RESOURCES
FOR THE FUTURE

Key Findings

This report provides information on policies to reduce greenhouse gas (GHG) emissions in Vermont.[1] It considers both *carbon pricing policies*, such as carbon taxes or cap-and-trade programs, and *nonpricing policies*, such as electric vehicle (EV) and energy efficiency incentives, weatherization programs and investments in low-carbon agriculture. This study aims to inform the policy dialogue but is not intended to address the complete universe of policy options. The key findings are presented below.

- Emissions in Vermont have been increasing since 2011, and the state is currently well above a pathway that would meet any of its GHG emissions targets.
- Vermont is unlikely to meet its emissions targets with a carbon-pricing-only strategy unless the carbon price is substantially higher than the prices modeled in this study ($19 to $77 per metric ton of CO_2 equivalent in 2025).[2] Vermont has a high share of emissions from transportation and heating fuel use; both sectors are difficult to decarbonize through carbon pricing or nonpricing policies.
- Combining moderate carbon pricing and nonpricing policy approaches could reduce emissions to meet Vermont's US Climate Alliance target; under this approach, emissions are projected to be 32–38 percent below 2005 levels in 2025 compared with the target of 26–28 percent.[3]
    - Combining policies such as those described in the study would not meet the state's statutory 2028 target (58 percent below 2005 levels or 50 percent below 1990 levels).
- Economic modeling of a range of carbon pricing designs (without nonpricing policies) suggests:
    - The combined climate and health benefits of the carbon pricing policies would exceed the economic costs for every carbon pricing scenario considered in this report.
    - Impacts on the state's GDP, level of employment, and overall economic welfare would be very small, regardless of carbon pricing policy design.
    - A carbon pricing policy could generate $74.7–$433.8 million in annual revenue in 2025, depending on the carbon price amount and number of sectors covered.
- In choosing how to use the revenue raised through a carbon pricing policy, policymakers face trade-offs among environmental outcomes, overall economic costs, and the impacts on different types of households. Policymakers can divide total revenues across multiple uses, balancing these tradeoffs.
    - According to our modeling analysis, **per household rebates** more than offset the costs of increased energy prices for the average low-income household.
    - **Reducing taxes on wage income** would lower the overall cost to Vermont's economy relative to other options considered, but these cuts would not fully offset higher energy prices.
    - Devoting revenue to **finance nonpricing policies** would reduce emissions further, but would also impose higher costs on Vermonters, because this would reduce funds that could be used to partially or fully offset the economic impacts on households of carbon pricing.

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1 Requested by the Vermont legislature in Act 11, Sec. C.110(3), June 2018.

2 See http://www.rff.org/blog/2017/calculating-various-fuel-prices-under-carbon-tax to convert carbon prices into changes in various fuel prices. For example, a $20 carbon price is equivalent to a gasoline tax of $0.18 per gallon. All prices and values are reported in 2015$. To convert 2015$ to 2018$, increase the dollar value by about 6 percent. For example, $19 in $2015 is $20.20 in $2018 (BLS 2019).

3 This report doesn't evaluate economic impacts of nonpricing policies, but some evidence indicates that reducing emissions via carbon pricing is both less costly and better for low-income households than similar reductions via nonpricing policies.

Executive Summary

This study, requested by the Vermont legislature through Act 11 in June 2018, provides objective information on methods to reduce greenhouse gas (GHG) emissions in Vermont. The report aims to inform the dialogue on climate policy in Vermont but is not intended to address the complete universe of public policy options nor offer recommendations on what policies the state should pursue. Vermont lawmakers, in consultation with stakeholders, are ultimately responsible for determining state policy to address GHG emissions, and we hope this report will aid them in their decision-making.

Vermonters are already acting to reduce GHG emissions and address climate change through the Regional Greenhouse Gas Initiative (RGGI), Efficiency Vermont, zero emissions vehicle (ZEV) standards, the state renewable energy standard (RES) and more. In 2015 (the most recent year data is available), Vermont's GHG emissions were about 10 million metric tons CO_2 equivalent (MMTCO_2e), a 2 percent decline from 2005 levels. However, emissions have been increasing since 2011, and the state is not on a pathway to meeting its emissions targets.[1] Vermont's emissions targets include: 26–28 percent below 2005 levels by 2025 (per the US Climate Alliance[2]) and 58 percent below 2005 levels by 2028 (per Vermont statute[3]). The state missed its 2012 target by a significant margin: actual emissions were about 12 percent below 2005 levels; the target was 37 percent below 2005 levels. If Vermont continues on its current course, it is not likely to achieve its GHG emissions goals: we project Vermont's emissions to be 11 percent below 2005 levels in 2025 in the absence of additional policies.

There are a number of policies that Vermont can pursue to further decarbonize. Each policy option has strengths and weaknesses, and each option has costs that may be unevenly distributed across Vermonters. In this report, we distinguish between two types of policies: *carbon pricing policies* and *nonpricing policies*. Carbon pricing policies such as carbon taxes or cap-and-trade programs provide an incentive to reduce emissions by increasing the price of fossil fuels in proportion to their emissions intensity; whereas nonpricing policies such as financial incentives, mandates, or direct investments do not rely on such a change in relative prices to reduce emissions. The scope of work for this project, as developed with the Vermont Joint Fiscal Office (JFO), includes a *quantitative* evaluation of the environmental and economic impacts of a set of carbon pricing policies and a limited *qualitative* discussion of nonpricing policies.

While a thorough quantitative analysis of nonpricing policies is beyond the scope of this project, we do provide a limited set of estimates to give Vermont policymakers some indication of the scale of emissions reductions possible through nonpricing policies. These estimates suggest that Vermont could reduce emissions in the range of 8–28 percent (relative to 2005) by 2025 with a comprehensive and ambitious set of nonpricing policies.[4] When this is combined with our estimates for emissions in the absence of policy, emissions are projected to be 19–40 percent below 2005 levels in 2025. However, substantial additional research and policy deliberation is necessary to determine both the specific policies to deliver these reductions and the full environmental and economic impacts of those policies.[5]

Our results indicate that, based on the pricing policies we examined, both the environmental and economic impacts of carbon pricing policies alone are likely to be relatively small, especially when compared with modeling analysis of the impacts of carbon pricing on the entire United States. Because Vermont's emissions are currently concentrated in transportation and heating, moderate carbon pricing alone is unlikely to produce the large reductions in GHG emissions that would be needed to meet Vermont's emissions targets. Historically, transportation and heating fuel uses are relatively insensitive to changes in fuel prices, and therefore we project relatively small emissions reductions in these sectors. The size of the environmental impacts of pricing policies depends on both the price and the number of sectors covered by the policy; the economic impacts depend also on how the revenues are used. Carbon revenue is an appealing feature of carbon pricing and can allow the state to address the negative consequences of carbon pricing, especially for low-income and rural households. For example, we find that using revenue for rebates (fixed payments per household) would make the average low-income households better off than they would be without carbon pricing (even ignoring the environmental benefits of the policy)—the rebates more than compensate the average low-income household for the increase in the cost of living caused by the carbon price.[6] On the other hand, our analysis shows that impacts on economic measures such as Vermont's gross domestic product (GDP) or total labor demand are likely to be negative under a rebate-only policy, but positive under other forms of revenue use—such as a reduction in the state's tax on wage income. As a result, Vermont's policymakers need to weigh the size of the overall economic costs with the distribution of those costs across households.

Below, we summarize the key results from the analysis on the environmental and economic impacts of carbon pricing in Vermont, as well as the combination of pricing and nonpricing policies.

Environmental Impacts

Greenhouse Gas Emissions

- Under the carbon pricing scenarios considered, Vermont's GHG emissions are projected to be 13–19 percent below 2005 levels in 2025 (with carbon prices ranging from $19–$77 per metric ton of CO2e) and 17–24 percent below 2005 levels in 2030 (with carbon prices ranging from $24–$98), in the absence of additional reductions from nonpricing policies.[7] For comparison, Vermont committed to emissions targets that are 26–28 percent below 2005 levels by 2025 when it joined the US Climate Alliance and the state has a statutory target of 58 percent below 2005 levels by 2028.

  - The size of reductions increases with both the carbon price and the number of sectors covered.[8] Table ES-1 reports emissions levels in 2025 under a) Transportation and Climate Initiative (TCI) cap-and-trade program focused only on the transportation sector, b) a Western Climate Initiative (WCI) cap-and-trade program that covers transportation and heating fuels, c) the ESSEX Plan, a carbon tax that covers all emissions except agricultural fuel and the electricity sector, and d) a high carbon price path ($60 in 2020 (in 2015$) rising at 5 percent above inflation annually) that covers all emissions except agricultural fuel and the electricity sector.[9]
  - Transportation and heating fuel uses are relatively insensitive (or inelastic) to moderate changes in fuel prices; emissions in these sectors are not projected to fall substantially in response to the carbon pricing levels considered here.

Table ES-1: Vermont GHG Emissions in 2025 by Alternative Policy Designs

GHG emissions relative to 2005

	Carbon Price Policy			
	TCI	**WCI**	**ESSEX**	**High Price**
Carbon Pricing-Only	-12.9%	-13.6%	-14.3%	-19.3%
Combined Pricing and Nonpricing approach	-31.6%	-32.5%	-33.7%	-38.0%

- Vermont is unlikely to meet its emissions targets with a carbon-pricing-only strategy, unless the carbon price is substantially higher than the range of prices modeled in this study.
- Carbon pricing and nonpricing strategies are not mutually exclusive. If Vermont pursued all the nonpricing policies discussed in this report, in addition to one of the carbon pricing policies considered in this report, a rough calculation suggests that the state could achieve reductions consistent with the Paris Agreement and the US Climate Alliance (26–28 percent below 2005

levels by 2025).[10] Table ES-1 also reports emissions reductions from a policy that combines the comprehensive VCAC policies and a more stringent RES policy with either the TCI or WCI cap-and-trade programs or the ESSEX Plan.

- The state's statutory goal of a 58 percent reduction in GHGs relative to 2005 by 2028 will be difficult to achieve with practical and realistic carbon pricing or nonpricing approaches, or a combination of both. However, the *high* price path modeled in this study ($60 in 2020 (in 2015$) rising at 5 percent above inflation annually) when combined with the comprehensive set of nonpricing policies, is estimated to produce emissions in 2030 that are 51 percent below 2005 levels—not far off the 2028 target.
- Emissions reductions from a Vermont-only policy (rather than a regional policy, such as TCI or RGGI) are expected to be partially offset by changes in emissions in neighboring Northeast states (a concept referred to as *emissions leakage*), though the projected leakage is very small in all scenarios studied: 0.2–2 percent of Vermont's emissions reductions are projected to be offset by increases in other states.
    - Drivers shifting their gasoline purchases to neighboring states such as New Hampshire could erode the effectiveness of a Vermont-only carbon price, but it is difficult to predict how much drivers will change their behavior.
    - A policy that covers all states in New England would not significantly change emissions reductions in Vermont (compared with an otherwise similar Vermont-only policy), but it would reduce emissions leakage, remove the incentive to shift fuel purchases to other states, and lead to much greater overall reductions in US GHG emissions.

Local Criteria Air Pollutant Emissions

- Decarbonization will lead to reductions in local criteria air pollutants that harm human health, such as nitrogen oxide (NO_x), ammonia (NH_3), carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter (PM_{10} and $PM_{2.5}$), and volatile organic compounds (VOCs).[11]
    - NO_x emissions are most responsive to carbon pricing; in 2025, emissions are projected to fall 2.1–11.6 percent relative to baseline, depending on the price and sectoral scope of the policy.
    - $PM_{2.5}$ emissions are least responsive to carbon pricing; in 2025, emissions are projected to fall 0.1–0.7 percent relative to baseline.
    - Using estimates on the value of reduced mortality and morbidity from reduced $PM_{2.5}$, NO_x, and SO_2 emissions (EPA 2017), reductions in these emissions are projected to provide annual benefits of $6.7–$38.9 billion (in 2015$) to Vermonters in 2025.[12]

Economic Impacts

The economic impacts of carbon pricing depend on the level of the price, the sectors covered, and how the revenue is spent. The use of revenue is as important as (or more important than) the price and sectoral coverage in determining the economic impacts of a carbon pricing policy. Macroeconomic, employment, and distributional impacts of carbon pricing all depend significantly on how the revenue is used. Additionally, alternative revenue uses often feature trade-offs between *efficiency*, the overall cost of the policy, and *equity*, the distribution of those costs across households. Finally, with few exceptions, we find that carbon pricing is not a free lunch; the gross cost (i.e., ignoring all environmental benefits of the policy) for the average Vermont household is positive. However, we also find that the benefits—reduced damages from CO_2 emissions and reduced health damages from local air pollutants—exceed costs for every carbon pricing scenario considered in this report.

Carbon Revenues

- A carbon pricing policy would generate significant carbon revenues for the state of Vermont. In 2025, the revenues are projected to be $74.7–$433.8 million (in 2015$), depending on the price and breadth of sectors covered. To put these numbers in comparison, in FY 2015, Vermont's income and estate taxes raised $843.9 million, and the consumption and property taxes raised $1,139.2 million and $1,062.1 million, respectively (VT JFO 2017).
    - Carbon pricing policies will also reduce revenues collected from existing taxes in Vermont, such as income and gasoline taxes, and increase the spending necessary to provide government services. A truly revenue-neutral policy must offset those effects.

State Gross Domestic Product and Sectoral Impacts

- With a carbon pricing-only policy, Vermont's state GDP is expected to be –0.01 to –0.09 percent lower in 2025 than it would be if the state does not adopt any additional decarbonization policies (business as usual, or BAU) and if the revenues are returned through fixed dividends (i.e., lump-sum rebates) to each household.[13] For example, if, in the absence of carbon pricing, state GDP would grow at an annual rate of 1 percent from 2018 to 2025, then the average rate of state GDP growth under these carbon pricing policies would be 0.987–0.997 percent over the same time period—these are changes that would be difficult to distinguish from statistical noise. By comparison, Vermont's state GDP fell over 1.6 percent between 2008 and 2009 during the last national recession.
    - The impacts are largely concentrated in the natural gas distribution sector (if natural gas heating is covered by the carbon price). Small but negative impacts in the construction, trade (fuel dealers and gas stations), and transportation (including trucking) sectors are partially offset by increases in output in communication and information and service industries.

    - The agricultural sector is projected to experience small declines in output, –0.1 to –0.5 percent lower output in 2025 compared with BAU, depending on the carbon price.
- If revenues are used to reduce the state's taxes on wage income, the model projects small increases in Vermont's state GDP (0.1 percent greater in 2025 than it would have been without the policy). Using the revenue to subsidize electricity rates produces a similar (but smaller) increase.
    - Relative to the policy with lump-sum rebates, industries that experience reduced output have smaller reductions and industries that experience increased output have larger increases when revenue is used to reduce taxes on wage income.
    - The electricity transmission and distribution sector experiences significant increases in output when revenue is used to subsidize electricity rates as demand for electricity increases with the decrease in retail rates.
- While policymakers may choose to allocate some portion of carbon revenues to financing various nonpricing policies or clean energy investments, it is beyond the scope of this analysis to quantitatively evaluate the macroeconomic impacts of such revenue use because of the difficulty of evaluating how that spending will be divided across industries and what economic effects it will have. Such investments could theoretically increase or decrease state GDP, but there is little empirical evidence on the state-level macroeconomic effects of such policies.

Shifts in Labor Demand

- The impacts on labor demand (total hours worked) largely mirror the impacts on output. Carbon pricing policies that decrease output relative to BAU (i.e., policies that use revenue for lump-sum rebates) will decrease labor demand, and policies that increase output relative to BAU (i.e., revenue used for cuts in other taxes or reductions in electricity rates) will increase labor demand.[14]
- We have not modeled the labor market effects of nonpricing policies. These policies could theoretically increase local employment and wages, for example, if they were to invest in infrastructure that boosts labor productivity in Vermont—but further analysis is required to estimate these potential employment impacts.

Changes in Economic Welfare

- The change in aggregate economic welfare, the most complete measure of the economic costs to households associated with a decarbonization policy, captures the impacts of changes in both prices and income on Vermont as a whole, but excluding all environmental benefits from the policy. These changes significantly depend on how the revenue is used.

- When revenues are returned to households via rebates, total economic welfare falls $4.3 million to $47.9 million (in 2015$) in 2020; in 2025, total economic welfare falls $7.1 million to $61.2 million (in 2015$), depending on the price level and the scope of sectoral coverage. These estimates reflect an average change in economic welfare of about $20 to $100 per Vermonter.
- When revenues are used to finance electricity subsidies, the change in economic welfare is about 20 percent smaller than the change in the policy with rebates; the subsidies reduce the economic impact of the carbon price by reducing the price of electricity.
- When revenues are used to finance reductions in Vermont's tax on wage income, the model projects an *increase* in aggregate economic welfare, even before considering the environmental benefits of the policy.[15]
- Modeling the change in economic welfare from dedicating revenue to nonpricing policies is beyond the scope of this study, though most evidence suggests it will be costlier than the other revenue options considered in this study.[16]

Net Benefits

- To determine whether the policy passes a cost-benefit analysis, the change in total economic welfare of each carbon pricing policy must be compared with the value of the environmental benefits, which incorporate reduced climate change damages and public health benefits from reduced air pollution. To evaluate the monetary benefit of reduced climate damages, we multiply the reductions in CO_2 emissions by the social cost of carbon (SCC).[17] For nonclimate health benefits, we use the estimates on reduced mortality and morbidity from reductions in local air pollutants, such as $PM_{2.5}$, NO_x, and SO_2 emissions.[18]
    - The combined climate and health benefits exceed the change in economic welfare for every carbon pricing scenario considered in this report, ranging from $7.1 million to $19.7 million in 2025.
    - As shown in the report, the climate and health benefits of carbon pricing policies are of similar magnitude.
    - The SCC required to justify the carbon pricing scenarios on a cost-benefit basis rarely needs to exceed $10 under the more moderate pricing scenarios. For example, the benefits of the WCI cap-and-trade program would still exceed the change in economic welfare in 2025 as long as the benefit of reduced CO2 emissions was greater than $5 per ton reduced (in 2015$).
    - Our analysis does not compare the climate and health benefits associated with the implementation of nonpricing policies to the costs of those policies. Both climate and health benefits could be large for such policies.[19]

Changes in Economic Welfare across Households

- The aggregate costs of these policies will not be evenly distributed across households. In Vermont, low-income and rural households spend a larger share of their income on fossil fuels than the average household, and thus will be disproportionately affected by higher energy prices. But that effect can be offset by the use of carbon pricing revenue, and in many cases these households would be financially better-off than they would be without the policy, even before considering any climate or health benefits—as shown in Table ES-2 below, where the two lowest-income quintiles (Quintiles 1 and 2) are better off with carbon pricing compared to no carbon pricing under all policies shown, when revenues are returned to households as rebates.
- Table ES-2 summarizes the change in economic welfare across income quintiles and urban/rural households for the TCI and WCI cap-and-trade programs, and the ESSEX Plan and high price carbon tax scenarios. The TCI and WCI cap-and-trade programs and the high price carbon tax scenarios rebates 100 percent of the revenue to in per-household rebates; the ESSEX Plan dedicates 25 percent of the revenue to rebates for low-income and rural households and 75 percent of the revenue for electricity subsidies to households and businesses.

Table ES-2: Change in Economic Welfare by Household Groups

Economic Welfare Change by Quintile in 2020 (2015$ per household)

	Carbon Price Policy			
	TCI	**WCI**	**ESSEX**	**High Price**
Quintile 1	$53	$96	$37	$414
Quintile 2	$18	$35	$24	$171
Quintile 3	-$18	-$38	$5	-$132
Quintile 4	-$22	-$15	-$46	-$82
Quintile 5	-$122	-$251	-$51	-$1,240
Urban (Chittenden County)	-$13	-$12	$0	-$122
Rural (Weighted average, all other counties)	-$20	-$42	-$8	-$191

- When carbon pricing revenue is used to provide lump-sum rebates (as in the TCI and WCI examples above), the policy raises economic welfare for lower- and middle-income households (i.e., these households are made better off, even ignoring the environmental benefits of the policy), because the rebates (which are a relatively large percentage of income for these households) more than offset the increase in expenditures for energy goods.
- Carbon prices with lump-sum rebates reduce economic welfare for higher-income households because the increase in energy expenditures is greater than the lump-sum rebates (which are relatively small compared to income for these households).
- Rural households are generally worse-off than urban households due to their higher share of energy expenditures, but the difference is not generally substantial. And, to the extent that rural households are also low-income, they may still be made better off (as discussed above).
- Economic welfare impacts are smaller when carbon pricing revenue is used to provide electricity subsidies and reductions in taxes on wage earnings. These impacts tend to be negative for the lowest-income households and positive for the highest-income households: the value of these subsidies or tax reductions is roughly proportional to income, and thus doesn't offset the low-income household's higher share of spending on energy goods. A similar result applies for rural households.
- Hybrid revenue use, such as the ESSEX Plan, can provide both protection to low-income households AND reduce the negative impacts on higher income households.
- Policies that use revenue to finance nonpricing policies such as electric vehicle purchase incentives and clean energy investment should, if well-implemented, further decrease emissions, but would forgo the benefits of returning the revenues through rebates, reductions in other tax rates, or subsidies to electricity rates.[20]

Methodology

To evaluate and compare the ability or potential of alternative carbon pricing policies to achieve reductions in GHG emissions, spur economic development, cause shifts in employment, and affect the cost of living in Vermont, we use a set of models developed by researchers at Resources for the Future (RFF). Using these models, we evaluate how environmental and economic policy outcomes vary by the level of the price, how the revenue is used, the number of sectors covered by the policy, and the geographic scope of the policy. In addition to evaluating the impacts on Vermont's GHG emissions and GSP, we also evaluate how consumer prices and household incomes change, how those changes affect aggregate state welfare, and how the changes are distributed across different household types, with a focus on low-income and rural Vermonters.

Conclusions

Given Vermont's current emissions profile, with emissions concentrated in transportation and heating fuels, decarbonizing the economy to meet the state's goals will not be easy. A quantitative evaluation of a set of carbon pricing policies suggests that a carbon pricing–only decarbonization strategy in Vermont is unlikely to produce the level of GHG emissions reductions required to meet the state's climate targets (unless the carbon price is set substantially higher than levels considered in this study). However, the analysis also demonstrates that the combination of a moderate carbon price (moderate in both price level and sectoral scope) with a comprehensive set of nonpricing approaches could allow the state to meet some, but not all, of its emissions reduction targets (though this combined approach would likely be costlier than achieving the same emissions reductions via a higher carbon price).

Economically, these types of carbon pricing policy approaches are most likely to produce small negative economic impacts ($20–$100 per person, ignoring all environmental benefits from the policy). However, the monetary benefits of reduced carbon dioxide emissions and cleaner local air are expected to exceed these costs. In choosing how to use the revenue raised through a carbon pricing policy, policymakers face trade-offs between environmental outcomes, overall economic costs, and the impacts on different types of households: returning all available revenue to households as rebates is likely to have the largest (though still quite small) overall economic cost but would more than compensate low-income households for higher energy prices, thus making these households better off overall (even when ignoring any environmental benefits); using all available revenue to reduce taxes on wage income may be beneficial to Vermont's economy overall but would impose costs on low-income households; devoting all available revenue to green investments may reduce emissions further but would impose higher costs on all Vermonters, including low-income and rural households, compared to other options that use revenues to partially or fully offset the economic burden imposed on households. In choosing how to use the revenue from a carbon pricing policy, policymakers will need to balance these trade-offs.