gallon in 2035.
2) Progress Towards Goals (✓): The CHS is estimated to abate 2.07 million metric tons of GHG emissions after ten years.
3) Equity (✕): Vulnerable populations may be unable to benefit from clean heat initiatives and would face a higher energy burden. Smaller fuel dealers may struggle to comply with the CHS due to the high administrative burden.

Fuel Tax Increase and Thermal Efficiency Benefit Charge (TEBC)

Levies an additional charge on fuel oil and propane sales

1) Cost-effectiveness (–): An increased fuel tax or TEBC would raise the price of fuel by an amount approximately equal to the tax; $0.02 to $0.04 per gallon. The fuel tax and TEBC are neutral in cost-effectiveness since they are not prohibitively expensive to maintain but still incur costs to consumers.
2) Progress Towards Goals (✓): The fuel tax and TEBC are effective at reducing emissions and meeting Vermont's climate goals since they disincentivize fuel consumption and fund clean heat initiatives such as the Weatherization Assistance Program.
3) Equity (✕): The fuel tax and TEBC, like the CHS, present equity challenges since increases in the price of fuel disproportionately burden lower-income households who spend a larger share of their income on fuel.

Biofuels Blending Requirement

Mandates fuel distributors to blend biodiesel into heating oil

1) Cost-effectiveness (–): The cost-effectiveness of a biofuel blending requirement is neutral, depending on the cost of importing biofuels from other states.
2) Progress Towards Goals (✓): A biofuel blending requirement modeled after Connecticut could abate 4.8 million metric tons of CO2 by 2050 (assuming consumption of fuel oil at 2023-2024 levels.
3) Equity (–): A biofuel blending requirement may increase the price of fuel, increasing burden on lower income households. Smaller fuel dealers may be adversely affected by a biofuel blending requirement since they have historically struggled to produce accurate biodiesel blends.

Low-interest Financing Programs

Provides households low-interest home energy loans for energy efficiency upgrades

1) Cost-effectiveness (✓): Financing is more cost-effective than rebates. Financing programs' cost-effectiveness can be further increased by offering loans as a parallel choice to rebates and accessing capital from government-sponsored financing institutions.
2) Progress Towards Goals (✓): Similarly to rebates, financing subsidizes energy efficiency upgrades, increasing adoption.
3) Equity (✓): Low-interest financing targeted towards lower income households is equitable since benefits are provided on a progressive scale. Financing programs resolve two barriers to adoption—high upfront costs and high discount rate—that disproportionately affect lower income households.

Energy Efficiency Utility (EEU) Modifications

Changes the structure, incentives, and mandate of EEUs

1) Cost-effectiveness (✓): Modifications to the EEU mandates and quantified performance indicators requires no additional appropriations.
2) Progress Towards Goals (✓): Modifications to their structure and mandate would increase EEU prioritization of climate programs. Allowing for projects to rollover would incentivize EEUs to make GHG reductions earlier rather than later.
3) Equity (✓): EEUs have demonstrated a strong commitment to equity.

Overall, all proposed policies met the criteria of making progress towards Vermont's climate and energy goals. Two policies, low-interest financing programs and EEU modifications, met the cost-effectiveness and equity criteria. The CHS, Fuel Tax, TEBC, and Biofuels Blending Requirement were either unable to meet or neutral on the cost-effectiveness and equity criteria. For any policy to succeed, three structural challenges must be addressed:

1. Expanding the skilled trades workforce to meet increasing demand
2. Strengthening grid infrastructure to support electrification while maintaining reliability
3. Fostering community engagement to encourage participation in energy initiatives

Tackling these issues is essential to ensuring Vermont's energy transition is effective and equitable.

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APPENDIX A: ENERGY EFFICIENCY UTILITIES QUANTIFIABLE PERFORMANCE INDICATORS

		BURLINGTON ELECTRIC DEPARTMENT		
QPI#	TITLE	PERFORMANCE INDICATOR	TARGET	WEIGHT
1	Total Resource Benefits	Present worth of lifetime electric, and water benefits	$15,273,300	25%
2	Electricity Savings	Annual incremental net MWh expected savings	12,778	30%
3	Summer Peak Demand Savings	Cumulative net summer peak demand expected savings	1.94	17%
4	Winter Peak Demand Savings	Cumulative net winter peak demand expected savings	1.95	14%
5	Weighted Lifetime MWh Savings	Cumulative Lifetime MWh Savings	176,652	9%
6	Administrative Efficiency	Total Administrative cost as a % of total budget	$43,739	5%
		EFFICIENCY VERMONT		
QPI#	TITLE	PERFORMANCE INDICATOR	TARGET	WEIGHT
1	Total Resource Benefits	Present worth of lifetime electric, and water benefits	$180,842,000	N/A
2	Annual Electricity Savings	Annual incremental net MWh savings	193,200	N/A
3	Statewide Summer Peak Demand Savings	Cumulative net summer peak demand kW savings	20,600	N/A
4	Statewide Winter Peak Demand Savings	Cumulative net winter peak demand kW savings	28,400	N/A
5	Lifetime Electricity Savings	Lifetime incremental net MWh savings	2,520,300	N/A
6	Greenhouse Gas Reduction	Electric energy and non-energy benefits (metric tons of CO_2)	98,500	N/A
7	Flexible Load	Annual kW of flexible load	2,260	N/A
8	Administrative Efficiency	5% administrative cost reduction	$1,078,100	N/A
		VERMONT GAS SYSTEMS		
QPI#	TITLE	PERFORMANCE INDICATOR	TARGET	WEIGHT
1	Savings	Annual incremental net Mcf expected savings	248,853	15%
		Green house Gas emissions	13,695	10%
2	Lifetime Natural Gas Savings	Present worth of lifetime natural gas avoided costs	$27,981,383	15%
		Lifetime Mcf Savings	4,265,242	15%
3	Peak Day Natural Gas Savings	Peak day incremental expected savings	1,384	15%
4	Residential Single Family Comprehensiveness	Percent of home energy audits converted to a measure installation within 12 months (existing)	30%	3%
		Percent of home energy audits converted to a measure installation within 12 months (Addison)	30%	2%

		Percent of all cost effective measures as well as those measures recommended by the audit and installed by the customers within 12 months (existing) Percent of all cost effective measures as well as those measures recommended by the audit and installed by the customers within 12 months (Addison)	70% 70%	3% 2%
5	Residential Audits	Energy audits completed; including comprehensive home performance, customer, energy snap shorts, low income, condominiums, and mobile homes	600 annually	5%
6	Long-term Market Transformation	Offer energy efficiency training for contractors	Two per year	5%
7	Business Comprehensiveness of Savings	Diversity of measures implemented in commercial projects (existing) Diversity of measures implemented in commercial projects (Addison)	5% control-related, 20% heating systems, heat recovery or domestic hot water systems, 5% process-related, and 15% shell or other-related	4% 1%
8	Administrative Efficiency	Administrative Cost reduction as a % of total budget	$97,707	5%

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