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Assessment of a Cap-and-Invest Program for Vermont

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Executive Summary

Background

In 2024, the Vermont State Legislature passed Act 148 (the Transportation Bill) which required the Agency of Natural Resources (ANR) and Agency of Transportation (AOT), in coordination with the State Treasurer and the Vermont Climate Council, to undertake a study to evaluate the pros, cons, costs, and benefits of Vermont participating in a cap-and-invest program to reduce climate pollution, as well as possible other complementary emission reduction programs. This study is being submitted to the State Treasurer who will make a recommendation of any viable approaches to the General Assembly by February 15, 2025.

Vermont's Act 153 (2020), the Global Warming Solutions Act (GWSA), requires that Vermont reduce its gross greenhouse gas (GHG) emissions by at least 26 percent below 2005 levels by 2025; 40 percent below 1990 levels by 2030; and 80 percent below 1990 levels by 2050. The 2021 Initial Vermont Climate Action Plan and 2023 Vermont Transportation Carbon Reduction Strategy identified strategies and policies to reduce emissions. Analysis completed as part of these efforts found while current strategies and policies being implemented by the State of Vermont, including the Advanced Clean Cars II and Advanced Clean Truck regulations, will not be sufficient to meet the GWSA emission reduction requirements for 2030 assigned to the transportation sector. The plans noted a cap-and-invest program and/or low-carbon/clean fuel standard as additional strategies that could be further evaluated to understand their potential to further reduce the state's emissions by 2030.

A cap-and-invest program would set a limit on the amount of greenhouse gas emissions that declines over time. The state auctions allowances up to the limit of the cap and then invests the revenue in measures and programs to further reduce emissions. The combination of a price on emissions and investment in emission reduction measures incentivizes and creates greater opportunities for consumers, businesses, and other entities to transition to lower-carbon alternatives. Revenue can also be used to invest in climate resilience measures or returned to disadvantaged consumers as dividend payments.

A low-carbon or clean fuel standard would set a declining limit on the rate of greenhouse gas emissions from a fuel. Fuel distributors or other regulated entities would be required to reduce the rate of emissions (carbon intensity) of the products they deliver by blending or substituting renewable fuels for conventional fuels or providing other low-emitting technologies to consumers. The increased demand for lower-emitting alternatives results in increased private sector investment in businesses supplying those alternatives at the lowest cost to fuel suppliers and ultimately consumers.

Study Objectives

This study evaluates cap-and-invest program options that include linking with other states' existing or proposed programs – either the Western Climate Initiative (WCI) implemented in California and Quebec, or the New York Climate Initiative (NYCI) under development by New York State. This study also evaluates the viability of a cap-and-invest program that covers only the transportation sector; an "all-fuels" cap-and-invest program that would cover not only transportation but thermal emissions from the residential, commercial, and industrial sector; as well as a program that covers transportation, thermal, and major stationary source emissions.

This study considers 1) the likelihood and timing of meeting legislatively required greenhouse gas emissions reductions by 2030 and 2050; 2) potential benefits to Vermont's households and businesses as measured through reinvestment in clean energy and efficiency, as well as possible dividend payments for qualifying households; 3) potential costs to Vermont's households and businesses resulting from increases in fossil fuel prices; 4) other benefits including public health benefits and the social value of carbon pollution reduction; 5) the administrative cost and level of effort required to implement a cap-and-invest program; and 6) the potential benefits and implications of adopting a low-carbon fuel standard along with a cap-and-invest program.

Findings on Effectiveness

The findings of this study are that:

- Vermont's participation in a cap-and-invest program would support additional progress towards meeting the 2030 and especially 2050 emission reduction requirements established in the GWSA. Because of the likely earliest feasible timing of starting a cap-and-invest program (2027 or 2028) and a subsequent delay of at least two to three years until benefits are fully realized, even cap-and invest with a high price will not enable the State to reduce emissions to levels required by the GWSA by 2030. However, the program (at any price level) would support emission reductions going into the 2030s with achievement of the required 2030 level anticipated to occur between 2031–2035, depending on time frame.

- The likelihood of reducing emissions to required levels magnitude of emission reductions will depend upon how allowances prices play out under the program Vermont chooses to join, as well as decisions the State makes about how allowance proceeds are used. If a cap-and-invest program is not implemented, it is anticipated that the State would reach its required 2030 level by the end of 2036.

- It is somewhat more likely that the 2050 required emissions level could be reached with a cap-and-invest program, although there are many uncertainties over this longer time frame. Joining a program with a higher projected allowance price, maximizing sectoral coverage, and focusing revenue in the most cost-effective investments, would increase the likelihood of Vermont reducing emissions to 2050 required levels per the GWSA but is also most likely to raise concerns about near-term affordability.

- Future allowance prices, which are a key determinant of both emissions reductions and economic and household cost impacts, are uncertain under both WCI and NYCI, but are likely to be higher under WCI as NYCI is expected to set a lower price ceiling than WCI. Three price scenarios were evaluated in this study. It is considered likely that the "low" price scenario would be roughly consistent with the NYCI program (not yet proposed) and the "medium" price scenario with current WCI price levels. The "high" price scenario is consistent with the price ceiling for the WCI program. It is important to note that neither the "low" or "high" price scenario reflect a currently established program that Vermont could readily join.

- Covering residential, commercial, and industrial thermal emissions, in addition to transportation fuels, would provide an alternative to the Clean Heat Standard currently under consideration by the Legislature and could help reduce emissions in these sectors. Administrative efficiency could be improved by covering all of these sectors under a single program.

- A low-carbon fuel standard implemented alongside a cap-and-invest program would increase the likelihood of achieving the emission reduction requirements of the GWSA but would add administrative complexity. Currently no neighboring state is pursuing a low-carbon fuel standard, although such a standard has been implemented by West Coast states. Absent a neighboring or regional partner to share the costs of program administration, establishment of a Vermont-only program would result in an increase in cost to compliance entities, and ultimately consumers, as compared to participation in a multi-jurisdictional program.

- Benefits and costs to Vermont's households and businesses (as well as emission reductions) will depend upon how auction proceeds from the program are reinvested, as well as the choice of program to join, sectoral coverage, and other program design considerations. The extent to which households at different income levels either receive net benefits or incur additional costs will also depend upon the details of how auction proceeds are used. If a portion of the proceeds and dividends are directed towards Vermont lower-income households in the form of rebates, most of these households would see net savings as a result of the program – however, providing rebates to lower-income households reduces the emissions reductions a cap-and-invest program is able to achieve.

- The State would expect to see modest net benefits for overall job creation, as well as public health benefits, if a cap-and-invest program were implemented. These benefits would scale with the level of allowance prices and reinvestment of proceeds.

Feasibility and Timing Considerations

- At this time, it is only feasible for Vermont to join the existing Western Climate Initiative (WCI) program, assuming that the State could agree on participation details with the current program participants. Considering the need to negotiate the terms of joining WCI with California, complete rulemaking and program design processes, the earliest practical date for Vermont to join the program is likely to be 2028, although a very aggressive timeline could potentially support implementation by as early as 2027. The implementation timeline will also depend on factors outside of the State's control, including approval by California and Quebec of Vermont's participation in the program. With a 2028 start date, revenues from auction proceeds could start to be made available by late 2028 or early 2029, with emissions benefits increasingly being realized in 2030 and beyond. The current WCI allowance price is roughly equivalent to $0.25 per gallon of fossil fuel.

- Rulemaking for the NYCI program has not begun, nor has a proposed rule been made public; The state currently appears likely to publish a reporting-only rule in 2025 based on public statements from the administration. As a result, we cannot anticipate when obligation for this program could start. Delays in New York's implementation of the program present challenges to Vermont's analysis and should be monitored. The anticipated NYCI allowance price is roughly equivalent to $0.10 per gallon of fossil fuel.

- Vermont would need to "ramp up" a program including hiring and training staff to manage and oversee compliance and revenue administration, and establishing processes (and/or expanding existing programs) for distributing revenue and ensuring accountability for its use. Under the "medium" price scenario the program could potentially generate $90-180 million in revenue in 2030 and beyond. For comparison, the current budget of Efficiency Vermont – a ratepayer funded program to invest in efficiency and reduce energy costs – is roughly $50 million per year. It could therefore take some time to get reinvestment funds fully flowing after the first auction is completed. Workforce and supply chain constraints could also affect Vermont's ability to quickly and cost-effectively spend larger amounts of money and achieve the resulting emission reductions.

1.0 Study Overview

1.1 Study Objectives

In 2024, the Vermont State Legislature passed Act 148 (the Transportation Bill) which requires the Agency of Natural Resources and Agency of Transportation to study a cap-and-invest program as a strategy that could support meeting the State's requirements for cutting climate pollution. The Vermont Agency of Transportation (AOT) in coordination with the Vermont Agency of Natural Resources' (ANR) Climate Action Office (CAO), has undertaken a study to understand and compare the costs and benefits of Vermont participating in a cap-and-invest program to reduce climate pollution, as well as possible other complementary emission reduction programs. This report is being submitted to the State Treasurer who will make a recommendation of any viable approaches to the General Assembly by February 15, 2025.

Vermont's Act 153 (2020), the Global Warming Solutions Act (GWSA), established greenhouse gas (GHG) emissions reduction targets and required the development of the Initial Vermont Climate Action Plan (CAP) which was adopted in December 2021. In November 2023, AOT published a Transportation Carbon Reduction Strategy pursuant to federal requirements and funding, which looked at emission reduction strategies and programs specific to the transportation sector. Analysis for the CAP and CRS found that while Vermont is making progress in reducing emissions, 2030 targets set forth in the GWSA are unlikely to be met without further action. One of the recommendations of the CAP was to further investigate a cap-and-invest program along with supportive policies such as a low-carbon fuel standard. The CRS recognized cap-and invest-as a program that could reduce emissions towards meeting the requirements of the GWSA. A cap-and-invest program would: place an annual limit on the amount of fossil fuel greenhouse gas emissions that declines over time; auction allowances equal to the annual emissions limit; require businesses emitting greenhouse gases or selling fuels that emit such gases to purchase allowances equal to their emissions; and invest the proceeds of the auctions in energy efficiency, renewable energy, electrification and other zero-emissions technologies, climate resilience, and equitable dividend payments designed to minimize the financial impact on low-income Vermonters. A low-carbon fuel standard would set a declining emission rate (carbon intensity) standard for fuels and similarly allow fuel producers to buy and sell credits for emission-reducing fuels and measures. This study takes an in-depth look at these market-based program options for Vermont and how they could help the state meet its requirements for reducing climate pollution and at what cost.

1.2 Background

The GWSA requires that Vermont reduce its gross GHG emissions at least 26 percent below 2005 levels by 2025; 40 percent below 1990 levels by 2030; and 80 percent below 1990 levels by 2050.[1] Based on a 2021 decision by the Vermont Climate Council, program design for each emissions sector is being developed to attain its share of these emissions levels in proportion to its share of statewide emissions in 2018.[2]

[1] The ANR's *Vermont Greenhouse Gas Inventory and Forecast: 1990-2021* (2024) reports a total of 8.56 million metric tons of carbon dioxide-equivalent emissions in 1990 across all sectors, and 9.86 MMT in 2005. Based on these reference levels, the required levels of emissions would be no more than 7.30 MMT in 2025, 5.14 MMT in 2030, and 1.71 MMT in 2050.

[2] "DRAFT Memo re: Establishing the Reference Year for Proportional Emissions Reduction by Sector and Interpreting 10 V.S.A. § 592 (d)." Memorandum to Cross-Sector Mitigation Sub-committee, October 19, 2021. J. Duval, R. Cowart, P.

(Footnote continued on next page...)

According to ANR the transportation sector was responsible for 40 percent of statewide emissions and the thermal (residential, commercial, industrial) sector was responsible for 34 percent of statewide emissions in 2018.

The 2021 Initial Vermont Climate Action Plan (CAP) as adopted by the Vermont Climate Council identifies specific initiatives, programs and strategies necessary to achieve the State's GHG emission reduction requirements, enhance carbon storage and sequestration, achieve net zero emissions by 2050, and build resilience and adaptation in our natural systems and built environment. The initial CAP primarily focuses on the initiatives, programs and strategies necessary to achieve the reductions required by 2025 and 2030. Many pathways and strategies laid out for the transportation sector align with programs that AOT is currently implementing. The CAP also recommended the adoption and implementation of the Advanced Clean Cars II (ACCII) and Advanced Clean Trucks (ACT) rules. Based on preliminary modeling, the Vermont Department of Environmental Conservation (DEC) estimates that ACCII and ACT will achieve 34 percent of the transportation sector GHG emissions reductions needed by 2030. The purpose of ACCII and ACT is to make electric vehicles available for sale in Vermont; however, the reductions estimated by DEC depend on the number of vehicles being purchased and replacing internal combustion engine vehicle miles traveled. AOT's current Capital Program includes investments in electric vehicle (EV) charging stations made possible by a significant amount of federal funding provided for this purpose in Fiscal Years 2022 - 2026; state-funded programs are providing incentives for purchasing EVs. While these policies and investments are a strong start towards getting cleaner and more efficient vehicles on the road and reducing the GHG emissions from the transportation sector, additional complementary policies and actions are needed to meet the 2030 requirements.

The 2021 CAP also included a recommendation that Vermont participate in the Transportation & Climate Initiative Program (TCI-P) – a regional cap-and-invest program – as a lead policy and regulatory approach to reduce emissions from the transportation sector. Just weeks prior to the CAP adoption, TCI-P became unviable, and the Climate Council agreed to include a notice in the CAP that the Council would continue work on an alternative recommended policy or set of policies to make up for the lack of sufficient transportation emissions reduction policy recommendations – as well as pursue TCI-P if it again became viable.

The 2023 Vermont Transportation Carbon Reduction Strategy (CRS) developed by AOT pursuant to the Infrastructure Investment and Jobs Act Carbon Reduction Program, and its accompanying planning and public engagement process, provided Vermont a timely opportunity to undertake additional analysis to quantify the gap that exists between emissions reductions expected from current policies and the implementation of other potential strategies and the required reductions of the GWSA. The CRS analysis indicates that Vermont may meet its 2025 reduction requirement in the transportation sector. However, even with additional investments and considering current policies including advanced clean cars and trucks rules, the modeling shows a gap between projected emissions in the transportation sector vs. the portion of GWSA emission reduction requirements for 2030 and 2050 that are attributable to the transportation sector. The CRS found that without adoption of additional polices this portion of the required emissions reductions in the GWSA will not be met and states that:

Walke, and R. Patch. Note that while this approach establishes greater certainty that emission reductions will be achieved in each sector, it also provides less flexibility for the most cost-effective emission reductions to be achieved, as it may be easier to reduce emissions in some sectors compared to others.

> *"Of the additional programs, a cap-and-invest and/or Clean Transportation Standard program are likely the two most promising options to close the gap in projected emissions vs. required emissions levels for the transportation sector.*"

While the CRS provides considerations for actions towards those additional policy options, it does not include a detailed analysis of the design or potential outcomes for such options and thus does not recommend an approach.

Expanded emission reduction programs can also help address Vermonters' cost burdens associated with energy use. In particular, Vermonters with lower incomes are disproportionately burdened by energy costs. While Vermont households with lower incomes typically use less energy than those with higher incomes, they spend a larger share of their income on energy. Transportation costs make up the largest share of the energy cost burden facing Vermonters (45 percent of total energy expenditures). Looking at the "all-in" costs, including vehicle purchase, fuel, and maintenance, there is a significant geographic disparity in transportation energy burden throughout the state, with higher burdens in the Northeast Kingdom and Southern Vermont. Averaged across Vermont, households with lower incomes (80 percent of the area median income, or AMI) spend 30 percent of their income, on average, on these "all-in" transportation costs, compared to 25 percent for Vermonters at the state median income. The scenarios explored in this study consider the degree and distribution of the transportation and housing energy burdens for Vermonters, and how a cap-and-invest program revenue could be allocated to address these disproportionate impacts.

1.3 Study Process

The study process included two primary components: 1) research and analysis of program options; and 2) stakeholder engagement. The research and analysis was conducted using a combination of original modeling and information available from other states and provinces that have implemented and/or studied cap-and-invest and low-carbon fuel standard programs. Analysis was done to understand the effect of a cap-and-invest program on:

- The likelihood and timing of meeting the requirements established by the Legislature in the GWSA for reducing GHG emissions.
- Potential benefits to Vermont's households and businesses as measured through reinvestment in clean energy, efficiency, and climate resilience, as well as consumer rebates.
- Potential costs to Vermont's households and businesses resulting from increases in fossil fuel prices.
- Other benefits including public health benefits and the social value of carbon pollution reduction.

The study also considers the administrative cost and level of effort required to implement a program, as well as the potential timeline for implementation. Finally, the study considers the potential benefits and implications of adopting a low-carbon fuel standard in addition to a cap-and-invest program. The study was guided by a Technical Advisory Committee that included representatives from the Vermont Climate Council, Cross-Sector Mitigation and Science and Data Subcommittees.

The study's stakeholder engagement process included two public meetings held virtually on October 3, 2024 to inform the public about the program and gather initial input. In addition, focus groups were held in November 2024 with representatives of the following groups:

- Potentially regulated entities (i.e., fuel suppliers and distributors and large stationary source emitters that could be subject to emissions limits under a cap-and-invest program).
- Vermont's business community.
- Environmental and community-based organizations, including organizations with a focus on equity.

Both the public and the focus group attendees will have the opportunity to learn more about the findings of the analyses when the outcomes are shared with the Vermont Climate Council in February.

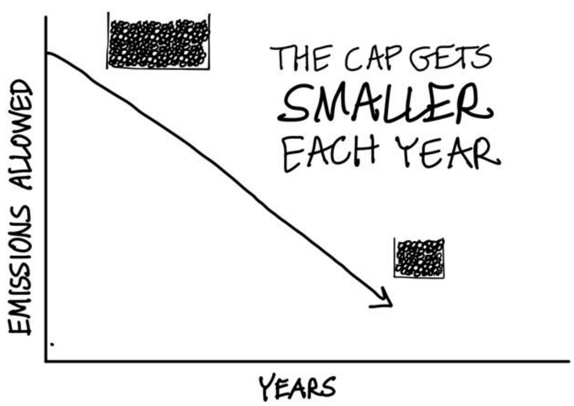
2.0 How the Program Would Work

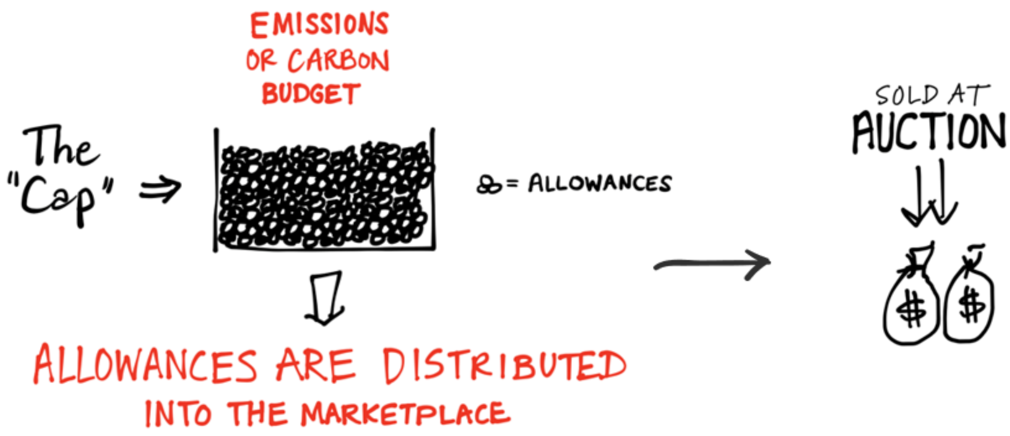
2.1 Cap-and-Invest Program

A traditional approach to regulating pollution sets a limit on emissions or emissions intensity – e.g., emissions per vehicle-mile from cars and trucks, or per megawatt-hour of power produced by electricity generation plants. The limits generally apply to every emitter within each source category. Examples include vehicle fuel economy and emissions standards such as Corporate Average Fuel Economy (CAFE), as well as powerplant and industrial source emissions regulations under the Clean Air Act. This approach can be effective, but may also be relatively costly, as some sources may find it harder or more expensive to reduce emissions than others who can reduce emissions more easily.

A cap-and-invest program is a complementary approach to reducing emissions. As illustrated in Figure 2-1, the state would set a declining cap on carbon emissions over time; this cap can reflect the state's requirements for reducing emissions under the Global Warming Solutions Act. The State would sell or distribute the rights to emit carbon, within that declining cap. Those rights are known as "allowances", where one allowance is the permission to emit one metric ton of carbon dioxide equivalent emissions. Companies that emit pollution can buy, sell, and trade allowances. Companies that can reduce emissions at a cost lower than the market allowance price will choose to reduce emissions; firms with higher costs will purchase allowances. Thus, the market price incentivizes emissions reductions at the lowest potential cost.

Figure 2-1 Cap-and-Invest Program





Graphics courtesy/adopted from Franz Litz

The state collects proceeds from auctioning the allowances. The state can then use the proceeds to invest in clean energy, energy efficiency, and other priorities to benefit Vermonters and further reduce pollution. The State can also choose to use proceeds for related purposes, such as climate resilience, or directly returning proceeds to Vermonters. The legislature must authorize the State to collect and distribute funds.

Vermont would have to choose which sources to cover. This study is investigating the options of:

1. Only covering fossil fuels for transportation (gasoline and diesel) as was called for by Act 148.
2. Also covering fossil fuels used for heating residential, commercial, and industrial buildings (natural gas, heating oil, and propane) – also known as "thermal" emissions.
3. Also covering industrial process emissions from large stationary sources.

In Vermont in 2021, the transportation sector accounted for 39 percent of emissions; thermal emissions were 31 percent; and industrial processes were 8 percent, meaning that up to 75 to 80 percent of the state's emissions could be covered. Some emissions are from sources that are too small or difficult to include.

"Regulated entities" are the businesses that would be required to acquire and periodically submit allowances to the state equal to the greenhouse gas emissions of the fuels they provide, or the emissions produced by their operations. Individual households and businesses would not be directly regulated and would not have a compliance obligation. Instead, fuel distributors and suppliers would be responsible for compliance, along with any large industrial sources covered.

Cap-and-invest programs can be created with guardrails to limit potential cost impacts to Vermont's household and businesses. One of the most significant is a "price ceiling" that sets an upper limit on the price at which pollution allowances can be sold by the state at auction. If the price exceeds the ceiling, additional allowances are introduced into the marketplace until the price is reduced to the ceiling. Regulated entities may also be able to bank allowances from one year to the next to reduce volatility, or to purchase offsets to cover some portion of their emissions.

Economy-wide cap-and-invest programs have been implemented in California and Quebec for approximately a decade. Washington State established a program in 2023, and New York State is currently developing a program with the likely earliest implementation year being 2027. Vermont has participated in a cap-and-invest program for electricity generation (the Regional Greenhouse Gas Initiative) since 2009.

2.2 Low-Carbon Fuels Standard

A low-carbon fuels standard (LCFS) sets a limit on the rate of carbon emissions for fuel supplied (e.g., grams of CO_2 emissions per joule of energy used in transportation services) with the rate declining over time. This type of standard is also known as a “clean fuels standard”, or if applied to specific sectors, may be called a “clean transportation standard” (for transportation fuels). This approach similarly can also form a basis for a “clean heat standard” (for home heating fuels), although as currently under discussion in Vermont a clean heat standard is not an intensity standard, but rather based on retirement of older, polluting equipment.[3] Standards for the emissions intensity of fuels are complementary to other standards that target the performance of vehicles and appliances.

The carbon intensity of a fuel can be reduced by blending or substituting conventional fuels with renewable fuels (such as ethanol, biodiesel, or renewable natural gas) with lower carbon emissions. While a cap-and-invest program typically regulates emissions occurring within a state, a low-carbon fuel standard is typically based on life-cycle carbon emissions, which may include out-of-state emissions associated with production and transport of the fuel as well as uptake of carbon in biomass grown for fuels. Some programs also establish credit systems so that different types of fuels or energy (such as electricity or green hydrogen) can be used to offset conventional fuel carbon intensities.

For example, California’s Low Carbon Fuel Standard for transportation fuels began implementation in 2011. Its goal is to reduce the carbon intensity of transportation services by 30 percent by 2030 and 90 percent by 2045. Under its program, each fuel is rated with a “carbon intensity” (CI) index that is a measure of its life-cycle carbon emissions. Low-carbon fuels below the benchmark generate credits, while fuels above the CI benchmark generate deficits. Credits and deficits are denominated in metric tons of GHG emissions. Providers of transportation fuels must demonstrate that the mix of fuels they supply for use in California meets the LCFS carbon intensity standards for each annual compliance period. A deficit generator meets its compliance obligation by ensuring that the number of credits it earns or otherwise acquires from another party is equal to, or greater than, the deficits it has incurred.[4]

Similar to a cap-and-invest program, LCFS establishes a market through which fuel suppliers can buy and sell credits to achieve the overall lowest-cost means of meeting the state’s carbon intensity benchmark. However, this market is internally revenue-neutral (after accounting for administrative costs) and does not create a pool of funds for the state to invest in emission-reducing activities or equity-focused consumer benefits like a cap-and invest program would. Instead, it relies on the increased demand for low emitting fuels and technologies created by the program to incentivize private sector investments in those businesses

[3] Act 18 (the Affordable Heat Act) – enacted May 24, 2023 – established the framework for the Public Utility Commission to design a Clean Heat Standard for approval by the Vermont General Assembly in 2025. Under this proposed standard, obligated entities, defined as fossil fuel wholesalers and dealers who sell or import fuel into Vermont to ultimately be used in homes and businesses, would be required to reduce emissions to meet GWSA targets. To do so, they would need to retire “Clean Heat Credits,” which can be created through facilitating customers to switch to a lower-emitting renewable energy source, or by installing equipment that avoids emissions. Alternatively, obligated entities could pay a statewide default provider called the “Default Delivery Agent.” The Public Utility Commission is currently designing the rules for how credits are valued and calculated, how obligations are set, and how compliance is verified, among other program design details. Source: https://publicservice.vermont.gov/clean-heat-standard, accessed December 23, 2024.

[4] https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard/about

that can deliver them at the lowest cost. It also does not set a specific emissions cap – total emissions may still vary with changes in activity levels (e.g., vehicle-miles of travel, total households or business energy use).

Unlike a cap-and-invest program, only a share of the LCFS credit price (dollars per ton) is reflected as a change in the cost of transportation fuels to consumers. For example, if the standard aims to reduce carbon intensity by 20 percent, approximately 20 percent of the credit price is reflected per ton of carbon in a transportation fuel, compared to roughly 100 percent of the allowance price under cap-and-invest. An LCFS requires a shift to cleaner fuels on the part of fuel suppliers but does not provide a direct cost incentive to reduce fuel use, although it could provide an indirect incentive depending upon whether average fuel prices are affected.

California's standard has evolved over time, including adding new crediting opportunities to promote zero emission vehicle adoption and other advanced technologies for the transportation sector, as well as crediting for specific emissions-reducing projects and for carbon capture and storage. California views its transportation LCFS as complementary to its cap-and-invest program, with the two programs in combination providing greater assurance that the state's overall emission reduction goals will be achieved.

Oregon, Washington, British Columbia, and Quebec have also implemented low-carbon fuel standards that apply to fuels used in multiple sectors, with the West Coast states and provinces linking into a single credit market with California. Quebec's program sets volumetric fuel requirements for low-carbon gasoline and diesel for the 2023 – 2030 period, increasing from 10 percent in 2023 to 15 percent in 2030 for gasoline, and from 3 percent to 10 percent for diesel.[5] New York State is not, at this time, pursuing a similar standard. Absent a neighboring or regional partner to share the costs of program administration, establishment of a Vermont-only program would result in an increase in cost to compliance entities, and ultimately consumers, as compared to participation in a multi-jurisdictional program.

[5] P-30.01, r. 0.1 - Regulation respecting the integration of low-carbon-intensity fuel content into gasoline and diesel fuel

3.0 Cap-and-Invest Options and Evaluation Criteria

3.1 Program Options

Vermont is a small state, and it would be a significant administrative burden to create its own, stand-alone program. There would also be cost efficiencies to regulated entities participating in a regional or multi-state program, since emissions allowances could be traded across a much larger marketplace, making it easier to find the most cost-effective means of reducing emissions. Therefore, this study does not contemplate a stand-alone, Vermont-specific program and instead considers two options for linking with an existing or planned program. The two options potentially available in North America are:

1. **Western Climate Initiative** (WCI) – Current participating entities include California and Quebec; Washington State is using the WCI emissions trading platform and is considering linking with the participating entities.[6]

2. **New York Climate Initiative** (NYCI) – Under development by New York State. Note that the state's recommendations have not been finalized and New York could also seek to link with WCI.

Each program has different parameters which may affect the likelihood of Vermont achieving its required emission reductions and the magnitude of other benefits and costs experienced. WCI has established parameters and a history of over a decade of operation. The outlines of a NYCI program have been suggested but not codified yet, so the exact parameters of a NYCI program are subject to some uncertainty. A draft rule may be published in 2025. The programs are compared in summary format in Table 3-1. Vermont's population and emissions are also presented to compare with those of the climate initiative participating entities. Complementary emission reduction policies adopted by the respective jurisdictions are also shown.

Table 3-1 Comparison of Western Climate Initiative and New York Climate Initiative

Program Parameter	Western Climate Initiative	New York Climate Initiative	Vermont
Program start year	2013 – 2015	2026 (earliest)	
Participating entities	CA + QC (linked) WA State (using platform)	NY State	
Total population of participating entities	47-55 million	20 million	0.7 million
Sectors covered	Economy-wide	Economy-wide not including electricity sector	Option to link one or all the sectors contemplated by the study to either program (transportation, thermal, or stationary sources)

[6] "Linking" means linking the market for allowances such that the market price would be the same for all covered entities in the program, regardless of the state or province in which they are based.

Program Parameter	Western Climate Initiative	New York Climate Initiative	Vermont
Emissions cap	CA: **294** MMT (2023); -32% by 2030; -77% by 2050 QC: **55** MMT (2021); -22% by 2030; carbon neutrality by 2050 WA: **68** MMT (2023); -45% by 2030; -95% by 2050	**233** MMT (2025); -27% by 2030; -90% by 2050	Total emissions of **8** MMT in 2021 Transportation: 3.24 MMT Thermal: 2.57 MMT
Price ceiling	$88 per ton in 2024 + (5% + inflation) / year	TBD but likely much lower than WCI	
Accounting	Direct emissions only; 100-year GWP	Some upstream & biogenic emissions; 20-year GWP	
Complementary policies	Advanced Clean Cars 2 (ACC2) + Advanced Clean Trucks (ACT) emissions standards Low-carbon fuels standard	ACC2 + ACT emissions standards	ACC2 + ACT emissions standards

MMT = million metric tons; GWP = global warming potential.

Observations from this comparison:

- The WCI is already established, and Vermont could link as soon as a program is authorized and ready – 2027 at the earliest, but more likely 2028. NYCI is not yet established and the ability and timeframe to link with the program is uncertain. If New York's program is established in 2027, Vermont could potentially link in that first year, but more likely starting in 2028. See Section 4.2.11 for a more complete discussion of potential timelines.

- In both programs, the total emissions and covered population of the participating entities would be many times greater than Vermont's emissions and population. Therefore, Vermont's participation would likely not have any meaningful effect on the allowance prices in either program.

- WCI has set a relatively high price ceiling over time (which has not been met yet) and NYCI is expected to set a much lower price ceiling. While a lower price ceiling, if reached, would generate less revenue and less certainty of meeting emission reduction requirements, it would limit potential impacts of the program related to fossil fuel price increases. In linking with WCI, Vermont would not have the benefit of ramping up the price as California did through its establishment of a program and would need to come in at the WCI allowance price at the time of joining (currently $30 per allowance, equivalent to $0.25 per gallon of gasoline) which could create significant financial challenges for Vermonters, particularly in the short-term.

- NYCI uses an accounting system that includes some upstream and biogenic emissions. If Vermont adopted a similar system, it would have a greater chance of reducing life-cycle emissions associated with activities in the state, but some of these reductions might occur outside of Vermont's borders. Vermont would not be required to adopt the New York inventory methodology to link with NYCI but it is unclear at this time how it would affect linkage.

3.2 Sectoral Coverage Options

This study evaluates the following options for sectoral coverage:

1. Transportation fossil fuels only (gasoline and diesel).

2. Transportation fossil fuels + other fossil fuels used for residential, commercial, and industrial (R/C/I) heating and appliances (natural gas, heating oil, propane) – also known as thermal emissions.

3. Transportation fossil fuels + other fossil fuels + process emissions from large stationary sources..

NYCI and WCI cover all of these sectors, but Vermont would have the option to link to either program with one or more sectors covered. It would not be required to cover all the sectors being analyzed in the study. Limiting the program to transportation fuels only could increase the likelihood of the transportation sector achieving the proportional emission reductions required under the GWSA. Expanding the program to cover other sectors provides more options for achieving emission reductions at the lowest cost, but less certainty regarding in what sector those emission reductions will occur. Emissions allocations could be traded across sectors to find the lowest-cost opportunities for reducing emissions. Currently, in Vermont, program design for each emissions sector is being developed to attain its share of these emissions levels in proportion to its share of statewide emissions in 2018; this approach is consistent with the 2021 decision by the Vermont Climate Council, but may need to be revisited if a cap-and-invest program is pursued.

An expanded program would also apply the emission reducing benefits of cap-and-invest to a larger share of Vermont's emissions – thus increasing the likelihood of the state meeting its overall emission reduction targets. It would also provide additional revenues that could be invested in residential and commercial efficiency and renewable energy as well as clean transportation programs.

Vermont currently has only five large stationary sources (over 25,000 tons CO_2 per year) that would potentially be included in the program.

To minimize the risk of industrial sources moving to a jurisdiction without a price on greenhouse gas emissions, a cap-and-invest program may be set up to provide free allowances to certain sources that are deemed to be a "flight risk". This report discusses that option. The study also included outreach to these potentially regulated emitters to better understand opportunities for emission reductions and potential concerns related to a cap-and-invest program.

3.3 Low-Carbon Fuel Standard

A low-carbon fuels program could be set up and implemented independently of a cap-and-invest program. could be implemented in tandem with cap-and-invest, or could be implemented at a later time. This study considered the potential interaction between the two programs and the degree to which the LCFS could increase the likelihood of Vermont reducing emissions to its statutory requirements in 2030 and beyond. The study also evaluates how implementing an LCFS might affect other considerations such as job creation and household costs.

3.4 Evaluation Criteria

This study evaluates the above program options based on 11 criteria:

1. Anticipated emission reductions in Vermont in covered sectors in 2030 and 2050, and likelihood of achieving these reductions.

2. Revenue generation.
3. Allowance price (cost/ton) over time.
4. Change in fuel/energy cost per gallon or unit of energy.
5. Macroeconomic effects, including job creation and effects on different industries.
6. Household-level benefits and costs to Vermonters, including benefits and costs to different income groups.
7. Social cost (value) of carbon reductions.
8. Health benefits resulting from reduced air pollution and other program benefits.
9. Potential for “leakage” of emissions to other states.
10. Implementation costs including program administration.
11. Potential timeline for implementing the program and investing the proceeds in beneficial programs.

Most of these criteria are closely related to, and will scale from, two primary factors – 1) the allowance price trajectory, and 2) sectoral coverage. Since the allowance price trajectories under both WCI and NYCI are uncertain, the study looked instead at three price trajectories (labeled “low,” “medium,” and “high” in this study) that could represent the range of impacts expected under NYCI or WCI. For reference, it is anticipated that fossil fuel price effects (including gasoline, diesel, and home heating oil) could range from $0.11-$0.13 per gallon under the low price scenario, $0.33-$0.41 under the moderate scenario, to $0.66-$0.83 per gallon under the high price scenario. Prices in WCI currently align most closely with the “moderate” scenario; prices under the NYCI program are more likely to align with the “low” scenario if the state sets a relatively low price cap. Should Vermont choose to initiate a cap-and-invest program, once the NYCI program is finalized, the state could evaluate which program (NYCI or WCI) to link with; currently WCI (the moderate price scenario) is the only option available to Vermont.

4.0 Evaluation of Cap-and-Invest Program Options

4.1 Summary of Findings

This section presents a summary of findings on the evaluation criteria, followed by a more detailed discussion of methods, assumptions, and findings in Section 4.2.

Table 4-1 compares the evaluation criteria based on price scenario (or program) options as well as sectoral coverage options and interaction with a low-carbon fuel standard.

Table 4-1 Cap-and-Invest Summary Findings

Criterion	Price Scenario or Program Option	Sectoral Coverage	Low-Carbon Fuels
1. Emission reductions	• Higher allowance price will support greater emission reductions. • The high price scenario (which does not currently exist as a program option) with at least 50% reinvestment of proceeds in emissions reducing activities has the potential to reduce the State's emissions to the required 2030 level by as early as the end of calendar year 2030,[a] if implemented rapidly – other scenarios are not likely to achieve 2030 GWSA levels until later in the decade, as late as 2035 under the low price scenario. • The high price scenario with significant reinvestment is also needed to reduce emissions to the required 2050 level by the end of calendar year 2049.	• Full sectoral coverage will achieve about 30 to 50 percent more emission reductions than covering the transportation only.	• Increases likelihood of reducing emissions to target levels, but some reductions may come upstream and out-of-state.
2. Revenue generation	• Revenue generation will scale to allowance price. • Low price scenario could generate \$30-60M annually by 2030; medium scenario could generate \$90-180M; high price scenario could generate \$180-340M.	• Revenue generation will scale with sectoral coverage. • Covering all sectors will provide nearly twice the proceeds as covering transportation only.	• Revenue-neutral after administrative costs.
3. Allowance price	• WCI is likely to see a higher price trajectory than NYCI – WCI has a relatively high allowance price ceiling, NYCI price ceiling is expected to be lower. • Price scenarios range from \$13 to \$80/metric ton CO_2 in 2030.	• Sectoral coverage would not affect allowance price. • Broader sectoral coverage means price would apply to residential and commercial fuels and/or stationary source emissions, not just transportation fuels.	• N/A

Criterion	Price Scenario or Program Option	Sectoral Coverage	Low-Carbon Fuels
4. Change in fuel/energy cost	• $1 per ton is equivalent to just under $0.01 per gallon of gasoline or diesel. • Fossil fuel price effects could range from $0.11-$0.13 per gallon under the low price scenario, $0.33-$0.41 under the moderate scenario, to $0.66-$0.83 per gallon under the high price scenario.	• Sectoral coverage would not affect the price of covered fuels. • Broader sectoral coverage means residential and commercial fuel costs would be affected as well as transportation fuels.	• Increases price for carbon-intensive fuels while reducing price for low-carbon fuels including electricity. Price effect is a function of both the price of lower carbon fuels and the program's carbon intensity reduction trajectory.
5. Macroeconomic effects	• Job effects will scale with funding available for investment. • Average annual net new job creation could range from 80 – 140 under low price scenario, 420 – 810 under high price scenario.	• Job effects will scale with funding available for investment. • Lower end of the job ranges is for transportation only, higher end is for full sectoral coverage.	• Modeling in WA suggests a net positive impact as electricity sector jobs increases outpace petroleum sector losses
6. Household benefits and costs	• Household effects (both positive and negative impacts) will scale with fuel price changes as well as how proceeds are used. • Directing investments and/or dividends to Vermont's lower-income households will result in most of those households saving money compared to their current fuel expenditures.	• Household effects (both positive and negative impacts) will be greater for expanded sector coverage compared to transportation only.	• Not evaluated.
7. Social cost (value) of carbon reductions	• Value of carbon reductions will scale with emission reductions. • Range of $40M under low price/transportation only scenario to $210M under high price/all sectors scenario in 2030.	• Value of carbon reductions will scale with sectoral coverage. • Full sectoral coverage will achieve about 30 to 50 percent more social cost savings than transportation only.	• Proportional to emission reductions.
8. Health benefits	• Health benefits will scale with emission reductions, which will scale with the price. • Program could save 7 to 12 lives in 2030, prevent 39 to 68 asthma cases in children, and yield $39 to $65 million in health benefits. • Benefits only quantified for the transportation sector.	• Health benefits will increase with emission reductions, which will scale with sectoral coverage. • Transportation sector is likely to see greater health benefits per unit of emissions reduced due to more direct population exposure to tailpipe air pollution as well as reinvestment of funds in active transportation programs that increase physical activity as well as reducing emissions.	• Provides health benefits from emission reductions to the degree that zero-emission vehicles are incentivized by lower electricity prices.

Criterion	Price Scenario or Program Option	Sectoral Coverage	Low-Carbon Fuels
9. Potential for leakage	• Higher price provides greater incentive for leakage.	• Industrial sector has highest leakage risk, which could be mitigated through free allowances.	• Not evaluated.
10. Implementation costs	• Estimated to be up to 5-10% of auction proceeds. • Due to fixed costs in managing the program, a higher price should mean a smaller proportion of proceeds are diverted to cover program administration. However, a higher price will increase implementation costs somewhat to cover management of a larger value of proceeds.	• Program administration costs should scale with the number of covered entities, which will increase with broader sectoral coverage.	• Would create additional costs to administer system for tracking and managing carbon intensity of fuels.
11. Implementation timeline	• WCI is active and could be joined pending participating members' approval. NYCI could start as early as 2027 but this is uncertain. • While Vermont could potentially join a program as early as 2027, 2028 is more likely to be the most feasible start year, with revenues being reinvested in emission reduction activities by 2029.	• Should not be affected by sectoral coverage.	• Could be implemented independently of cap-and-invest.

[a] Achieving the required 2030 level by the end of 2030 would be one year later than required by the GWSA, which states that the level must be achieved by December 31, 2029.

Note that uncertainties in a variety of factors that could affect the program's impacts could lead to different impacts observed in practice. Examples of these uncertain factors include population and economic growth trends, evolving technologies, economic factors such as oil and other energy prices, and federal policies.

4.2 Detailed Methods, Assumptions, and Findings

4.2.1 Emission Reductions

Methods and Assumptions

The first step in estimating emission reductions from a cap-and-invest program is to develop a baseline projection of the state's emissions for the year 2030 and beyond, through 2050. At the time of this analysis, the state was beginning to develop an updated baseline for the 2025 Climate Action Plan update but this information was not yet available for use on this study. Instead, the project team developed its own projections considering past trends and future adopted policies.

For each fuel-sector combination, projections in emissions intensities, expressed in million metric tons (MMT) of carbon dioxide-equivalent (CO_2e) per unit of U.S. gross domestic product (GDP), were calculated on an annualized basis using information from the U.S. Energy Information Administration's (EIA) Annual Energy

Outlook (AEO) 2023 reference case projections.[7] From a benchmark year, the study team's model assumes that emissions intensities decline at a linear rate over time at the rate estimated from AEO projections. Emissions intensities in each year are then converted into emissions levels using GDP projections also from the AEO 2023. See Appendix B for additional details.

The effects of a cap-and-invest price signal (see Section 4.2.3) on emissions and emissions intensities were estimated for 2030 using a large-scale regional general equilibrium model.[8] This estimation process yields predictions in emissions intensity elasticities – how emissions for each fuel-sector in the economy would be expected to respond to a dollar change in the price of cap-and-invest allowance. Since Vermont's industrial sector is small and each potentially regulated entity in that sector is unique, no elasticities were applied to industrial process emissions – i.e., it is assumed that the price effect alone will not lead to changes in those emissions.

Finally, the additional emissions benefits of reinvesting auction proceeds into emissions-reducing activities were estimated. This step required assumptions about the use of the auction proceeds estimated as described below. Three reinvestment scenarios were considered:

- A "**no reinvestment**" scenario, in which all revenues, net of administrative costs, are returned directly to consumers and/or businesses (e.g., through dividend payments) or invested in non-emissions reducing activities such as climate resilience. It is conservatively assumed that 10 percent of gross revenues are set aside to cover costs of administering the program (see Section 4.2.10),

- A "**50 percent reinvestment**" scenario, in which half of revenues are spent on emissions-reducing activities, and the remainder (after administrative costs) are returned directly to consumers and/or businesses (e.g., through tax relief) or invested in non-emissions reducing activities such as climate resilience.

- A "**full reinvestment**" scenario, in which all revenues (after setting aside 10 percent for administrative costs) are spent on emissions-reducing activities.

In the scenarios with emissions-reducing reinvestment, the proceeds directed towards emissions-reducing activities were allocated as follows:

- For the transportation-only scenario, all proceeds are directed into transportation programs. For the scenarios including other sectors, 56 percent are directed to transportation programs and 44 percent to residential and commercial programs, in proportion to those sectors' relative shares of emissions.[9]

- Within the transportation sector, proceeds were directed as follows:

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[7] The EIA's AEO 2023 is the most recent projections from the AEO publicly available. No projections were updated in 2024, and the next set in 2025 will not be released until after this report this complete. The benchmark projections for emissions intensities are calculated using projections for the New England region and applied to Vermont's benchmark emissions levels.

[8] The analysis uses emissions elasticities estimated from the Resources for the Future (RFF)-DR general equilibrium model.

[9] Given the small number of industrial source emitters that might be covered and the potentially unique opportunities for emission reductions for each emitter, reinvestment into industrial source emission reduction is not explicitly modeled. However, the program could include revenue directed to those covered emitters.

- One-third to vehicle-travel reduction activities such as transit service improvements, pedestrian and bicycle investments, and micromobility services.
- One-third to incentives to purchase light-duty zero-emission vehicles and charging infrastructure.
- One-third to medium- and heavy-duty fleets for zero-emission vehicles and charging infrastructure to serve those fleets.

- Within the residential/commercial thermal sector (if included), proceeds were directed as follows:
  - Two-thirds to residential energy efficiency and/or clean energy sources, using electrification of home heating (heat pumps) as the illustrative strategy.
  - One-third to commercial energy efficiency and/or clean energy sources, also considering electrification of heating as the illustrative strategy.

For the proceeds not invested in emissions-reducing activities, half were assumed to be returned to consumers (households), e.g., through dividend payments, while the other half were assumed to be spent on other activities such as climate resilience. While this assumption does not affect the emissions analysis, it does affect the net household cost impacts of the program. The household cost incidence analysis included additional assumptions about the degree to which incentives or rebates were distributed across different income ranges. That analysis considered two scenarios, one in which benefits were equally distributed, and one in which they were targeted towards low- to moderate-income households to ensure equity benefits from the program. Those scenarios are described in more detail in Section 4.2.6.

The productivity of emissions-reducing investments (i.e., tons of emissions reduced per cumulative million dollars of investment) was estimated based on a combination of literature sources and previous studies in Vermont. The productivity assumptions are shown in Table 4-2. The values shown are estimates for 2030 emissions; estimates for other years were scaled in different ways (see Appendix B). These numbers are average estimates only; actual emissions productivity could be higher or lower depending upon the specific investments made and other supportive or non-supportive policies and economic and technology conditions in place at the time.

Table 4-2 Investment Productivity

Subsector/Activity	Annual Tonnes CO_2 per Cumulative $M	Source
Transportation – vehicle-travel reduction[a]	50	Vermont AOT, Transportation Carbon Reduction Strategy (2023).
Transportation – light-duty ZEVs and infrastructure	-	Assuming no incremental benefits beyond the requirements established under Vermont's Advanced Clean Cars rules, which require manufacturers to deliver increasing shares of ZEVs, up to 100% in 2035 and beyond.[b]
Transportation – medium- and heavy-duty ZEV fleets and infrastructure	250	Vermont AOT, VT Transportation Carbon Reduction Strategy (2023).

Subsector/Activity	Annual Tonnes CO_2 per Cumulative $M	Source
Residential efficiency	263	Based on heat pump impacts as developed from Deetjen et al (2021) and Bernard et al. (2024). A U.S. DOE synthesis of weatherization programs provides similar estimates. See Appendix B for details and references.
Commercial efficiency	263	Assumed to be the same cost-effectiveness as residential efficiency.

[a] Vehicle-travel reduction strategies include investment in non-driving modes such as transit, pedestrian and bicycle infrastructure, and micromobility programs, to increase travel alternatives and reduce travel in single-occupancy vehicles.

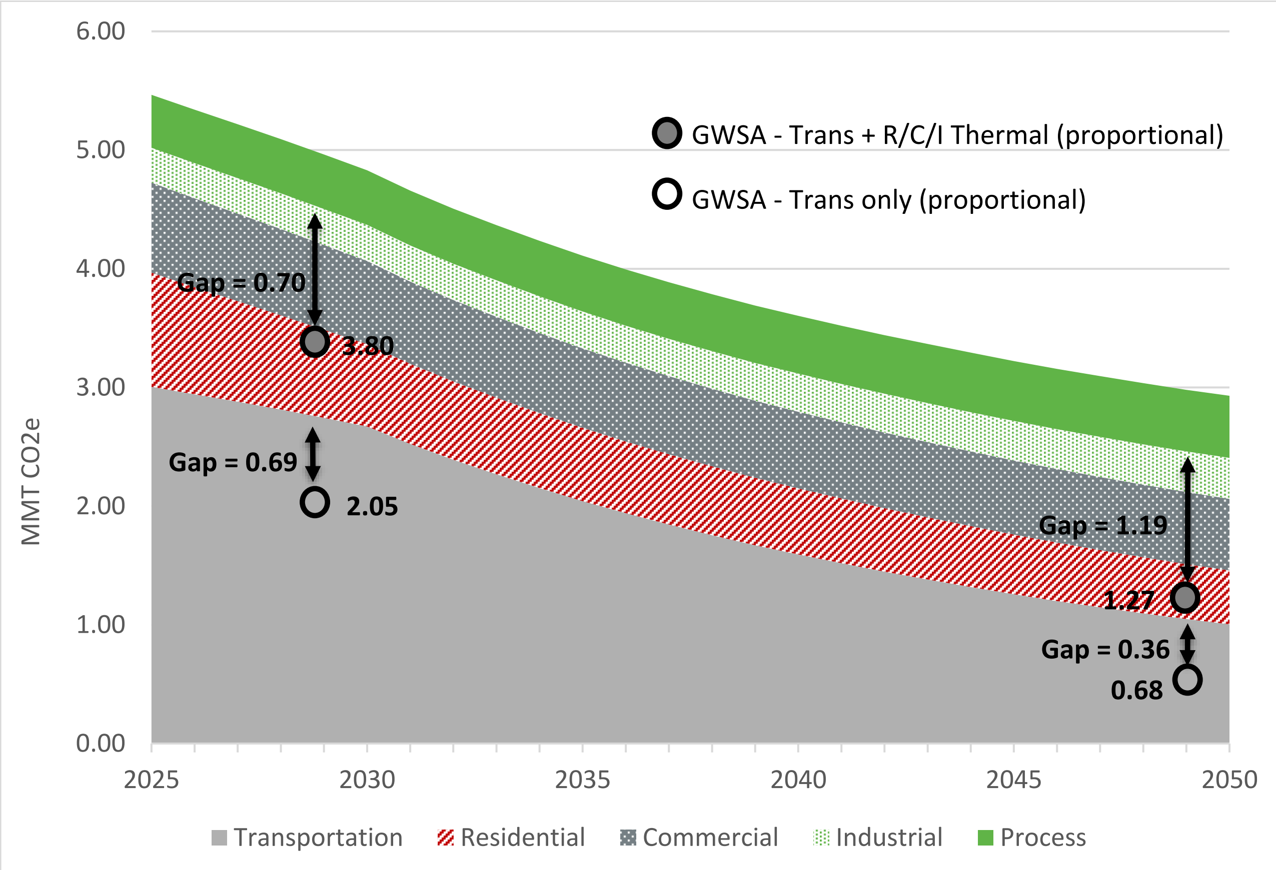
[b] Even though no additional emissions benefits are estimated from this investment, the investments affect the household cost analysis by returning money to consumers through vehicle and infrastructure incentives. They will also help the State make the necessary investments to support achievement of ZEV requirements under the Advanced Clean Cars rules.

Findings

Figure 4-1 shows the baseline emissions projected in Vermont for the potentially covered sectors through 2050. The figure also compares the GWSA-required emissions level for each sector and the gap between baseline forecast levels and the gap, for the “transportation only” and “transportation and thermal fuels” sectoral coverage options. Table 4-3 compares the forecast and gap for all three sectoral coverage options including industrial process emissions. Those comparisons are made against 2029 and 2049 forecasted emissions because the GWSA requirements are based on emissions reported through December 31 of the previous year (i.e., 2029 and 2049, respectively), so the “2030” and “2050” levels calculated as reductions from 1990 emissions should be compared to 2029 and 2049 emissions levels. Emissions in 2029 are projected to be 4.96 million metric tons of carbon dioxide-equivalent (MMT CO_2e). This compares with a legislatively required level of 4.05 MMT CO_2e, based on sector proportionality requirements – leaving a gap of 0.91 MMT.[10] Emissions in 2049 are projected to be 2.98 million MMT CO_2e. This compares with a legislatively required level of 1.35 MMT CO_2e – leaving a gap of 1.63 MMT. Looking at only the transportation sector, the 2030 transportation gap of 0.69 MMT represents the majority of the gap for the combined sectors, while the 2050 transportation gap of 0.36 MMT is a smaller fraction of the overall combined sector gap in that year.

[10] The GWSA required levels shown in this study are slightly different than they would be for the total transportation and residential/commercial/industrial sectors as shown in ANR’s 1990-2021 Vermont GHG inventory. This is because emissions from wood burning were excluded in this study. Those emissions made up 3.3 percent of R/C/I thermal emissions in 2019, the closest year to 2018 shows in detail in ANR’s inventory. Including all emissions from those sectors would yield GWSA required levels of 4.11 MMT for 2030 (2029 reporting year) and 1.37 MMT for 2050 (2049 reporting year). This is based on a 40 percent overall reduction from 1990 by 2030, and an 80 percent overall reduction by 2050, with the transportation sector responsible for 40 percent, R/C/I thermal responsible for 34 percent, and industrial process responsible for 6 percent of the 2030 and 2050 emissions based on their 2018 shares of total emissions.

Figure 4-1 Baseline Emissions Projections for Potentially Covered Sectors



Source: Resources for the Future and Cambridge Systematics. "Transportation" includes gasoline, diesel (onroad and offroad), jet fuel/aviation, and "other" CO_2 and non- CO_2 emissions. "Residential," "commercial," and "Industrial" include oil, propane, natural gas, and other thermal emissions except for wood. "Process" includes industrial process emissions. The GSWA levels and gap for all sectors including process emissions are not shown due to space limitations.

Table 4-3 Baseline Projected Emissions, GWSA Levels, and Baseline Gap for Each Sectoral Coverage Option

Scenario	2029 Baseline	GWSA Level by 2030	2029 Gap	2049 Baseline	GWSA Level by 2050	2049 Gap
Transportation Only	2.74	2.05	0.69	1.05	0.68	0.36
Transportation + R/C/I Thermal	4.50	3.74	0.76	2.46	1.25	1.21
Transportation + R/C/I Thermal + Industrial Process	4.96	4.05	0.91	2.98	1.35	1.62

Various factors could cause the actual baseline to differ from projected values. These include factors such as higher or lower rates of population and economic growth; changes in federal policies such as emissions standards or investments in clean technology; higher or lower energy prices that could affect consumer energy demand; and technology trends that increase or decrease the use of GHG-emitting technologies.

The following figures show the estimated effects of the cap-and-invest price on GHG emissions in 2029, under nine scenarios combining three price levels and three sectoral coverage levels. Figure 4-2 shows effects with no reinvestment in emissions-reducing activities, Figure 4-3 shows effects with 50 percent reinvestment, and Figure 4-4 shows effects with full reinvestment of auction proceeds (less administrative costs). The price effect alone, not considering emissions-reducing reinvestment of proceeds, is expected to close the gap vs. the 2030 required level by about 40 percent under the medium price scenario with full sectoral coverage. However, even the high price scenario with full reinvestment is insufficient to fully close the gap. Note that these are idealized scenarios in which the program is raising auction proceeds starting in 2027 with reinvestments initiated in 2028, and the full effects of the price signal as well as the reinvestments begun in 2028 are realized in calendar year 2029. In reality there is likely to be a longer lag between program implementation and achievement of full emission reductions, as it will take time for businesses and consumers to adapt and take advantage of the new incentives created by the program and for all of the money initially raised to be spent. The numbers shown in the figures are provided in Appendix B.

Figure 4-2 GHG Emissions in 2029, No Reinvestment

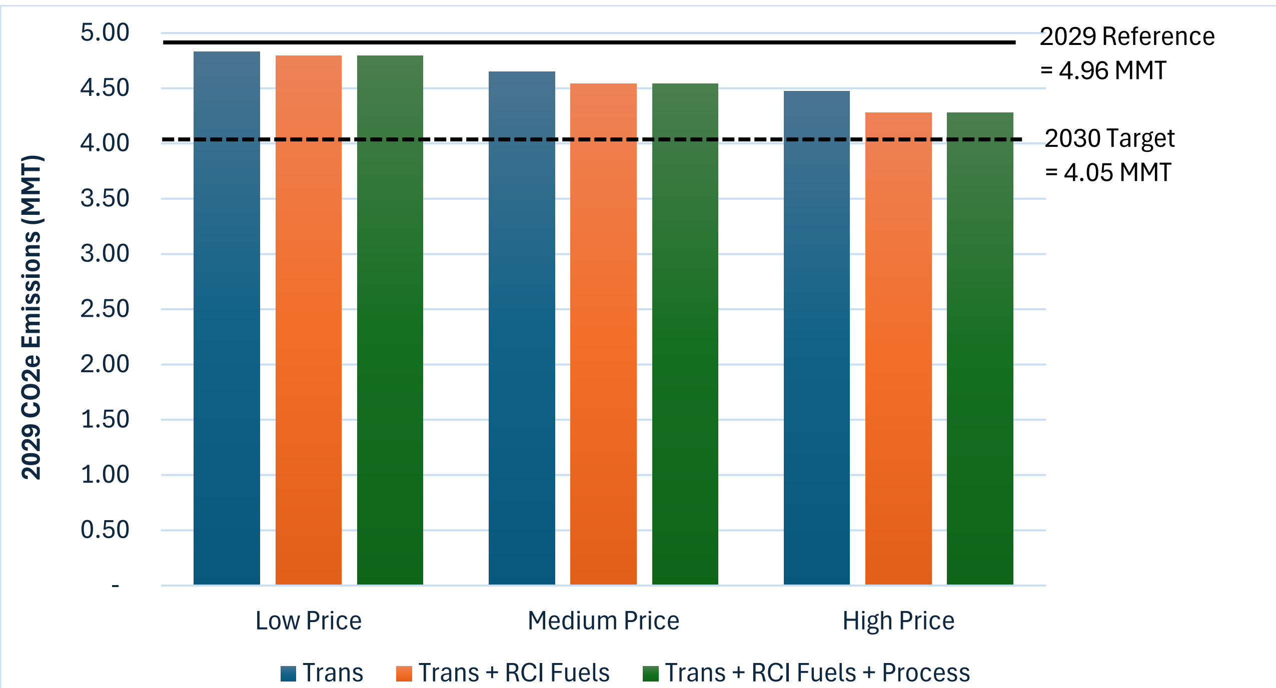


Figure 4-3 GHG Emissions in 2029, 50% Reinvestment

Figure 4-4 GHG Emissions in 2029, Full Reinvestment

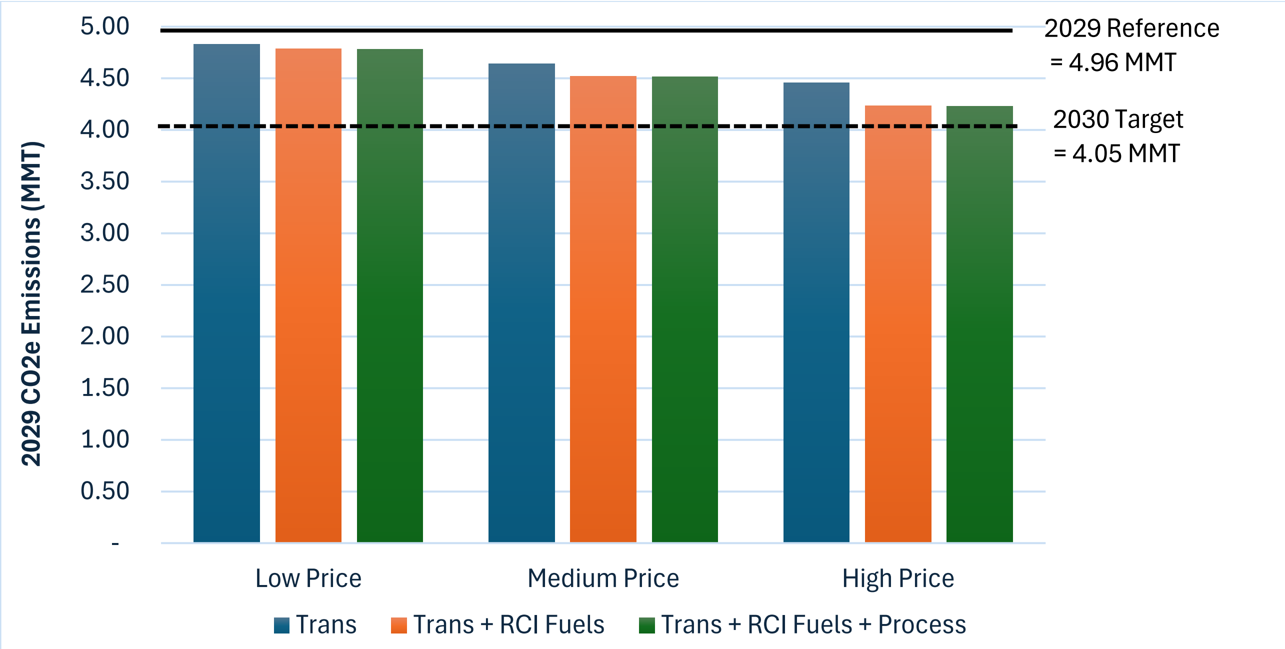


Figure 4-5 shows how transportation sector only emissions would compare with that sector's respective baseline and required GWSA levels in 2029. The figure shows all three reinvestment scenarios. This illustrates how the transportation sector could perform if the cap-and-invest program covered only that sector. None of the scenarios would reach the required GWSA level, although the medium price scenario would close about half the gap and the high price scenario would close about three-quarters of the gap. Note also that there is very little initial effect of the reinvestment. This is because it is expected to take some years before transportation sector reinvestments result in enough infrastructure and service improvements and fleet turnover to substantially reduce emissions.

Figure 4-5 Transportation GHG Emissions in 2029

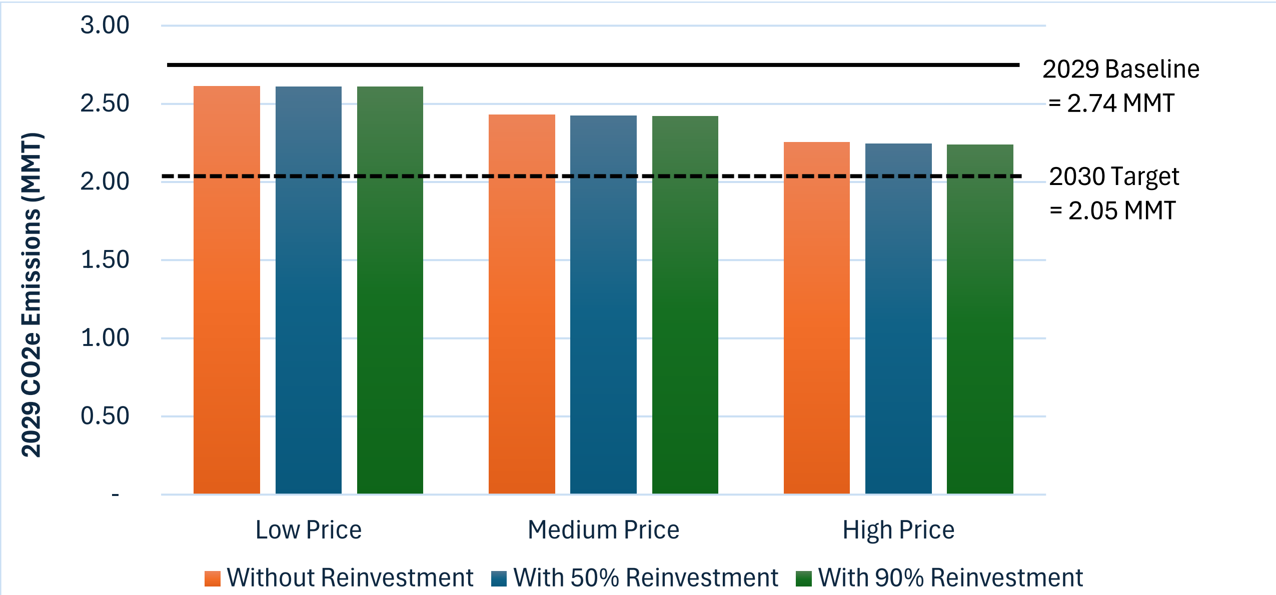


Figure 4-6 shows projected emissions annually through 2050 under each scenario, with 50 percent reinvestment of proceeds. Under the low-price scenario, the 2030 level would be reached by 2034 or 2035. Under the medium price scenario, the 2030 level would be reached by 2031 to 2033.

Figure 4-6 Projected Emissions Through 2050 (50% reinvestment)

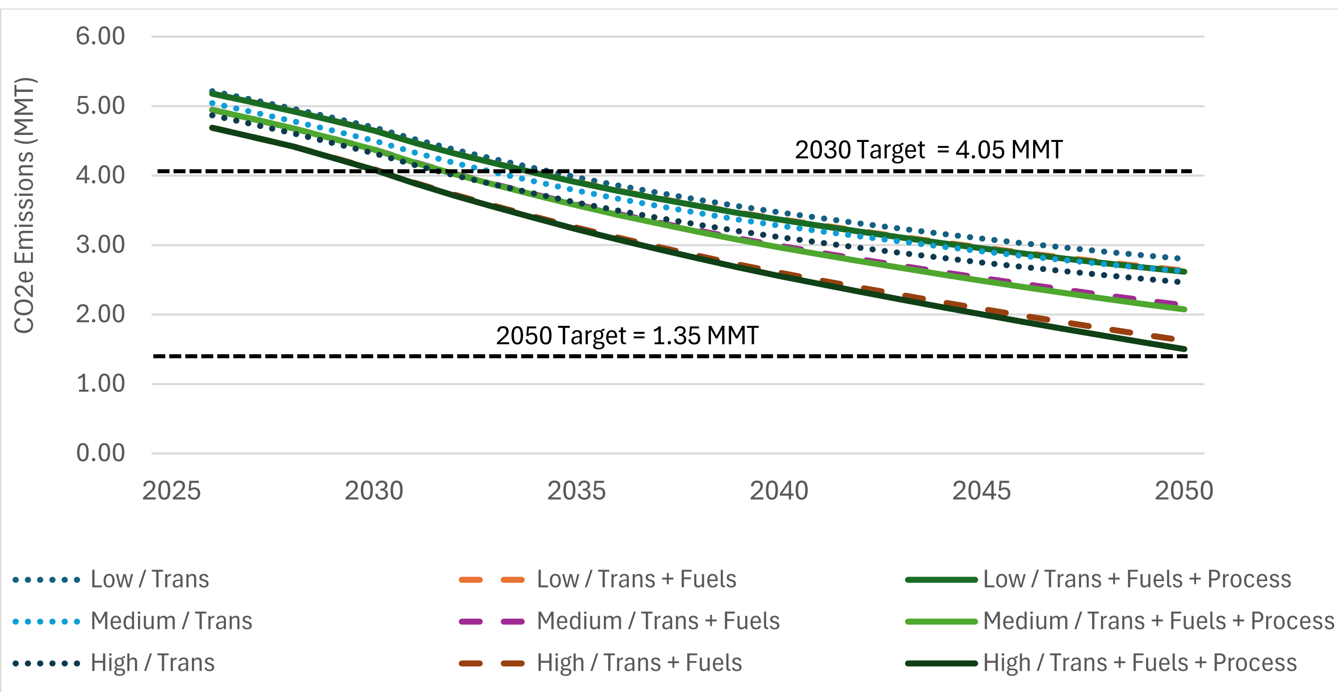


Figure 4-7 shows projected GHG emissions in 2049 (to compare with 2050 required levels based on calendar year 2049 emissions) with 50 percent reinvestment, and compares those to the reference or baseline projection and the GWSA required level. The gap could be mostly but not fully closed under the high price scenario with full sectoral coverage. Figure 4-8 shows projected emissions under full reinvestment. In that case the gap could be fully closed under the high price scenario with coverage of at least the transportation and thermal sectors.

Figure 4-7 GHG Emissions in 2049, 50% Reinvestment

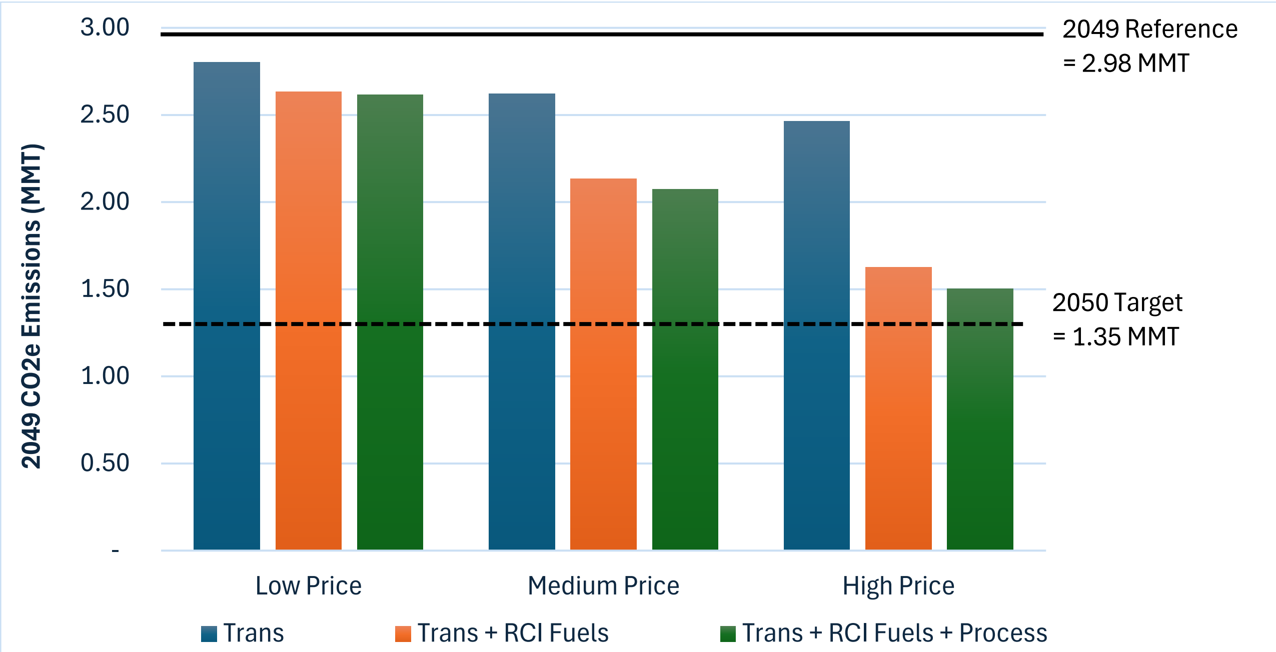


Figure 4-8 GHG Emissions in 2049, Full Reinvestment

4.2.2 Revenue Generation

Methods and Assumptions

The gross revenue generated from auction proceeds was estimated for each scenario by multiplying the estimated covered emissions in each scenario by the allowance price per ton of emissions for that scenario.

Findings

Table 4-4 shows the estimated proceeds in 2030 under the various scenarios. Values are shown in millions of 2024 dollars. Coverage of residential and commercial fuels would increase revenue by about two-thirds, with coverage of industrial process emissions adding incrementally.

Table 4-4 Estimated 2030 Auction Proceeds by Scenario (2024 $M)

Scenario	Transportation	Transportation + Thermal	Transportation + Thermal + Process
Low Price	$ 32	$ 54	$ 59
Medium Price	$ 94	$ 157	$ 175
High Price	$ 177	$ 299	$ 336

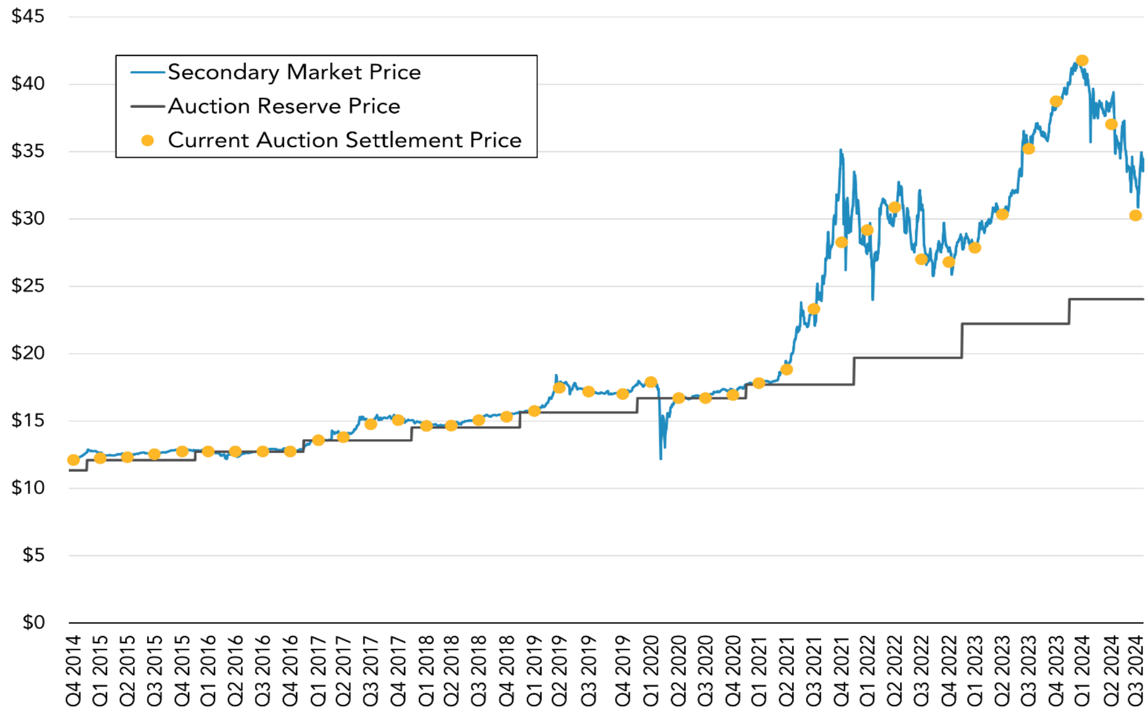
4.2.3 Allowance Price

Methods and Assumptions

We assume that Vermont will be a “price-taker” when joining another cap-and-invest program, i.e., the allowance price will be determined by the broader market of the participating entities and Vermont will have no measurable influence on the price regardless of Vermont’s choice on sectoral coverage and allowance supply. (For comparison, Vermont’s population is about 3 percent of New York State’s population, and less than 2 percent of the population of the current WCI participating jurisdictions.) Prices will be subject to the cap established under either program.

A price history is available for WCI; prices started in the range of $10 to $15 per ton and are currently in the range of $30 to $35 per metric ton of CO_2e emissions (Figure 4-9), with a November 2024 auction clearing price of $31.91. WCI has set a price cap of $88 per ton in 2024, increasing at 5 percent + inflation each year. Future WCI prices could range anywhere between the auction reserve price (the lowest possible price) and the price cap. The November 2024 WCI auction clearing price was $31.91. The NYCI program has not yet been finalized and therefore a price cap and history are not available. However, it is likely that the price cap will be much lower than the WCI price cap. New York agencies evaluated three price ceiling cases in their preliminary analyses, all of which were binding and caused emissions to exceed the modeled cap.

Figure 4-9 Western Climate Initiative Price History



Source: California Air Resources Board (2024). Cap-and-Trade Program Data Dashboard. Accessed November 2024.

Findings

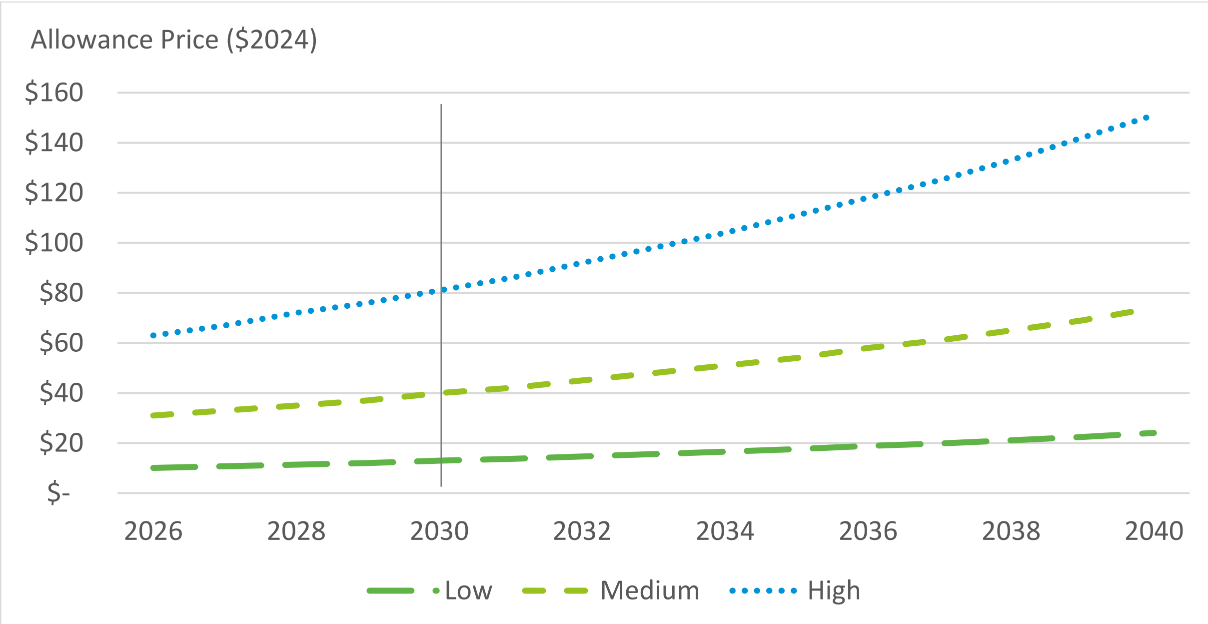
Because of the uncertainty in future price trajectories under either program, it would be inappropriate and potentially misleading to assign a specific price trajectory to a particular program. Instead, the analysis considers a range of potential future allowance prices, and the results illustrate how those different price trajectories could affect potential outcomes for Vermont. Once NYCI rules have been finalized, there will be a better understanding of what the range of prices might look like under either program option.

Three illustrative price trajectories were modeled:

- **Low** – approximately **$13 per ton** in 2030 – lower than any published scenarios for NYCI or WCI. This price reflects a starting price similar to the WCI program's year one price, with a 5 percent annual increase. This price path is more likely to be associated with the NYCI program depending on the details in the final rule and is well below the WCI price floor.
- **Medium** - approximately **$40 per ton** in 2030 – consistent with a mid-range projection and recent price trends for WCI, and in the range of previously published NYCI scenarios.
- **High** - approximately **$80 per ton** in 2030 – consistent with a high projection for WCI (approaching the price ceiling), and likely exceeding the NYCI ceiling and outside the range of that program.

Figure 4-10 illustrates the modeled price trajectories. In reality, prices are likely to be volatile rather than smooth, unless the program price ceiling is low enough that the price simply follows the ceiling. Otherwise, prices will fluctuate depending on factors such as economic output, consumer demand, emissions intensity of this output and demand, relative costs of different technologies, and relative market prices of different energy sources.

Figure 4-10 Modeled Price Trajectories



4.2.4 Change in Fuel/energy Cost

Methods and Assumptions

Changes in the cost per gallon of fossil fuels, including gasoline, diesel, and home heating oil, are estimated by assuming that the allowance price is directly passed on to consumers. The change in price per gallon is therefore a direct function of the carbon content of the fuel and the allowance price. U.S. EPA provides the following emission factors measured in kilograms (kg) of carbon dioxide (CO_2) per gallon: gasoline = 8.78; diesel and home heating oil (#2 distillate) – 10.21; ethanol - 5.75.[11] With a 10 percent ethanol blend in gasoline, this equates to 0.0085 metric tons CO_2 per gallon of gasoline, or $0.0085 per $1 change in allowance price; and 0.0102 metric tons per gallon of diesel or home heating oil, or $0.0121 per $1 change. In round numbers, $1 per ton of CO_2 equates to approximately 1 cent per gallon.

It is possible that fuel suppliers may absorb some of the added costs, in which case the cost impact to end-users (residents and businesses) would be lower than shown. However, while difficult to verify, it is assumed that fuel suppliers elect to pass the cost of cap-and-trade on to consumers in full.[12]

Findings

Table 4-5 shows the change in cost per gallon of fossil fuel under the various scenarios, assuming a 100 percent pass-through of allowance prices to consumers. Values are shown in 2024 dollars per gallon.

[11] U.S. EPA (2024). GHG Emission Factors Hub.

[12] ICF (2017). Post-2020 Carbon Constraints: Modeling LCFS and Cap-and-Trade.

Table 4-5 Estimated Fossil Fuel Price Effects in 2030

Scenario	Motor Gasoline	Motor Diesel & Home Heating Oil[a]
Low Price	$0.11	$0.13
Medium Price	$0.34	$0.41
High Price	$0.69	$0.83

[a] Price effects for home heating oil are only for the scenarios including residential and commercial sector coverage.

The most recent (August 2024) WCI auction settlement price was $30.24 per ton, which equates to $0.26 per gallon gasoline and $0.31 per gallon diesel. NYCI allowance prices are not currently available as the program has not been initiated and no auctions have taken place.

4.2.5 Macroeconomic Effects

Methods and Assumptions

Macroeconomic effects – describing the size of the state's economy – are evaluated in this study using the metric of new jobs created per year. (Other common metrics include gross state product and total personal income.) The estimates for this study are based on analysis conducted in 2020 by Cambridge Systematics for the Transportation and Climate Initiative (TCI). That analysis used the Regional Economic Models, Inc. (REMI) model, a dynamic model that is one of the leading models used for economic policy analysis. Inputs considered changes in costs to consumers, businesses, and government, in a variety of categories such as vehicle expenditures, fuel expenditures, other operating costs, consumer spending on other items, and government investments. The TCI analysis accounted for the effects of increased prices to consumers and businesses as well as reinvestment that was returned to businesses and consumers in the form of incentives or lowered costs. These effects considered incentives for electric or zero-emissions vehicles as well as investments to encourage shifts from car and truck travel to less emissions-intensive modes such as transit, active transportation, and freight rail, or to otherwise reduce vehicle-travel and associated emissions.

State-specific results from the TCI analysis were identified for Vermont for different cap and reinvestment scenarios, and compared with the average annual auction proceeds that Vermont would be estimated to receive. The approximate impact ranged from **2.8 to 6.9 net new jobs in 2032 per annual million dollars in revenue** for the 2022 through 2032 period. The midpoint of that range, 4.9 new jobs per annual million dollars, was selected to estimate the potential job impacts in 2030.

This illustrative analysis applies transportation sector results from the TCI analysis. The job impacts per price level or reinvestment level in other sectors (residential, commercial, industrial) would not necessarily be the same as for transportation. However, the TCI results are taken as illustrative of the magnitude and direction of macroeconomic effects that might be observed from a cross-sectoral program of investments. There are many similarities in how a cap-and-invest program would affect the transportation and residential/commercial thermal sectors. For example:

- Buyers of more efficient equipment (e.g., electric vehicles, heat pumps) would receive rebates or loans that offset higher up-front costs on that equipment, and/or invest in such equipment with the expectation of saving fuel costs over time.

- Households and businesses might have increased options that allow them to reduce their consumption of fossil fuels while achieving other benefits – such as multi-modal transportation options that reduce the need for driving, and access to weatherization programs that make homes more comfortable while also reducing energy costs.
- Households and businesses that still use fossil fuels would pay slightly higher prices for those fuels, which also might lead them to reduce consumption by a modest amount.
- To the extent that households and businesses realize net savings in energy costs, they will have more money to spend on other items or invest in production – money that will flow back into Vermont's economy.

Findings

The cap-and-invest scenarios evaluated here would result in between 80 and 810 net new annual jobs, which ranges up to 0.2 percent of the total state labor force depending upon the scenario.[13] Table 4-6 shows the estimated number of net new jobs that would be created in 2030 under the various scenarios.

Table 4-6 Macroeconomic Impacts: Estimated Change in Vermont Jobs in 2030

Scenario	Transportation	Transportation + Thermal	Transportation + Thermal + Process
Low Price	80	130	140
Medium Price	220	380	420
High Price	420	720	810

The TCI analysis found that most sectors of the economy would experience a net increase in jobs as a result of cap-and-invest for transportation. However, some sectors might see small decreases in jobs as a result of changes in how consumers spend money – for example, if they spend more money on electricity and vehicle purchases but less money at gas stations and auto repair facilities.

4.2.6 Household Benefits and Costs

Methods and Assumptions

An emissions cap-and-invest program will offer both financial benefits and financial costs to Vermonters. Benefits may include direct subsidies from the program's investments (subsidies for home heating, building efficiency, and electric vehicles), rebates or dividends, and reduced energy expenditure from electrification, Costs may include increased energy expenditure for households that are unable to electrify. We used RFF's Incidence Model to examine the way that the overall benefits and costs of the program may fall across households of different income levels and in different parts of the state. We looked at 2030 as a representative year, considering a program that starts in 2027 with reinvestment of proceeds and/or return of dividends beginning in 2028.

[13] The Bureau of Labor Statistics reports 357,400 civilian jobs in Vermont as of November 2024.

RFF's incidence model uses survey and administrative data to determine the share of total expenditures on key goods and services (transportation fuel, home heating, electricity, food, etc.) that belong to households of different income groups and regions. Fuel expenditure changes (gasoline, heating oil, natural gas) from the carbon price and investment analysis were shared out to Vermont households proportional to their original share of expenditures on those goods. Electricity expenditure changes were shared out proportional to households' original expenditure on heating fuel, because all increased electricity spending in the investment analysis was due to electrification of home heating. Vehicle maintenance savings from reduced vehicle-miles traveled were shared proportional to households' original expenditure on vehicle maintenance. Subsidies for electric vehicles, home heating equipment, and housing energy efficiency were shared out to the lowest three income quintiles proportional to their original expenditures on those goods, representing income-targeted subsidies. Dividends (labeled as "rebates") were offered to households in the lowest three income quintiles as per household lump-sum dividends, representing an income-targeted dividend.[14]

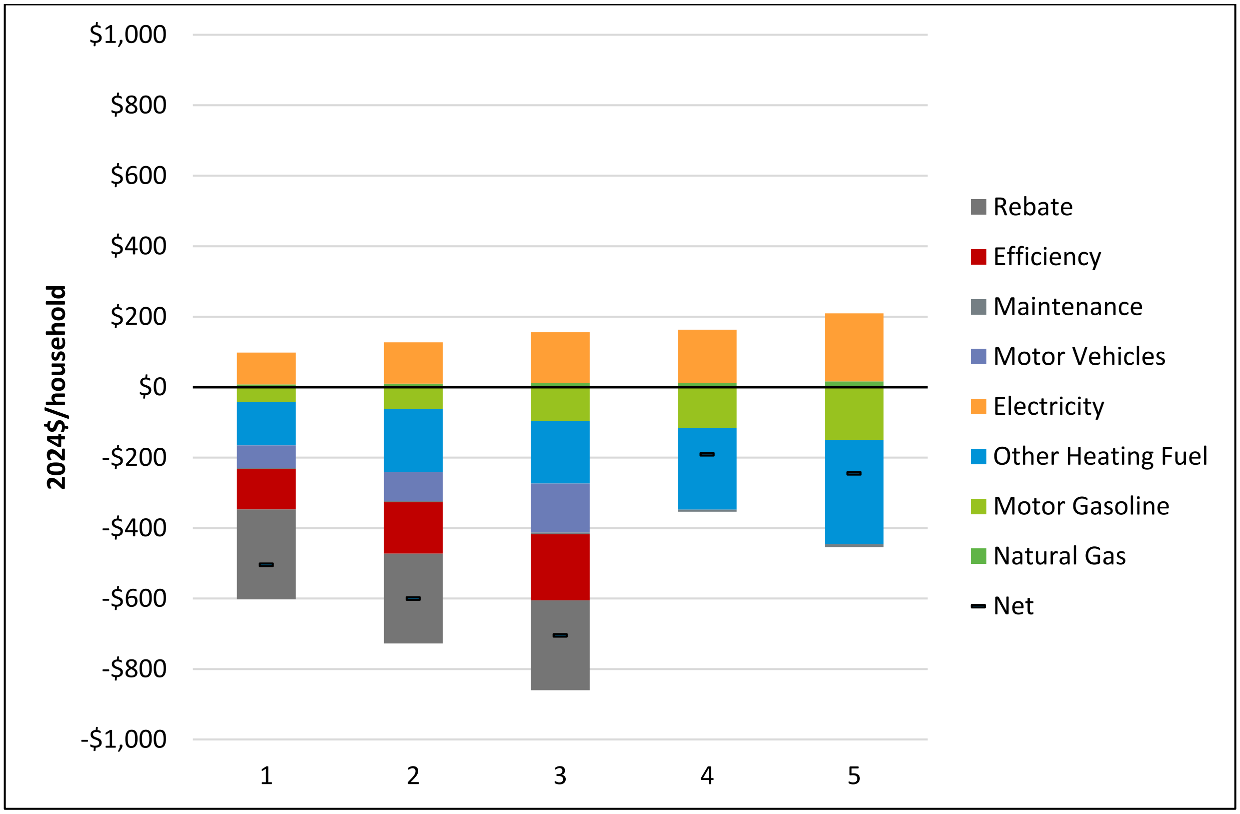
The financial impact on households will vary according to how able a household is to adjust its consumption of fossil fuels in response to the carbon price and whether it receives subsidies. We present results for average households that *do* adjust their fuel expenditure both in response to the carbon price and the subsidies and for average households that *do not* adjust their fuel expenditures in response to the carbon price and subsidies. These can serve as partial bookends of the effects of the policy.

[14] The lowest household income quintile represents households with the lowest 20 percent of incomes; quintile 2 represents the next 20 percent of households; etc., until quintile 5 represents the highest-earning 20 percent of households.

Findings

When households adjust their energy expenditures (reduce fossil fuel expenditures and increase electricity expenditures) in response to the carbon price, households have lower energy expenditures on average across income quintiles and counties than prior to the policy. While some spend more on fossil fuels, some also reduce consumption of those fuels to varying degrees and all receive dividends; the net effect is a decrease in average expenditures. Including subsidies and dividends directed to the bottom three income quintiles, the average households in the bottom three income quintiles are left financially better off overall than prior to the policy, saving between $500 and $700 per year on average (Figure 4-11).

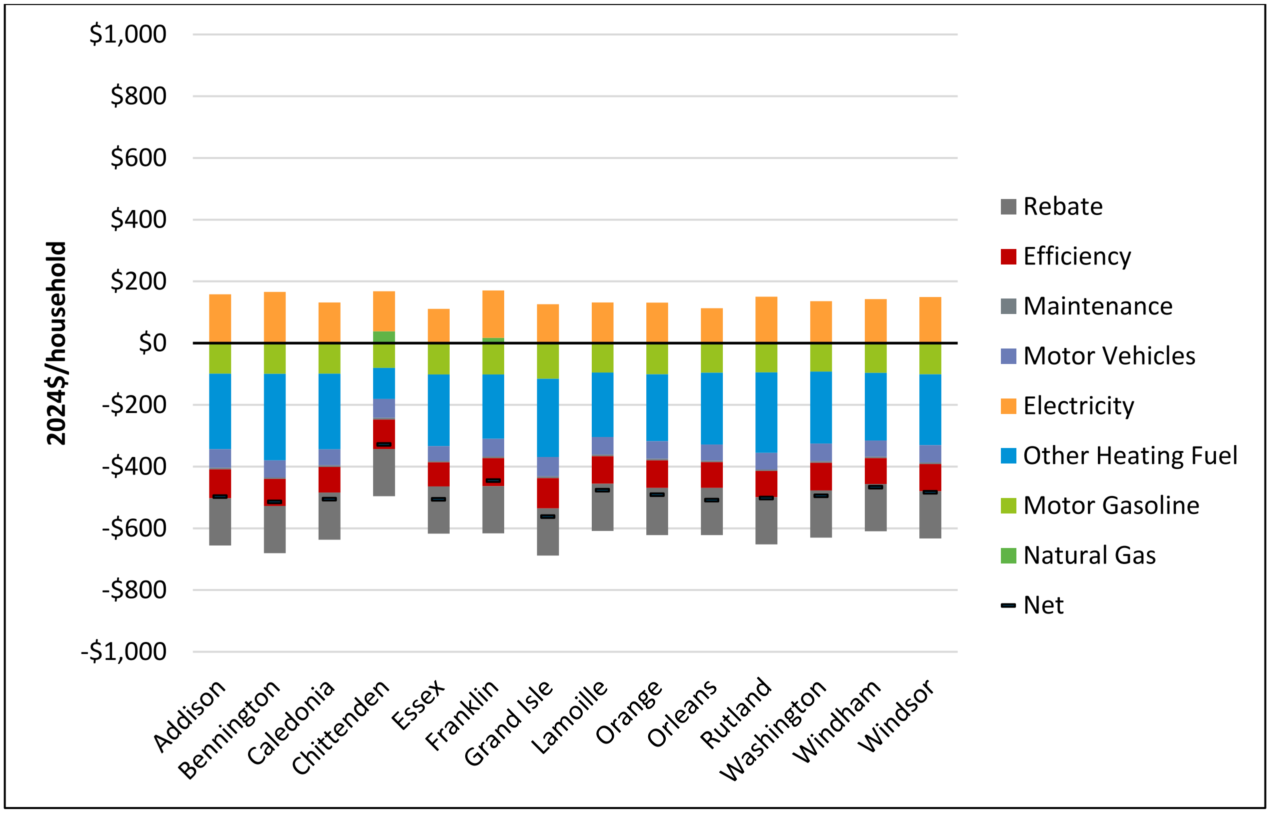
Figure 4-11 Household Expenditure Change by Income Quintile



Note: Figure shows results in 2030 with 50 percent reinvestment of proceeds in emissions-reducing activities; medium price scenario; coverage of transportation + thermal sectors; targeting of rebates and incentives to lower three income quintiles. Individual households will see different cost changes depending upon their specific fuel mix and consumption level.

The average net changes in expenditures are generally consistent across Vermont counties (Figure 4-12). There is slightly less average change in Chittenden County than other counties. This is because we assumed only households with existing oil furnaces are targeted for rebates/incentives, while there is a higher prevalence of natural gas-using household in Chittenden County as compared to many counties which have no gas service. Natural gas is currently much cheaper and also less carbon-intensive than heating oil, so replacing oil furnaces represents the more cost-effective approach to reducing residential thermal emissions at this time.

Figure 4-12 Household Expenditure Change by County



Note: Figure shows results in 2030 with 50 percent reinvestment of proceeds in emissions-reducing activities; medium price scenario; coverage of transportation + thermal sectors. Individual households will see different cost changes depending upon their specific fuel mix and consumption level.

Not every household will be able to adjust their fuel expenditures or will receive subsidies, especially in the early years of the program. Such households will see their energy expenditures rise as a result of a policy. An income targeted subsidy (such as a tax refund or utility bill rebate) can partially insulate households like these from financial costs. Figure 4-13 shows an example in which households in the lower three income quintiles (i.e., the lower 60 percent of Vermont's total households) receive such refunds or rebates. These three quintiles would experience a nearly neutral effect for the lowest two income quintiles, and less than $200 per year net cost for the middle income quintile. Figure 4-14 shows that the change would be relatively similar across counties, with less overall effect in Chittenden County.

Figure 4-13 Expenditure Change with No Adjustments to Fuel Use and With Targeted Subsidies, by Income Quintile

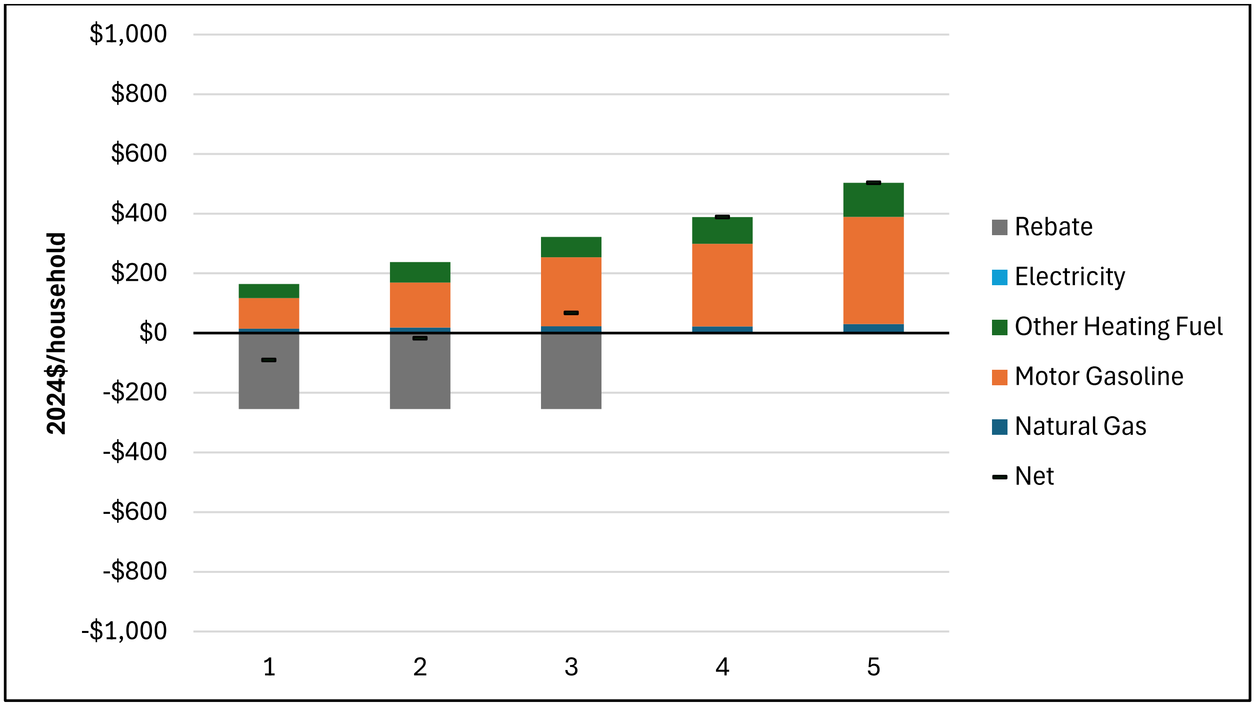
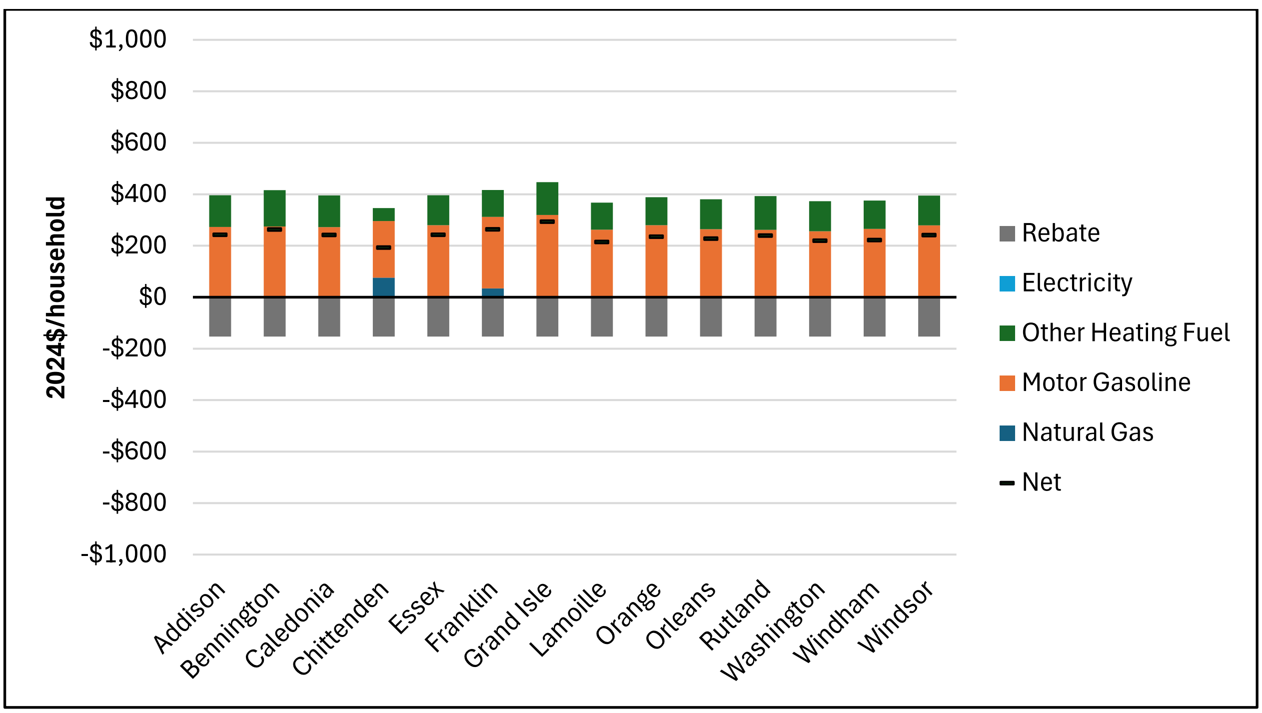


Figure 4-14 Expenditure Change with No Adjustments to Fuel Use, by County



Note: Figures show results in 2030 with 50 percent reinvestment of proceeds in emissions-reducing activities; medium price scenario; coverage of transportation + thermal sectors; targeting of rebates and incentives to lowest three income quintiles. The figures show averages across all households. Individual households will see different cost changes depending upon their specific fuel mix and consumption level.

A representative household analysis was also conducted to consider how households might take advantage of incentives and the financial implications of doing so. This analysis looked at two examples:

- A household replacing an end-of-life oil furnace with a heat pump; and
- A household replacing an oil furnace with 10 years remaining life with a heat pump.

Key assumptions are shown in Table 4-7. Figure 4-15 and Figure 4-16 show the results. For the end-of-life replacement, the heat pump costs approximately $8,000 more than a new oil furnace, which can be reduced to a $6,000 difference with the current rebate. Within three to four years, the annual energy cost savings pay for the initial investment. In the case of replacing an oil furnace that still has remaining life, the initial investment (without a rebate) is $13,500, which pays for itself after seven to eight years in fuel cost savings. This is a simple example used for illustrative purposes; many Vermonters use multiple heat sources, such as electricity, oil, and/or wood, in combination.

Table 4-7 Key Assumptions for Illustrative Household Analysis

Parameter	Value	Source
New heat pump	$13,500	Energy Solutions. Heat Pump Cost Analysis: Key Takeaways. Presentation by Kyle Booth. Note – costs will vary depending on size of house, existing ductwork, and other installation factors such the need for electrical service upgrades.
New oil furnace	$5,700	Energy Solutions, https://www.forbes.com/home-improvement/hvac/oil-furnace-cost/
Heat pump rebate	$2,000	Efficiency Vermont currently offers $1,000 to $2,000 for ducted heat pumps
Home heating fuel $/gal (2030)	$4.81	U.S. DOE Annual Energy Outlook (AEO) 2023 national price forecasts scaled to VT using U.S. DOE State Energy Data System (SEDS) 2023
Residential Electricity $/kWh (2030)	$0.19	AEO 2023 national price forecasts scaled to VT using SEDS 2023
Annual home heating oil consumption (gal)	764	Based on Vermont Comprehensive Energy Plan (2022) – lower end of range assumes weatherization as prerequisite
Heat pump EER	3.0	Bernard, L. et al (2024); Vermont Department of Public Service

Figure 4-15 Illustrative Household Cashflow – Heat Pump Replaces End-of-Life Oil Furnace

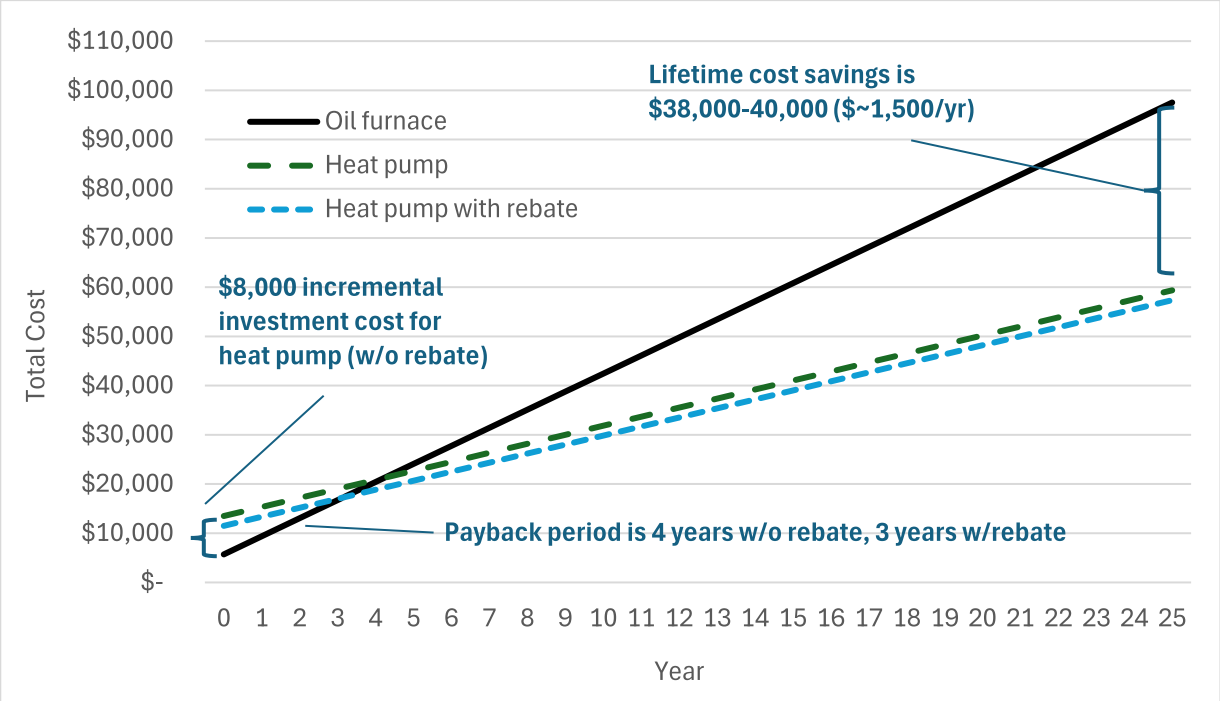
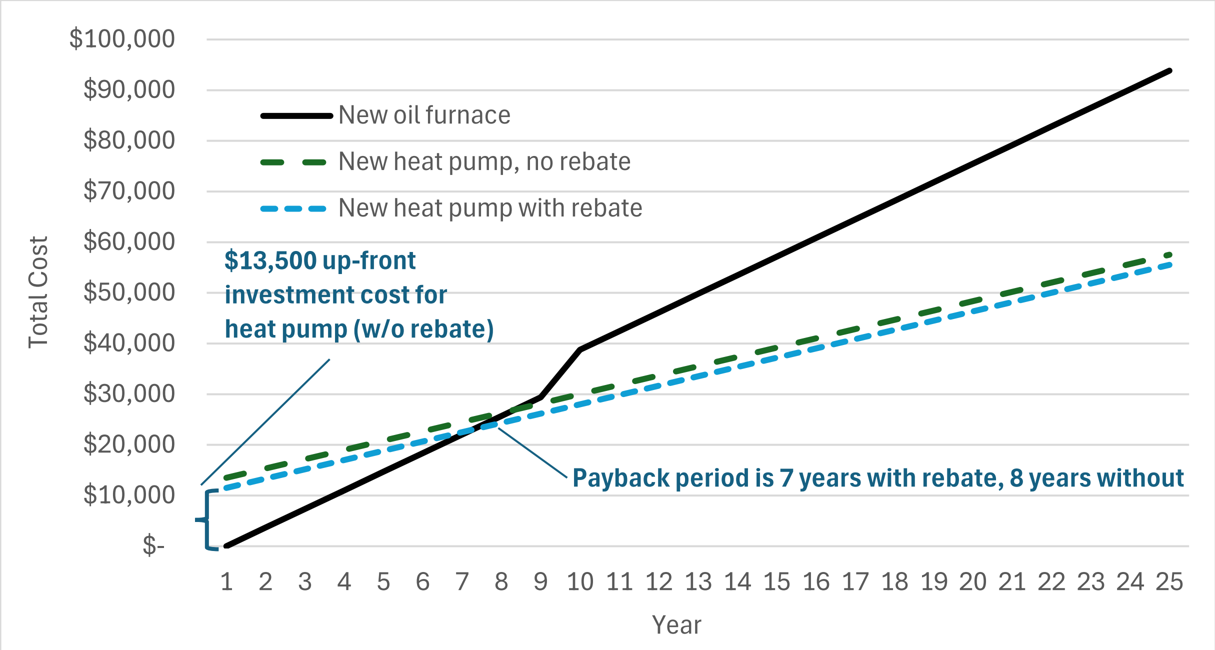


Figure 4-16 Illustrative Household Cashflow – Heat Pump Replaces Oil Furnace with 10 Years Remaining Life



The initial cost gap, even for a furnace that needs to be replaced, could discourage many households from purchasing a heat pump despite the long-term energy cost savings. Households have the following options for covering the additional cost:

- Households with sufficient cash available can front the cost.
- Low- or zero-interest loans could be made available that are paid back over time in energy savings.
- A rebate can narrow or close the gap.

The State will need to ensure that some combination of loans and/or rebates are available to help make heat pumps financially viable for all Vermonters, not just wealthier households.

4.2.7 Social Cost (Value) of Carbon Reductions

Methods and Assumptions

The social cost of carbon is an estimate of the economic damages over a period of time in a defined geographical area associated with a small increase in carbon dioxide emissions, conventionally one metric ton, in a given year. Those economic damages include changes in agricultural productivity, human health, property damages, and changes in energy system costs. The social cost or value of carbon emission reductions was estimated by multiplying the estimated emission reductions by a social cost per ton of carbon emitted. Vermont has chosen to use a social cost of carbon aligned with the U.S. Environmental Protection Agency's (EPA) November 2023 estimates for a regulatory impact assessment assessing global damages at a near-term discount rate of 2 percent, as recommended by the Vermont Climate Council Science & Data Subcommittee.[15] The 2030 value is $230 per ton of CO_2 in 2020 dollars, which is equivalent to $275 per ton in 2024 dollars.[16]

Findings

Table 4-8 shows the estimated social benefits of the carbon emissions reduction under the various scenarios in 2030. These benefits include the benefits associated with reinvestment as well as the price effects of the program, using the 50 percent reinvestment scenario as illustrative. Benefits at other levels of reinvestment will be proportionately lower or higher. Values are shown in millions of 2024 dollars.

Table 4-8 Estimated Social Benefits of Carbon Emissions Reduction in 2030 (2024 $M)

Scenario	Transportation	Transportation + Thermal	Transportation + Thermal + Process
Low Price	$38	$50	$50
Medium Price	$90	$125	$126
High Price	$140	$203	$205

[15] "Science & Data Subcommittee recommendations re: Updates to the Social Cost of Greenhouse Gases." Memorandum from Science & Data Subcommittee to Vermont Climate Council, August 9, 2024.

[16] U.S. EPA (2023). EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances. Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review". EPA-HQ-OAR-2021-0317. Adjustment of 2020 to 2024 dollars made using the U.S. Bureau of Labor Statistics CPI Inflation Calculator.

4.2.8 Health Benefits

Methods and Assumptions

Strategies to reduce greenhouse gas emissions, such as electric vehicles, will help to reduce emissions of other harmful air pollutants, thereby benefiting public health. Trucks and buses contribute disproportionately to other harmful air pollution, especially fine particulate matter ($PM_{2.5}$) and nitrogen oxides (NO_x). These pollutants can cause or exacerbate asthma, lung disease, heart disease, and other respiratory and cardiovascular problems. Vehicle operators and yard and maintenance workers will especially benefit from reduced exposure to workplace air pollution from trucks and buses.

Reinvestments in active transportation options also provide further benefits by increasing physical activity as people walk and bike more. A 2019 assessment by the Vermont Department of Health found that two out of five Vermont adults do not get enough physical activity. Physical inactivity increases the risk for chronic diseases like heart disease, diabetes, stroke, and dementia, which cause 40 percent of all deaths in Vermont. Meeting the transportation goals in Vermont's Comprehensive Energy Plan could save 2,000 lives and $1.1 billion in avoided costs by 2050.[17]

The public health benefits of cap-and-invest for transportation were evaluated for the TCI region in the Transportation, Equity, Climate and Health (TRECH) Project.[18] This study provides results for the state of Vermont as well as the entire region. The study considered the physical activity and air pollution health benefits of transportation emission reductions and reinvestments. The study was based on a mix of emission-reducing activities including vehicle electrification and VMT reduction strategies, all of which would reduce other air pollutant emissions. The VMT reduction strategies included active transportation investments (biking, walking, and transit) that would increase physical activity. Benefits from the TRECH study are shown in Table 4-9. These are for the "25 percent reduction cap" scenario in that study, the most ambitious scenario, and were scaled per MMT of carbon reduction by the project study team based on emissions levels for the different scenarios as published by the Georgetown Climate Center.[19] The "low" and "high" estimates provide a range for different investment scenarios.

Table 4-9 Health Benefits in Vermont for TCI Cap-and-Invest

Benefit Metric	Low	High	Average	Average Benefits per MMT CO_2e
Deaths avoided - physical activity	2.2	3.4	2.8	19
Deaths avoided - air pollution	4	4	4	27
Asthma avoided (age 0-18)	35	44	40	266

[17] Vermont Department of Public Health (2019). "Improving Health Through Transportation."

[18] Harvard School of Public Health. TRECH Project Research Update Preliminary Results – February 2021; TRECH Project Technical Appendix, October 6, 2020.

[19] Georgetown Climate Center. "Modeling Methods and Results from TCI Regional Policy Design Process." Accessed September 2024.

The health benefits from covering the transportation sector were scaled for this study based on average benefits per ton of transportation CO_2e reduced, using CO_2e reductions as a proxy for air pollution reductions and investment in active transportation. The benefits will vary depending upon how Vermont chooses to use its auction proceeds, as different types of reinvestment will result in different levels of health effects of dollar spent.

Residential and commercial sector clean energy and efficiency investments can also have health benefits. Household combustion appliances, such as unvented gas stoves, heaters, furnaces, and wood-burners, are the primary sources of these home contaminants. Health effects can include carbon monoxide poisoning, decreased lung function, cardiovascular disease, and a variety of other problems.[20] A recent study estimated that gas stoves are responsible for 13 percent of childhood asthma nationwide[21] – pointing to the benefits of replacing gas with electric appliances (such as induction stoves) that can use electricity generated by renewable sources and do not emit air pollution. Installing a whole-house mechanical heating, ventilation, and air conditioning (HVAC) system – such as a heat pump – can reduce the moisture and humidity in a home, which in turn, reduces dust mite numbers and decreases allergen levels.[22]

Weatherization can affect indoor air quality in positive or negative ways. Findings from a literature review on indoor air quality after energy efficiency retrofits found that indoor radon and formaldehyde concentrations tended to increase after retrofits that did not add whole-house mechanical ventilation. Additionally, the materials added to homes during retrofits, such as sealants and insulation, can be sources of indoor air pollutants.[23] On the other hand, weatherization work can remove moldy objects from the home and repair moisture intrusion points that lead to mold, and this work often includes repairing and improving home HVAC systems.[24] Modern weatherization programs typically ensure that ventilation is maintained or improved at the same time as the building is sealed against heat loss.

Limited data are available to quantify the benefits of residential and commercial emissions-reducing investments that might be made under a cap-and-invest system in Vermont. The transportation benefits from the TRECH study would not necessarily scale to other sectors, since the health benefits per unit of emissions will vary depending upon population proximity and exposure to air pollution sources, and physical activity benefits from active transportation investment do not have a similar analogy in the RCI sectors. Therefore, only benefits for transportation sector coverage are shown in this study.

Findings

Table 4-10 shows illustrative health effects as measured in terms of avoided deaths, avoided asthma cases, and the monetary value of those effects from the transportation-sector emission reductions projected in this study under the 50 percent reinvestment scenario.

[20] Green and Healthy Homes Initiative. Weatherization and its Impact on Occupant Health Outcomes.

[21] Gruenwald, T., et al (2023). "Population Attributable Fraction of Gas Stoves and Childhood Asthma in the United States." *Int. J. Environ. Res. Public Health* 2023, *20*(1), 75; https://doi.org/10.3390/ijerph20010075

[22] Warner, J., et al .(2000). "Mechanical ventilation and high-efficiency vacuum cleaning: A combined strategy of mite and mite allergen reduction in the control of mite-sensitive asthma." *Journal of Allergy and Clinical Immunology* 105, no. 1 (2000): 75-82.

[23] Fisk, W.; B. Singer and W. Chan (2020). "Association of residential energy efficiency retrofits with indoor environmental quality, comfort, and health: A review of empirical data." *Building and Environment* August 2020, 107067.

[24] Green and Healthy Homes Initiative *(ibid)*.

Table 4-10 Estimated Value of Health Benefits in 2030 (Transportation Sector)

Scenario	Deaths avoided - physical activity	Deaths avoided - air pollution	Asthma avoided (age 0-18)	Value of health benefits (2024 $M)
Low Price	3	4	36	$50
Medium Price	3	5	48	$66
High Price	3	5	48	$66

4.2.9 Potential for Leakage

Methods and Assumptions

“Leakage” refers to a situation in which emission reductions in Vermont are offset by increases elsewhere; for example, if an industry or another polluting or source or activity simply moves some of that activity to another state instead of reducing net emissions. For this study, a qualitative assessment of potential leakage effects was conducted, based on a combination of quantitative data and experience from other programs. The study also considers program design approaches to mitigate potential leakage.

Findings

The industrial sector may have the highest risk of leakage if directly regulated. However, mitigation can be considered in program design by allocating free allowances to emissions intensive trade exposed industries (EITE) rather than auctioning them to these industries. EITEs are identified based on their imports and exports as a share of total shipments. The Western Climate Initiative allocates allowances to EITE industrial emitters in proportion to their output, benchmarked to 90 to 100 percent of that industry’s average emissions per unit of output.[25] This eliminates any incentive to shut down or reduce production (which could hurt the state’s economy) by allocating allowances based on historical emissions.

In the transportation sector, there may be cross-border effects if vehicle drivers (residents and visitors) choose to buy gas in neighboring states rather than Vermont. However, we anticipate that these effects would be incremental, and further mitigated if New York is also in a cap-and-invest program. Other sources of leakage could include renewable fuel blending being diverted in Vermont to reduce the amount of covered fuel, rather than a net increase in renewable fuel production.

In the residential and commercial sector, leakage could come in the form of households and/or businesses choosing to locate in other states as a result of higher (fossil fuel) energy costs. However, depending on program design, households could also receive benefits through rebates or refunds that would, overall, offset a portion if not all of those higher costs (see Section 4.2.6), and could be perceived as beneficial by many households.

Concern was also raised in the stakeholder outreach conducted for this study about the potential for suppliers of heating oil and other fuels to “tank up” in a neighboring state where fuels are not subject to the carbon cap, and deliver this fuel in Vermont, since delivery routes sometimes cross state borders. However,

[25] California Air Resources Board. Allowance Allocation; International Carbon Action Partnership. Canada - Québec Cap-and-Trade System.

this is primarily an enforcement issue, as fuel suppliers are already required to report all fuel sales to the Department of Taxes.

It is possible that as part of a multi-jurisdiction cap-and-invest program, relatively more emission reductions might take place in other states with relatively lower reductions in Vermont. However, our analysis of state-specific price elasticities (i.e. the degree to which people change their consumption in response to a change in price) suggests that responses to price effects in Vermont will be fairly similar to other states considered, including California, New York, and Washington. Therefore, relative levels of emission reductions might be similar in Vermont to other states that may be joined in a program.

4.2.10 Implementation Costs

Methods and Assumptions

A cap-and-invest program would require the State of Vermont to hire additional staff and/or contract work to administer the program, including establishing and updating regulations, allocating and auctioning emissions on a quarterly or annual basis, enforcing participation for obligated entities, distributing auction proceeds, and monitoring and reporting on prices, proceeds, emissions benefits, and other program outcomes.

To estimate other costs as measured in staff time and contracted resources, the study team collected data from Quebec and Washington State, as well as Vermont's existing Efficiency Vermont program. The team also evaluated program costs and fees for Western Climate Initiative, WCI, Inc., a nonprofit entity that administers the auctioning of allowances and collection of proceeds for WCI participants and others who choose to use its services. If Vermont were to join WCI it would use WCI, Inc's services. New York might also choose to make use of WCI's services even if it does not link programs with other WCI participants, or it might establish its own trading platform.

Obligated entities would also incur administrative costs associated with program compliance. At a minimum, these costs would include administrative time for reporting on fuel sales or emissions levels and purchasing necessary allowances. Entities that chose to reduce their emissions rather than buy allowances might incur additional costs to implement with those emissions-reducing activities (although they might also realize offsetting cost savings, for example, if activities such as investments in efficiency or renewable energy reduce their energy costs).

Findings

WCI, Inc. is fully funded by the jurisdictions that utilize the services it provides; costs are assigned based on a combination of jurisdiction-specific costs (e.g., onboarding) and the size of the jurisdiction's program as measured by its emissions cap. In 2023, WCI, Inc's program budget was $12.4 million to serve California and Quebec. If Vermont were to participate with a budget in proportion to its population (as a proxy for emissions) the cost to Vermont would be about $200,000; the actual cost would likely be somewhat higher due to the inclusion of fixed costs to serve another jurisdiction.

Quebec indicated that it has about 90 staff dedicated to the program, including 32 to manage its inventory and carbon market; 50 to manage implementation of proceeds; and 8 for other purposes. About 10 of these positions are estimated to be fixed regardless of the size of the program, with the remainder scaling based on the program size (emissions cap and proceeds). Assuming 10 fixed staff for Vermont and the rest scaling to Quebec in proportion to population, Vermont would require about 16 staff to administer the program. At an average loaded cost of $150,000 per staff position (salary, benefits, and other overhead) the additional cost to the state would be about $2.5 million annually conservatively assuming WCI fees of $300,000. This is equivalent to 2 to 3 percent of the program proceeds under the medium price scenario, which most closely corresponds to Quebec's current participation in WCI. If it is assumed that 10 staff are fixed and the remainder scale in proportion to program proceeds, the annual cost would be about $1.9 to $2.1 million under the low price scenario or $2.8 to $3.4 million under the high price scenario (with the higher cost representing higher sectoral coverage). This represents 4 to 6 percent of program costs for the low price scenario, or 1 to 2 percent for the high price scenario.

Information on administrative costs for Washington State was not available at the time of this writing. However, program requirements stipulate that set-asides for program administration cannot exceed 5 percent of total auction revenue.[26]

Vermont's Efficiency Vermont program provides one indication of what administrative costs might be to implement emission reduction programs. Over the 2021-2023 period this program reported a total of $14.1 million in administrative costs or about 8 percent of the overall program budget of $153 million.[27]

From these examples it can be concluded that administrative costs would likely be on the order of 5 percent of program proceeds, with up to 10 percent representing a probable upper bound. Under higher levels of proceeds (corresponding to a higher price), the share of proceeds devoted to administrative costs would likely decrease even though total administrative costs would increase, since some costs are fixed regardless of the scale of the program. With a lower price and lower proceeds, the share would likely be higher. Expanding sectoral coverage would likely increase administrative costs in rough proportion, although there might be some variation depending upon the number of regulated entities and the range of reinvestment programs administered in each sector. The reinvestment analysis in this study conservatively assumes that administrative costs would be up to 10 percent of program proceeds.

Available information was insufficient to quantify administrative costs to obligated entities.

4.2.11 Implementation Timeline

There are a number of challenges and uncertainties regarding the timeline for Vermont to start a cap-and-invest program. Given what is currently known, it seems likely that 2028 would be the earliest practical start year for the program, with full emission reduction benefits not being realized until 2030 or later.

- If Vermont identifies NYCI as the preferred program to join, New York State must still adopt rules for and implement its program. The timeline for this is uncertain. If New York State finalizes rules in early 2025 it could potentially launch its program in 2027 with Vermont potentially joining as early as 2027 or 2028; however, there is significant risk of a delayed start date.

- At this point, only the WCI program is established and running and joining the WCI program would pose less risk of schedule delays. However, WCI allowance prices could raise concerns related to household impacts, depending on the decisions that Vermont makes regarding reinvestment of auction proceeds; such concerns could potentially require additional deliberation to build in adequate safeguards to protect vulnerable households against fossil fuel price increases.

[26] Washington Department of Ecology. "Cap-and-invest auction revenue." Accessed December 2024.

[27] Efficiency Vermont (2024). Efficiency Vermont Savings Claim Summary 2023.

- The WCI participants (California and Quebec), or New York State, would need to approve Vermont's participation in their program. This may involve negotiating specific terms and conditions for Vermont's participation. The timeline for gaining these approvals is unknown.

- Given the current uncertainty surrounding the establishment of NYCI and the potential concerns related to household impacts as a result of current WCI allowance prices, one option would be for Vermont to start by only establishing reporting requirements. This would have the dual advantages of better positioning the State to implement a program a future point in time and also help regulated entities gain experience with reporting before they could be required to obtain allowances.

- if initiated, the auction process would raise a significant amount of money for reinvestment in emission reduction programs. It will take time to launch and scale up the reinvestment programs – staff will need to be hired and processes will need to be created for publicizing the availability of funds, reviewing applications, awarding funds, collecting performance data, and ensuring accountability. Workforce and supply chain constraints may also limit the rate at which funds can be spent and emissions reducing equipment implemented. Some emission reduction strategies, such as pedestrian and bicycle infrastructure, can take years to program and construct. As a result, it is likely that for a program starting in 2027, the full amount of emission reductions related to reinvestment may not be realized until well into 2029 or beyond. Correspondingly, a program starting in 2028 may not fully realize its benefits until well into 2030 or beyond. Since the 2029 calendar year is the year for which Vermont's GWSA 2030 emissions levels are to be measured, this calls in the question the ability of a cap-and-invest program (or any new program, for that matter) to achieve those required 2030 levels.[28] The program would still make significant progress towards reducing emissions later in the 2030s and ultimately meeting required levels for 2050.

[28] Price effects of the program could be realized more immediately, or even to some degree in anticipation of the program. However, while consumers and businesses might be able to make some immediate adjustments to their activities based on the higher price of fossil fuels (such as making some trips by non-driving modes or tele-travel), many of the changes that could be made to adapt to higher fuel prices (such as buying more efficient vehicles or equipment, or switching to lower-carbon fuel supplies) will take time to fully occur.

5.0 Low-Carbon Fuel Standard

5.1 Overview

A low-carbon fuel standard can work in tandem with cap-and-invest to achieve greater emission reductions and/or more certainty that target emission levels will be met. Generally, a cap-and-invest system requires obligated entities to reduce their overall emissions or pay for allowances to cover their emissions. An LCFS requires obligated entities to reduce the carbon *intensity* of their production. That means that a producer cannot lower their LCFS obligation simply by reducing production. This promotes fuel diversification, which can drive innovation and investments and support emissions reductions in hard to decarbonize sectors like transportation. Unlike a cap-and-invest, where revenue generated from the program can be spent by the state legislature in a variety of ways, an LCFS generates credits specifically for producers of low carbon fuels including biofuels and electricity used for transportation – providing revenue that these fuel producers can invest in production. California views its transportation LCFS as complementary to its cap-and-invest program, with the LCFS program providing focused incentives for innovation and investment in the transportation sector and the two programs in combination providing greater assurance that the state's overall emission reduction goals will be achieved.

5.2 Evaluation Criteria

5.2.1 Emission Reductions

Policymakers face a choice when establishing the carbon emissions intensity cap for fuels. Emission reductions from an LCFS will be proportional to this cap, with a lower cap leading to higher emission reductions. Vermont's baseline transportation sector carbon emissions are projected to be 2.4 MMT in 2030 (direct emissions only – not including upstream emissions associated with fuel production and distribution, much of which is likely to occur outside of Vermont). If an LCFS were introduced reducing the carbon intensity of transportation fuels by 10 percent from current levels, approximately 240,000 metric tons of CO_2e would be reduced in 2030. Since the carbon intensity limit is a fuel-cycle limit, some of these reductions might occur outside of Vermont's borders.

5.2.2 Revenue Generation

Similar to a cap-and-invest program, LCFS establishes a market through which fuel suppliers can buy and sell credits to achieve the overall lowest-cost means of meeting the state's carbon intensity benchmark. However, this market is internally revenue-neutral (after accounting for administrative costs) and does not create a pool of funds for the state to invest in emission-reducing activities or other equity-focused consumer benefits like a cap-and invest program would. Instead, it relies on the increased demand for low emitting fuels and technologies to incentivize private sector investments in those businesses that can deliver them at the lowest cost.

5.2.3 Social Cost (Value) of Carbon Reductions

The social cost or value of carbon emission reductions associated with an LCFS program would be proportional to any emissions benefits of that program above and beyond cap-and-invest emissions benefits, as discussed in Section 5.2.1.

5.2.4 Allowance Price

An LCFS would establish a market for carbon intensity credits, in which fuel suppliers must offset any emissions they generate over the set standard by purchasing LCFS credits. This market would be independent of the cap-and-invest allowance market. However, it is possible that an LCFS could reduce allowance prices under a cap-and-invest program by reducing the demand for carbon allowances from the transportation sector. By incentivizing fuel suppliers to transition to lower emissions-intensive fuels through a separate program, the emissions, and therefore demand for allowances, should be lowered. A California study found that a reduction of 3.14 MMT in transportation emissions in 2030 through a declining intensity standard could yield a reduced allowance price spread of $5 to $29 per ton by 2030.[29] Because Vermont is considering joining a larger program, the addition of an LCFS on the Vermont transportation sector is unlikely to drive broader market prices downward. It would, however, increase emission reductions in Vermont that might otherwise have been realized in other states.

5.2.5 Change in Fuel/Energy Cost

A main appeal of a tradable performance standard such as an LCFS is that it incentivizes investment in low carbon fuels. Unlike the cap-and-trade program, which collects revenues from allowances sales that can be distributed to various other uses by the state, proceeds from the purchase of LCFS credits go directly to sellers of low carbon fuels, lowering their costs. There may still be price effects to the degree that low-carbon fuels needed to meet the requirement are more expensive than traditional fuels, and for those who still rely on carbon intensive fuels and must cover the cost of purchasing LCFS credits. The California Air Resources Board notes that data from third party commodities markets experts show the current LCFS pass-through to California consumers is $0.10 per gallon of gasoline. However, they estimate that as consumers increase their use of low carbon intensity fuels and more efficient vehicles, fuel costs per mile will be reduced by 42 percent - translating to savings of over $20 billion in fuel expenditure every year by 2045. For light-duty vehicles (cars, pickup trucks, sport utility vehicles, vans, and minivans) these fuel cost savings will be even more pronounced, cutting costs to Californians in 2045 by more than 50 percent.[30]

A Washington State study examined the potential fuel price effects of adopting a low-carbon fuel standard in Washington. The study found that such a standard may increase the cost per unit for some fuels, but decrease the cost for others. The study estimated an initial increase of $0.17 to 0.19 per gallon of gasoline or diesel (or renewable blends) in 2031, with the increase declining after that as renewable diesel blending is no longer needed for compliance (due to increasing electrification) and Washington-produced renewable diesel can be fully exported to other markets. On the other hand, electricity prices would decrease since as a low-carbon fuel, credits for electricity would help fuel suppliers deliver energy within their overall carbon intensity limit.[31]

5.2.6 Macroeconomic Effects

The Washington State clean fuel cost-benefit report also considered direct and indirect changes in jobs expected as a result of changes in demand for different fuels from implementing an LCFS. For the 2023-

[29] ICF (2017). Post-2020 Carbon Constraints.

[30] LCFS Facts.pdf

[31] Washington Department of Ecology (2022). Clean Fuel Cost Benefit Analysis Report. Prepared by BRG Energy and Climate.

2032 period, the study estimated an annual loss of about 40 jobs in the petroleum sector. However, the electrification sector would gain over 60 jobs in 2023 increasing to over 100 jobs in 2032, for a net gain of 20 to over 70 jobs.[32]

Changing fuel prices could impact consumer purchasing power, which in turn could have secondary effects on employment. The Washington State clean fuel cost-benefit report noted that the impact of transportation fuel prices on employment is uncertain. Generally, the LCFS would tend to reduce household spending power available to consumers who own vehicles that consume gasoline and diesel, while increasing the spending power of consumers who drive vehicles that consume electricity or lower-carbon fuels.

5.2.7 Household Benefits and Costs

Households may face additional costs and receive new benefits from an LCFS program. Carbon-intensive fuels may become more expensive as suppliers trade credits to comply with the program, but to a smaller degree than the same carbon price ($/ton) that would be embodied in cap-and-invest. Over time, the availability of low carbon fuels is expected to expand and their cost to decline due to an LCFS. Unlike the cap-and-trade program, an LCFS program does not generate proceeds to be distributed directly to consumers in the form of dividends or rebates. Changes in household expenditures as a result of an LCFS would be driven by changes in consumption due to changing prices and different fuel blending practices.

5.2.8 Health Benefits

The health benefits from Vermont adopting an LCFS would be proportional to the incremental air pollution emission reductions achieved from the LCFS as a result of converting vehicles to electricity and other cleaner-burning fuels.

The Washington State clean fuel cost-benefit report modeled the health benefits of a collective suite of emissions reducing policies, including the state’s adopted Advanced Clean Car and Advanced Clean Truck standards (which Vermont has also adopted), but did not specifically distinguish the impacts of LCFS. The study found an estimated value of reduced mortality of $1.8 to $3.8 billion (2020 dollars) as a result of reduced $PM_{2.5}$ emissions, mostly from diesel trucks.

5.2.9 Potential for Leakage

Potential leakage effects from an LCFS might be expected to be similar to the effects of the cap-and-invest program – notably, if higher prices for fossil fuels cause businesses or consumers to purchase fuel in neighboring states or even move their place of business or residence. However, the positive price effects expected for low-carbon fuels, including electricity, should largely mitigate the negative effects of fossil fuel price increases.

5.2.10 Implementation Costs

Creating an LCFS program would create additional costs to the state to administer the system for tracking and managing the carbon intensity of fuels. Currently no neighboring state is pursuing a low-carbon fuel standard, although such a standard has been implemented by West Coast states. Absent a neighboring or regional partner to share the costs of program administration, establishment of a Vermont-only program

[32] Washington Department of Ecology, *ibid*.

would result in an increase in cost to compliance entities, and ultimately consumers, as compared to participation in a multi-jurisdictional program. Vermont could still leverage some resources from other states' LCFS programs, such as California's database of certified carbon intensities of fuels.

Fuel suppliers will also take on some implementation costs. With both a cap-and-invest and an LCFS in place, they would face two costs – the purchase of carbon allowances, and the purchase of LCFS credits.

5.2.11 Implementation Timeline

The implementation timelines for LCFS and cap-and-invest could be similar, and the programs would not need to be implemented simultaneously. Because an LCFS promotes fuel diversification and lowers compliance costs for a cap-and-invest program, it could be implemented prior to the cap-and-invest program. However, it would also be feasible to begin a cap-and-invest program first and implement LCFS later, as experience is gained with administration, reporting, and monitoring of the cap-and-invest program. There is no significant benefit to sequencing such that the development of one policy should be delayed to enable the prioritization of the other. An additional consideration is that no neighboring state is currently implementing an LCFS program; therefore Vermont would need to establish its own stand-alone program rather than joining with an existing program, likely requiring additional administrative time for program development.

6.0 Stakeholder Input

Public and stakeholder outreach was conducted in October 2024 to introduce the study, explain how a cap-and-invest program works, and solicit input on opportunities and concerns related to a cap-and-invest program for Vermont. The engagement events included:

- Two virtual public meetings held October 3, 2024.
- Three focus groups conducted with 1) potentially obligated entities – (November 7), 2) other Vermont businesses (November 18), and 3) environmental and community groups (November 21).

Summaries of the meetings and focus groups, as well as recordings and presentations for the public meeting, can be found here. A summary of input is provided below.

Potentially Obligated Entities and Other Businesses

In addition to project team and Technical Advisory Committee members, the "potentially obligated entities" focus group included four participants representing four organizations. The "other businesses" focus group included 16 participants representing nine organizations. Both groups expressed generally similar feedback, which can be summarized as follows:

- Renewable fuel suppliers expressed potential support for the program.
- Concerns were expressed over potential cost impacts and any related effects on business growth in the State.
- Concerns were expressed over administrative requirements for obligated entities, especially small businesses.
- A preference was expressed for one emissions regulation program over multiple sector-specific programs.
- The State was urged to keep administrative requirements for the program simple.
- Questions were identified about small fuel distributors and distributors who cross state borders on a delivery route and how they would be regulated.
- A need was identified for additional understanding among some parties about what the program would mean for them.

Environmental and Community Groups

In addition to project team and Technical Advisory Committee members, this focus group included 21 participants representing 18 organizations. Organizations included nonprofits, research entities, and state and regional agencies. Key messages included:

- Participants expressed strong support for the program as a cost-effective way of achieving emission reductions.

- A key benefit of the program is to provide a pool of resources for reinvestment in emissions reduction. No other new funding opportunities are on the horizon.
- The State needs to focus on supporting equity with the program's proceeds and making sure rural and low-income Vermonters are not left behind or overburdened in the energy transition.
- The State needs to involve people in the conversation about how funds will be used.
- Communicating the "how and why" of the program will be critical to building support.
- The State should be transparent in its analysis about assumptions regarding the use of proceeds, and should consider looking at alternative scenarios.

General Public

A total of 73 people (links) attended the two virtual public meetings. As of January 12, 2025 the meeting recording has been viewed 122 times. The meetings provided opportunities for engagement through responses to poll questions and a question-and-answer period. Participants were also invited to share their input directly with the study team via email or phone. Polling indicated that about three-quarters of respondents new nothing or "a little" about cap-and-invest, with the remainder knowing "a lot."

Participants were asked, via polling, "What additional information or resources, if any, would help to increase your knowledge of cap-and-invest programs?" Through both the poll and Q&A:

- Many of the respondents requested more information about states in which similar programs are working, success and challenges for those programs, effects of the program on fuel prices, and the resulting impacts to consumers and businesses including how their activities or the state's economy might be affected.
- Some questions also focused on the mechanics of the program, such as how biofuels would fit in and how cap-and-invest would relate to the proposed Clean Heat Standard.
- Additional questions included where to find resources on making home improvements and vehicle choices; how the state would facilitate workforce development; and whether other types of price incentives might be considered.

7.0 Discussion of Program Options

7.1 Choice of Program to Join

- Both the future WCI and NYCI price trajectories are uncertain. However, due to expected different price ceilings, linking with WCI is likely to result in a higher allowance price than NYCI, especially since the WCI has ramped up to their current price over almost two decades and if Vermont linked with WCI, Vermont would need to come in at their current price. Linking with NYCI would allow Vermont to align with a program as it comes online.

- Linking with WCI would provide a larger price signal to reduce emissions, resulting in higher household and business cost impacts, a greater likelihood of achieving overall emissions reduction requirements, and more money for reinvestment. Similarly, macroeconomic and health benefits would be proportionately larger linking with WCI.

- The WCI market is larger than the NYCI market and could result in less likelihood of emission reductions occurring within Vermont. Still, both programs are large by comparison to Vermont. New York State alone produces about 30 times the emissions of Vermont, and WCI entities produce over 50 times the emissions of Vermont.

- NYCI has the advantage of being implemented in another U.S. state that shares a long border with Vermont – reducing the potential for cross-border effects due to Vermont price differentials with its neighbors. While Quebec also borders Vermont, the international crossing makes border effects a lesser consideration.

- Many details of NYCI are not yet finalized; unless Vermont makes a decision to join WCI, any final recommendation on which program to link to would need to be deferred until NYCI rules are released.

7.2 Sectoral Coverage

- Modeling suggests that expanding coverage to the residential, commercial, and/or industrial sectors could yield 30 to 50 percent greater emission reduction benefits than covering only the transportation sector. Expanding coverage, however, might not be pursued if the Legislature decides to implement a Clean Heat Standard.

- Broader coverage allows more opportunity for cost-effective emission reductions (those with the least economic impact/most benefit) but also less certainty on achieving transportation reductions.

- Broader coverage is consistent with the other programs that Vermont might link to – both WCI and NYCI would cover multiple sectors including transportation, residential, commercial, and industrial.

- Evidence is mixed on whether the transportation sector is more or less responsive to price and investment signals than thermal and stationary sources. If it were less responsive, a multi-sector program would likely result in greater emissions in residential, commercial, and industrial sectors compared to transportation.

- Strong regulations in the transportation sector (Advanced Clean Cars and Advanced Clean Trucks) that have been put in place in Vermont may limit any additional emissions benefit from cap-and-invest for transportation on greenhouse gas emissions, since manufacturers are already required to sell increasing numbers of zero-emission vehicles. However, investments of cap-and-invest proceeds can also complement and support these clean vehicle regulations and building out infrastructure to support electric vehicles.

7.3 Low-Carbon Fuel Standard

- Cap-and invest sets a limit on the total amount of emissions the covered sectors can produce. In contrast, an LCFS would set a limit on the intensity of emissions from covered fuels and would therefore provide less certainty (on its own) in reaching an overall emissions level, although it might help the cap-and-invest program to achieve its objectives.

- Cap-and-invest generates revenue from the auction of allowances that the state invests in measures to accelerate emission reductions and to address disproportionate economic effects on consumers. A LCFS creates demand for lower-emitting fuels and technologies that increases over time. The private sector responds by investing in businesses that can deliver those fuels and technologies at the lowest cost to fuel suppliers and ultimately consumers.

- While consumers are initially exposed to increased fuel costs from both approaches, over time both provide more options to consumers to choose lower emitting fuels and technologies, and both provide resources to make those options more affordable.

- Regulators in California and Washington believe LCFS plays an important complementary role to cap-and-invest. LCFS would increase the likelihood of achieving transportation sector emission reductions.

- Adopting an LCFS would add policy and regulatory complexity, which could be a reason to defer further consideration until a cap-and-invest program is established and working.

7.4 Other Considerations

- How the State chooses to spend the proceeds from the cap-and-invest auction has important implications for both total emissions reductions of the program, as well as the equity implications of the program. Ultimately, the legislature will need to decide how to spend any proceeds, including 1) which sector(s) and program(s) are funded, 2) any direction of rebates, incentives, or dividends to lower-income households, small businesses, etc.; and 3) how any revenue not reinvested in emissions-reducing activities is spent.

- The efficacy of cap-and-invest at reducing emissions may also depend upon other complementary policies such as advancements in clean vehicle and/or clean equipment standards; as well as factors largely beyond the state’s control such as federal policies, economic conditions, technology development, and changing consumer preferences.

Appendix A. Other Program Design Considerations

This section offers additional consideration on program design for a potential Vermont cap-and-invest program. It considers:

- GHG accounting systems and how Vermont might reconcile any differences in its accounting system vs. a program it chooses to join.
- Cost containment mechanisms.
- Approaches to allocating allowances.

A.1 GHG Accounting

A cap-and-invest program is often referred to as a carbon pricing policy because obligated entities are required to pay for their emissions footprint. But each program may make different choices about what emissions are actually attributable to an obligated entity, and which emissions types are actually covered by the program. For example, most cap and trade or cap-and-invest programs cover more than just carbon. Both California and the planned New York program also cover methane (CH_4), which can be expressed in CO_2 equivalent (CO_2e). These decisions raise the issue of GHG “accounting” or how the compliance obligation for relevant entities is calculated. For linking programs, accounting methods are relevant, because they can impact the cost of compliance and the abatement incentive across jurisdictions.

The two most relevant accounting decisions for Vermont to consider are the CO_2e calculation for methane emissions, and whether to include upstream emissions associated with different fossil fuels. We discuss each of these in depth below.

New York’s Climate Leadership and Community Protection Act (CLCPA), along with Maryland’s Climate Solutions Now Act, have defined carbon dioxide equivalent to mean the amount of carbon dioxide by mass that would produce the same global warming impact as a given mass of another greenhouse gas over an integrated 20-year time frame after emissions occur. This approach (GWP20) is more stringent in accounting for the global warming potential of methane emissions than the IPCC recommended 100-year global warming potential (GWP100) approach, which is the approach adopted by most states including Washington and California. An implication of New York’s alternative emissions accounting is that for those greenhouse gasses, such as methane, that have a shorter residence time in the atmosphere than CO_2, the CO_2e conversion will involve a larger factor being applied to the methane emissions than would be the case with GWP-100 accounting. A larger factor (GWP20) would lead to a higher price applied to methane emissions or more carbon equivalent allowances required by methane emitters.

According to New York program administrators, Vermont would have the flexibility to choose a different GWP than New York, even if they hope to link with the NYCI program. In a system where VT uses GWP100 and New York uses GWP20, a methane emitter in New York would have to buy more allowances than a methane emitter in VT, meaning that emitters will be more inclined to reduce emissions in New York. Unfortunately, if an equivalent investment to reduce methane emissions at the source (such as building heating) were made in New York, it would free up more allowances than if the same investment were made and the same emissions reduction at the source were achieved in VT, which means that aggregate emissions reductions would be less than anticipated based on the emissions reductions achieved in New York. A similar phenomenon could occur due to the inclusion of upstream emissions. New York's CLCPA counts upstream emissions, many of which occur outside of the state, towards its climate goals. Reduction in upstream emissions is an important part of achieving the law's requirements. Including upstream emissions means that fuels like natural gas that have higher upstream emissions intensities will be required to retire more allowances for compliance than fuels with lower upstream emissions. The impact of linking with a program that does not include upstream emissions is similar to that of the different GWPs. Firms in states that count upstream emissions will have higher costs of compliance, and therefore more incentive to abate emissions.

New York program designers have expressed interest in designing their program to facilitate linkage. That means they will likely take steps to accommodate states with different accounting systems. There are a few options they might explore to mitigate undesirable impacts of merging different accounting systems. One solution would be to count all emissions in New York using the same GWP as VT and then have New York retire enough allowances to cover the difference between GWP20 CO2e and the GWP100 CO2e accounting approaches before auctioning the remainder. The advantage of this approach is that it would be a simple way to enable linking. The disadvantage is that it would weaken the incentive for sources obligated in New York to search for ways to reduce methane emissions and it would impose a commensurate additional cost on the state to find other sources for emissions reductions.

Alternatively, the New York program could use the GWP20 to convert methane emissions covered by the program to CO_2e and include all those emissions under the cap. If New York creates a link to a state (such as Vermont) that employs a different GWP accounting, it could use a trading ratio to require more than one CO_2 allowance from the linked program with a GWP100 approach to cover CO2e emissions from methane sources covered by the in-state program. In a similar vein, the other state (in this case, Vermont) may want to discount allowances that might be used to cover methane emissions specifically covered by its program. Such an approach would enhance the incentive to reduce methane emissions in the state with the greater cost on methane. However, it may not be possible to identify a trading ratio ex ante that reflects the speciation of emissions or the emissions reductions that would be achieved in each jurisdiction. Consequently, the NYCI program may need to issue two types of emissions allowances, one for general combustion-related CO_2 and one for CO_2e from methane. A trading ratio between jurisdictions could be established for trading of CO_2e from methane, and methane-related allowances would have to be treated separately from CO_2 allowances. However, methane-related emissions allowances could not be exchanged with CO_2 related allowances within either jurisdiction or an opportunity for arbitrage by sequentially trading within a state and then between states which would reintroduce additional allowances and could reduce real emissions reductions.

Neither the NYCI nor WCI programs have explicitly set guidelines for how accounting mechanisms may or may not need to be aligned to facilitate program linking. Those decisions would need to be made in agreement with existing program administrators. That being said, program designers have expressed interest in facilitating linking and the benefits of linking create a direct incentive for states to find creative solutions to integrating diverse accounting systems.

A.2 Cost Containment

A cap-and-invest program delivers emissions reductions through creating a price signal that disincentivizes emitting carbon emissions and makes emissions-reducing investments more appealing. A real consequence of this policy approach is that some goods and services will become more expensive. Understandably, policy makers would like to make sure that households don't face onerous costs associated with a cap-and-invest program, but cost containment or affordability measures must be considered carefully so as not to mute the price signal designed to reduce emissions. For example, offering fuel suppliers subsidies to fully cover their cost of complying with the policy would surely reduce program costs, but would completely eliminate the emissions reducing signal. Below we discuss cost-containment measures and how they can be implemented with program goals in mind.

- Price ceilings: Vermont may consider the price ceiling established by the existing program. The WCI price ceiling in 2024 was $88.22. NYCI has not yet announced a price ceiling but did express intention to include a price ceiling in their pre-proposal outline. In their preliminary analyses they tested three different price ceiling trajectories. In 2030, prices ranged from $30 to $64 per ton of CO_2e. Generally, Vermont should expect to accept the price ceiling policy established by the existing program it joins. If Vermont wanted to set a lower price ceiling, they could offer to compensate firms for some portion of their compliance costs. For example, if Vermont joined WCI with a $90 price ceiling but was unwilling to tolerate such high prices, Vermont could set an internal price ceiling and offer to compensate firms for any difference between the Vermont price ceiling and the WCI allowance price. This could be viewed unfavorably by the host program and would need to be negotiated at the time of joining. It would also lead to lower emissions reductions in Vermont by muting the price signal on carbon emissions. This would also reduce the amount of revenue available for investments and dividends.

- Free allocation: Rather than paying firms back for some share of allowance prices, Vermont could give firms some allowances for free. As discussed in the free-allowance allocation section below, this is typically used selectively for firms that policy makers think may respond to carbon prices by exporting production to a different state. Giving allowances away for free to fuel suppliers based on production could lower costs, but at the expense of emissions reductions that might have come from reduced production of fossil fuels. This would also decrease revenue available for investments and dividends.

- Investments: Investment of revenue, when done strategically, can reduce costs of complying with a cap-and-invest program. By subsidizing EVs, heat pumps, and other clean energy technologies, policy makers can reduce the number of households exposed to increased fuel prices. By targeting funds to low-income or high-fossil fuel consumption households, a cap-and-invest program can simultaneously increase program affordability and emissions reductions. This cost containment mechanism furthers the goals of the cap-and-invest policy, but is not equally helpful to all households. For those that cannot take advantage of subsidies or investments, costs may still be higher.

- Dividends: Dividends are a highly flexible way of addressing cost containment in a cap-and-invest program. A portion of revenues can be used to offer direct cash payments to state residents to cover any increases in costs from higher prices of goods and services. Importantly, this can make households whole while still preserving the higher gas prices that would encourage a household to choose an EV over an internal combustion vehicle. Dividends have been used in the WCI program for the benefit of rate payers, offering hundreds of dollars a year in benefits. Payments can be varied based on income, geography, or other details that may be related to households' exposure to increased prices. New York State is also committed to spending 30 percent of their program on dividends. In their Affordability Study, they suggest different payment schedules based on income and whether residents live upstate, downstate, or in New York City.

A.3 Approaches to Allocating Allowances

Most carbon markets use one of three approaches to initially distribute emission allowances. One is an allowance auction, which is increasingly common and provides revenue that can be directed toward investments to accelerate decarbonization or for compensation to consumers for changes in energy costs. A second approach is free allocation to regulated firms based on their *historic* level of emissions or another closely related metric. This approach, called "grandfathering", was common in early markets but has largely been phased out. A third approach, called output-based allocation, is free allocation to regulated firms that is regularly updated based on the firm's *current* level of productive activity.

- Grandfathered free allocation: this method is based on historic emissions, which is the approach that was evident in the sulfur dioxide (SO_2) emissions trading program under the 1990 Clean Air Act. Grandfathered free allocation provides an incentive to reduce emissions; however, it does not provide an incentive to keep facilities in service. Under the SO_2 trading program, facilities continued to receive allocation even after they shut down. In a state-level program, grandfathering would reward firms even if they moved activity to out of state, perhaps to higher emitting facilities, thereby undermining environmental goals and the state's economy. Further, because the use of a freely allocated emissions allowance has a market-valued opportunity cost, firms will capitalize that value by raising product prices for consumers, without associated auction proceeds to provide compensation. Hence, grandfathered allocation is not advisable for a state-level program and in general has been rejected under any program design, except in special circumstances for example for temporary compensation or during a phase-in or trial period for a carbon market.

- Free output-based allowance allocation: this method is intended to encourage businesses to maintain levels of production while still providing firms with incentives to invest in reducing their emissions intensity. By giving an obligated entity allowances for free, the program administrator offers them an asset that they can either use for compliance in the program or sell for revenue. If efficiency investments would allow them to sell allowances for net revenue gain, they would be incentivized to make those investments. The allocation is based on the level of productive output, so that if a facility reduces its emissions but maintains activity it can realize rewards. If productive activity is reduced, the free allocation is reduced accordingly, which provides an incentive to maintain economic activity. Because output-based allocation scales with output, it offers no incentive to reduce emissions by reducing production. That makes it a particularly poor tool to encourage emissions reductions for entities who have limited capacity to make emissions efficiency investments.

Free allocation has an opportunity cost because it implies there would be fewer allowances that would be available for auction and less revenue would be available for investments or for compensation to consumers through dividends. Providing more allowances to less efficient firms also can be counter-productive from an emissions reduction perspective. Economists often favor allocating allowances based on an efficient emissions-intensity benchmark (such as tons per unit of product) distinguished by industry, but not by firm. Under this approach, firms that are cleaner than the average will gain a competitive advantage. In general, firms face varying levels of competition from out of state and some may face only a small chance of relocating production out of state due to carbon pricing, or the price threshold that would trigger such a move is very high. Calibrating the amount of free allocation to the risk to competitiveness of the regulated industry will minimize the opportunity cost of free allocation and preserve allowances for auction.

In principle, output-based allocation should have a small effect on the downstream prices faced by firms using those products or by consumers of those products compared to the absence of a program. This occurs because the compliance cost of surrendering allowances is offset by the earning of an allowance with each unit of production. In practice, the impact on prices depends on the design of free allocation programs. If there is great heterogeneity in emissions intensities within a sector, benchmark allocation may require some firms to purchase additional allowances to meet their compliance obligation, while other firms may receive an allocation that is greater than their emissions. The research literature provides a strong conceptual justification for free output-based allocation for industries that are exposed to unfair competition from unregulated firms. In existing carbon markets such as in California or the European Union, *ex ante* predictions suggested that if firms were exposed to competition from abroad and they had to buy all their allowances, the introduction of a carbon price would trigger a severe relocation of production out of the jurisdiction. In those jurisdictions and elsewhere free output-based allocation has been implemented as a remedy. *Ex po*st assessments of those programs are ongoing and thus far, in some part due to remedies such as output-based free allocation, there is little evidence that the dire predictions of the relocation of production have been realized. However, there is evidence that free allocation has in some cases been too generous, providing windfalls for firms and subtracting from proceeds that could serve other purposes.

Generally, free allocation requires a thoughtful consideration of the allocation methodology and is best used sparingly for trade exposed industries, rather than broadly across a cap-trade-and-invest program. Output-based free allocation is most effective in preventing incentives to shift production out of state while maintaining an incentive to make investments that improve the emissions intensity of production. Applied more broadly, it can be used to limit the cost impact of the program during a reporting year for jurisdictions that need more data about demand for allowances to set up a program. Because it mutes the price signal to consumers to reduce consumption, output-based free allocation is less cost effective than auctioning allowances and should be introduced sparingly and with purpose.

Appendix B. Additional Technical Documentation

This section offers additional technical documentation on the baseline emissions forecasts, targets, and key assumptions in the household impacts analysis.

B.1 Baseline Emissions Projections

The project team used a base year of 2023 for the study's emissions projections, based on preliminary GHG Inventory numbers provided to the project team by ANR. Covered sources include CO_2 and non-CO_2 emissions from gasoline, diesel, heating oil, natural gas, and propane.

To estimate future baseline emissions, we assume a constant annual growth rate of the ratio of emissions (E) to gross domestic product (GDP) in year t, or Et/GDPt, for 2023-2030 (model parameter beta1) and 2030-2050 (model parameter beta1b) for each fuel/sector. These values are estimated from the EIA Annual Energy Outlook (AEO) 2023 Reference Case using emissions intensity projections by fuel/sector for the New England region. We further adjust beta1 and beta1b for the transportation sector to match the forecast of 2.4 MMT CO_2e in 2030 and 0.76 MMT CO_2e in 2050 provided in the Vermont Carbon Reduction Strategy (Agency of Transportation, 2023), which takes into account the adopted Advanced Clean Cars and Trucks rules. Emissions intensities projections are then converted into emissions levels by assuming values of GDP growth over time. In this analysis, we calculate U.S. values of GDP(t)/GDP2023 values for year t = 2025 to 2050 from the EIA AEO 2023 and apply those rates to Vermont (which assumes that Vermont grows at the same rate as the U.S.).

Industrial process emissions were inflated in future years in the same proportion as industrial fuel use. Industrial fuel use is projected to grow at a modest rate, as growing output is offset partially by reduced fuel intensity per unit of output.

B.2 GWSA Maximum Emissions by Sector

It was necessary for this study to estimate the "target" level of emissions that the covered sectors are expected to achieve in 2030 and 2050, i.e. the maximum each sector would be allowed to emit, for comparison against projected emissions under each study scenario.

The Global Warming Solutions Act (GWSA) establishes requirements for Vermont to reduce emissions 40 percent from 1990 levels by 2030 (January 1, 2030 – i.e., measured for calendar year 2029), and 80 percent from 1990 levels by 2050 (January 1, 2050 – i.e., measured for calendar year 2049). Those reductions must reflect the relative contribution of each source or category of source of emissions. Based on a 2021 decision by the Vermont Climate Council, program design for each emissions sector is being developed to attain its share of these emissions levels in proportion to its share of statewide emissions in 2018. Those shares were: transportation – 40 percent; residential, commercial, and industrial thermal – 34 percent; industrial process – 6 percent, for the sectors potentially covered by cap-and-trade. The remaining 20 percent would be in sectors not covered (electricity, agriculture, and waste management).

The ANR's *Vermont Greenhouse Gas Inventory and Forecast: 1990-2021* (2024) reports a total of 8.56 million metric tons of carbon dioxide-equivalent emissions in 1990 across all sectors. Based on this reference level, the required levels of emissions across all sectors would be no more than 5.14 MMT in 2030, and 1.71 MMT in 2050. Table B-1 shows the calculated maximum levels for each sector included in this study using the proportional shares determined by the Vermont Climate Council. This cap-and-invest study also made minor exclusions for sources not covered in cap-and-invest, namely, residential and commercial wood emissions. Adjusted levels were calculated based on excluding these emissions. Specifically, the thermal sector level was reduced by 3.3 percent. These adjustments are based on the subsector emissions shares reported in the ANR inventory for 2019 (the inventory did not provide subsector breakdowns for 2018). Industrial process emissions were not adjusted; however, we note that not all industrial sources included in ANR's inventory might be covered by a cap-and-invest program that would cover only larger sources. It is not known what share of these emissions might be excluded.

Table B-1 Estimated GWSA Maximum Emission Levels for Covered Sectors (MMT CO_2e)

Sector	1990	Proportional Share	2030	2050
Unadjusted				
Transportation/Mobile Sources		40%	2.05	0.68
Residential/ Commercial/ Industrial Thermal		34%	1.75	0.58
Industrial Processes		6%	0.31	0.10
All Sources	8.56		5.14	1.71
Adjusted for Non-Covered Subsectors		**Adjustment**		
Transportation/Mobile Sources		**100.0%**	**2.05**	**0.68**
Residential/ Commercial/ Industrial Thermal		96.7%	1.69	0.56
Industrial Processes		100.0%	0.31	0.10
Trans + R/C/I Thermal			**3.74**	**1.25**
Trans + R/C/I Thermal + Industrial Process			**4.05**	**1.35**

B.3 Emissions and Household Impact Analysis

Key assumptions for the analysis of the impacts of reinvestment and the household cost impact analysis are described below. Table B-2 shows the key assumptions and data sources for the productivity of reinvestments at achieving emissions reductions.

Table B-2 Investment Productivity Assumptions for Reinvestment Analysis

Type of Investment	Annual Tonnes CO_2 / Cumulative $M	Source	Notes
Transportation - VMT reduction	50	VT Transportation Carbon Reduction Strategy (2023). Mix of micromobility, bike/ped investments, electric transit.	Value is for 2030; based on a CO_2 reduction in 2030 of 6,500 tonnes for a cumulative investment of $142M over the 2025-2030 period for the "transportation investment and services" scenario. Reduced in future years in proportion to ratio of projected year X light-duty vehicle emission rates (grams per mile) to year 2030 emission rates.

Type of Investment	Annual Tonnes CO_2 / Cumulative $M	Source	Notes
Transportation - HH LDV - EVs	-	Assuming no incremental benefits beyond ACC2.	
Transportation - MHD ZEV fleets	250	VT Transportation Carbon Reduction Strategy (2023).	Value is for 2030; based on an average across different types of MHD ZEVs of approximately 3,000 annual tonnes reduced per annual $M invested, with an average 12-year vehicle lifespan per federal guidance for buses (3,000 / 12 = 250). Reduced in future years in proportion to ratio of projected year X heavy-duty conventional vehicle emission rates (grams per mile) to year 2030 emission rates.
Residential efficiency	263	Based on heat pump impacts as developed from Deetjen et al (2021) and Bernard et al. (2024) estimating a net present value of $190 per tonne, and amortized over a 20-year lifespan. A DOE synthesis of weatherization programs (Lovaas, 2015) provides similar $/ton estimates.	$190/tonne = 5,263 annual tonnes per annual $M (1 / 190 * 1,000,000); 5,263 / 20 = 263 annual tonnes per cumulative $M over equipment lifespan. Value applies for all years.
Commercial efficiency	263	Assumed to be the same cost-effectiveness as residential efficiency.	

Table B-3 shows current Vermont energy use as drawn from the EIA State Energy Data Systems (SEDS).

Table B-3 EIA SEDS – Vermont Energy Use (Trillion BTUs, 2022)

Fuel Type	Residential	Commercial
Diesel/ home heating oil	4.1	7.7
Natural gas	9.6	3.3
Electricity	7.5	6.5

https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_use/com/use_com_VT.html&sid=VT

Table B-4 shows projected energy prices for 2030 as used in the Incidence Model household cost analysis, with 2024 projected prices shown for context. These energy prices were calculated by taking AEO 2023 price projections and scaling them to Vermont by comparing SEDS 2023 prices in VT to the SEDS 2023 national average prices.[33]

Table B-4 Residential Energy Price Projections for Vermont

Year	Electricity (2024$ / kWh)	Motor Gasoline (2024$ / gallon)	Natural Gas (2024$ / thousand cubic feet)	Other Heating Fuel (2024$ / gallon)
2024	$ 0.20	$ 3.63	$ 18.00	$ 5.34
2030	$ 0.19	$ 3.36	$ 15.33	$ 4.81

[33] Note that Vermont Department of Public Service (DPS) has provided electricity rate forecasts of $0.212 per kWh in 2024, increasing to $0.245 per kWh in 2030, in nominal dollars. Expressed in 2024 dollars the 2030 price would be $0.210 per kWh, about 10 percent higher than the value used in the study. Also, the rates used are average rates inclusive of both variable and fixed customer charges; due to the presence of fixed charges the marginal rate (i.e., the amount the customer pays for each additional kWh if they are already a customer) would be lower than the average rate.

Table B-5 shows the share of expenditures by various vehicle and fuel categories by income quintile and county. Shares of Vermont expenditures belonging to households of different quintiles and counties are calculated using Bureau of Labor Statistics Consumer Expenditure Survey data (2013-2019), U.S. Census American Community Survey data (5 year data, 2021), and SEDS 2020.

Table B-5 Incidence Model Shares (% of total state expenditure, residential, by category)

Category	Efficiency	Electricity	Maintenance	Motor Gasoline	Motor Vehicles	Natural Gas	Other Heating Fuel
Income Quintiles							
1	11.24%	12.99%	9.77%	9.18%	8.18%	13.41%	12.16%
2	14.25%	16.86%	15.30%	13.45%	10.40%	17.11%	17.70%
3	18.38%	20.66%	19.16%	20.63%	17.63%	20.98%	17.62%
4	20.79%	21.72%	23.63%	24.70%	25.72%	20.65%	23.09%
5	35.34%	27.77%	32.14%	32.05%	38.08%	27.85%	29.43%
Counties							
Addison	5.84%	6.32%	5.81%	5.91%	5.88%	0.54%	6.81%
Bennington	5.40%	6.58%	5.41%	5.90%	5.36%	0.73%	7.74%
Caledonia	4.46%	4.53%	4.50%	5.08%	4.39%	0.29%	5.85%
Chittenden	26.99%	23.58%	26.70%	21.74%	27.25%	82.96%	12.60%
Essex	0.95%	0.87%	0.97%	1.19%	0.92%	0.04%	1.26%
Franklin	7.32%	8.00%	7.32%	7.88%	7.35%	10.70%	7.49%
Grand Isle	1.23%	1.01%	1.22%	1.40%	1.25%	0.17%	1.42%
Lamoille	4.08%	3.86%	4.08%	4.17%	4.08%	0.35%	4.26%
Orange	4.80%	4.52%	4.84%	5.22%	4.83%	0.47%	5.18%
Orleans	4.13%	3.61%	4.17%	4.57%	4.06%	0.16%	5.13%
Rutland	9.13%	10.37%	9.20%	9.79%	9.04%	0.75%	12.50%
Washington	9.63%	9.31%	9.66%	9.52%	9.67%	1.14%	11.14%
Windham	6.81%	7.45%	6.86%	7.51%	6.70%	0.50%	7.94%
Windsor	9.22%	9.99%	9.26%	10.12%	9.22%	1.21%	10.68%

Table B-6 shows household counts and income by quintile. Income is assumed to grow at 1.6 percent per year and population at 0.4 percent per year between 2023 and 2030 following the AEO 2023's assumptions that GDP grows at 1.6 percent per year between 2022 and 2030 and that population grows at 0.4 percent between 2022 and 2050.[34] 2023 values of total income and total population are taken from the Census Bureau.[35] Shares of total state income belonging to each income group and county are taken from the RFF incidence model. Income cut-offs are taken from the RFF incidence model's processing of American Community Survey data.

Table B-6 Household Counts and Income Levels by Quintile

Category	Household Count 2023	Household Count 2030	Average Income per Household 2023 (thousand 2024$)	Average Income per Household 2030 (thousand 2024$)	Income Range 2019 (thousand 2024$)
Income Quintiles					
1	54,465	56,008	$ 29	$ 31	$ 0 - $ 44
2	54,465	56,008	$ 58	$ 63	$ 44 - $ 77
3	54,465	56,008	$ 85	$ 92	$ 77 - $ 113
4	54,465	56,008	$ 119	$ 130	$ 113 - $ 167
5	54,465	56,008	$ 242	$ 263	$ 167 +
Counties					
Addison	15,230	15,661	$ 112	$ 122	
Bennington	15,111	15,539	$ 105	$ 114	
Caledonia	13,073	13,443	$ 91	$ 99	
Chittenden	68,874	70,825	$ 126	$ 137	
Essex	2,986	3,070	$ 77	$ 84	
Franklin	19,731	20,290	$ 100	$ 108	
Grand Isle	3,083	3,171	$ 125	$ 135	
Lamoille	11,158	11,474	$ 118	$ 128	
Orange	13,127	13,499	$ 98	$ 106	
Orleans	12,099	12,442	$ 86	$ 94	
Rutland	26,262	27,007	$ 91	$ 99	
Washington	26,222	26,965	$ 104	$ 113	
Windham	19,852	20,415	$ 95	$ 103	
Windsor	25,516	26,240	$ 105	$ 114	
Total	**272,324**	**280,041**			

[34] https://www.eia.gov/outlooks/aeo/assumptions/pdf/Macro_Assumptions.pdf

[35] https://www.census.gov/quickfacts/VT

Tables B-7, B-8, B-9, and B-10 show reference case emissions by sector and scenario emissions for each of the nine scenarios (low, medium, and high price; transportation, transportation + RCI fuels, transportation + RCI fuels + industrial process emissions), with the various levels of reinvestment. These tables show effects of the price starting in 2027 and reinvestment effects starting in 2028. If the program were to start in 2028 or later, emissions would be equal to reference case emissions until the program benefits are seen.

Table B-7 Reference Case Emissions by Sector (MMT CO_2e)

Year	Trans	RCI Fuels	Industrial Process	Total
2025	3.01	2.01	0.45	5.47
2026	2.94	1.95	0.45	5.34
2027	2.88	1.88	0.45	5.22
2028	2.81	1.82	0.46	5.09
2029	2.74	1.76	0.46	4.96
2030	2.67	1.70	0.46	4.83
2031	2.52	1.67	0.46	4.66
2032	2.39	1.65	0.46	4.51
2033	2.27	1.63	0.47	4.37
2034	2.15	1.62	0.47	4.24
2035	2.04	1.60	0.47	4.11
2036	1.94	1.58	0.47	3.99
2037	1.85	1.56	0.48	3.89
2038	1.76	1.55	0.48	3.79
2039	1.67	1.54	0.48	3.69
2040	1.59	1.52	0.49	3.60
2041	1.52	1.51	0.49	3.52
2042	1.45	1.50	0.49	3.44
2043	1.38	1.49	0.50	3.37
2044	1.32	1.47	0.50	3.29
2045	1.26	1.46	0.50	3.22
2046	1.20	1.45	0.51	3.16
2047	1.15	1.44	0.51	3.10
2048	1.10	1.42	0.52	3.04
2049	1.05	1.41	0.52	2.98
2050	1.00	1.40	0.52	2.93

Table B-8 Scenario Emissions without Reinvestment (MMT CO_2e)

Year	Low / Trans	Low / Trans + Fuels	Low / Trans + Fuels + Process	Medium / Trans	Medium / Trans + Fuels	Medium / Trans + Fuels + Process	High / Trans	High / Trans + Fuels	High / Trans + Fuels + Process
2027	5.09	5.05	5.05	4.91	4.81	4.81	4.74	4.55	4.55
2028	4.96	4.93	4.93	4.78	4.68	4.68	4.61	4.42	4.42
2029	4.83	4.79	4.79	4.65	4.54	4.54	4.47	4.28	4.28
2030	4.70	4.66	4.66	4.51	4.40	4.40	4.34	4.14	4.14
2031	4.53	4.49	4.49	4.34	4.23	4.23	4.18	3.97	3.97
2032	4.38	4.33	4.33	4.20	4.08	4.08	4.03	3.82	3.82
2033	4.24	4.20	4.20	4.06	3.94	3.94	3.91	3.68	3.68
2034	4.11	4.06	4.06	3.94	3.80	3.80	3.78	3.55	3.55
2035	3.99	3.94	3.94	3.81	3.68	3.68	3.67	3.43	3.43
2036	3.87	3.82	3.82	3.70	3.56	3.56	3.56	3.31	3.31
2037	3.77	3.71	3.71	3.60	3.45	3.45	3.46	3.20	3.20
2038	3.67	3.61	3.61	3.50	3.34	3.34	3.37	3.10	3.10
2039	3.57	3.52	3.52	3.41	3.24	3.24	3.28	3.00	3.00
2040	3.49	3.43	3.43	3.33	3.15	3.15	3.20	2.91	2.91
2041	3.41	3.35	3.35	3.25	3.07	3.07	3.13	2.83	2.83
2042	3.33	3.26	3.26	3.18	2.99	2.99	3.06	2.75	2.75
2043	3.25	3.19	3.19	3.11	2.91	2.91	2.99	2.68	2.68
2044	3.18	3.11	3.11	3.04	2.84	2.84	2.93	2.61	2.61
2045	3.11	3.04	3.04	2.97	2.77	2.77	2.87	2.54	2.54
2046	3.05	2.97	2.97	2.91	2.70	2.70	2.81	2.47	2.47
2047	2.99	2.91	2.91	2.85	2.64	2.64	2.76	2.41	2.41
2048	2.93	2.85	2.85	2.80	2.58	2.58	2.70	2.35	2.35
2049	2.88	2.79	2.79	2.75	2.52	2.52	2.66	2.29	2.29
2050	2.83	2.74	2.74	2.70	2.46	2.46	2.61	2.24	2.24

Table B-9 Scenario Emissions with 50% Reinvestment (MMT CO_2e)

Year	Low / Trans	Low / Trans + Fuels	Low / Trans + Fuels + Process	Medium / Trans	Medium / Trans + Fuels	Medium / Trans + Fuels + Process	High / Trans	High / Trans + Fuels	High / Trans + Fuels + Process
2027	5.09	5.05	5.05	4.91	4.81	4.81	4.74	4.55	4.55
2028	4.96	4.93	4.93	4.78	4.68	4.68	4.61	4.42	4.42
2029	4.83	4.79	4.79	4.64	4.53	4.53	4.46	4.26	4.25
2030	4.69	4.65	4.65	4.50	4.38	4.37	4.32	4.09	4.08
2031	4.52	4.47	4.47	4.33	4.19	4.19	4.15	3.90	3.89
2032	4.37	4.32	4.31	4.18	4.02	4.02	4.00	3.72	3.71
2033	4.23	4.17	4.17	4.04	3.87	3.86	3.87	3.56	3.54
2034	4.10	4.04	4.03	3.91	3.72	3.71	3.74	3.40	3.38
2035	3.98	3.91	3.90	3.78	3.58	3.57	3.61	3.25	3.23
2036	3.86	3.79	3.78	3.67	3.45	3.44	3.50	3.11	3.08
2037	3.75	3.67	3.67	3.56	3.33	3.31	3.39	2.97	2.94
2038	3.65	3.57	3.56	3.46	3.21	3.19	3.29	2.84	2.81
2039	3.56	3.47	3.46	3.37	3.09	3.07	3.20	2.72	2.68
2040	3.47	3.38	3.37	3.28	2.99	2.97	3.11	2.60	2.56
2041	3.39	3.29	3.28	3.20	2.89	2.86	3.04	2.49	2.44
2042	3.31	3.20	3.19	3.12	2.80	2.77	2.96	2.39	2.33
2043	3.24	3.12	3.11	3.05	2.70	2.67	2.89	2.28	2.22
2044	3.16	3.04	3.03	2.98	2.61	2.58	2.82	2.18	2.11
2045	3.09	2.96	2.95	2.91	2.53	2.49	2.75	2.08	2.00
2046	3.03	2.89	2.88	2.85	2.44	2.40	2.69	1.98	1.90
2047	2.97	2.82	2.81	2.79	2.36	2.31	2.63	1.89	1.80
2048	2.91	2.76	2.74	2.73	2.28	2.23	2.57	1.80	1.70
2049	2.85	2.69	2.68	2.67	2.21	2.15	2.51	1.71	1.60
2050	2.80	2.63	2.62	2.62	2.13	2.07	2.46	1.62	1.50

Table B-10 Scenario Emissions with 90% Reinvestment (MMT CO_2e)

Year	Low / Trans	Low / Trans + Fuels	Low / Trans + Fuels + Process	Medium / Trans	Medium / Trans + Fuels	Medium / Trans + Fuels + Process	High / Trans	High / Trans + Fuels	High / Trans + Fuels + Process
2027	5.09	5.05	5.05	4.91	4.81	4.81	4.74	4.55	4.55
2028	4.96	4.93	4.93	4.78	4.68	4.68	4.61	4.42	4.42
2029	4.83	4.78	4.78	4.64	4.52	4.52	4.46	4.24	4.23
2030	4.69	4.64	4.64	4.50	4.35	4.35	4.31	4.05	4.04
2031	4.52	4.46	4.46	4.32	4.16	4.15	4.13	3.84	3.82
2032	4.37	4.30	4.30	4.17	3.98	3.97	3.97	3.64	3.62
2033	4.23	4.16	4.15	4.02	3.82	3.80	3.83	3.46	3.43
2034	4.09	4.02	4.01	3.89	3.66	3.64	3.70	3.28	3.25
2035	3.97	3.88	3.88	3.76	3.51	3.49	3.57	3.11	3.07
2036	3.85	3.76	3.75	3.64	3.37	3.34	3.45	2.95	2.90
2037	3.74	3.64	3.63	3.53	3.23	3.20	3.34	2.79	2.73
2038	3.64	3.53	3.52	3.43	3.10	3.07	3.23	2.64	2.57
2039	3.55	3.43	3.42	3.33	2.97	2.94	3.13	2.49	2.42
2040	3.46	3.33	3.32	3.24	2.86	2.82	3.04	2.35	2.27
2041	3.38	3.24	3.23	3.16	2.75	2.70	2.96	2.22	2.13
2042	3.30	3.15	3.13	3.08	2.64	2.59	2.88	2.09	1.99
2043	3.22	3.06	3.05	3.00	2.53	2.48	2.80	1.97	1.85
2044	3.15	2.98	2.96	2.93	2.43	2.37	2.73	1.84	1.71
2045	3.08	2.90	2.88	2.86	2.33	2.26	2.66	1.72	1.57
2046	3.01	2.82	2.80	2.79	2.23	2.16	2.59	1.60	1.44
2047	2.95	2.75	2.73	2.73	2.14	2.05	2.52	1.48	1.31
2048	2.89	2.68	2.65	2.67	2.05	1.96	2.46	1.36	1.17
2049	2.83	2.61	2.58	2.61	1.96	1.86	2.40	1.25	1.04
2050	2.78	2.55	2.52	2.56	1.87	1.76	2.34	1.13	0.91

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