The Beacon Hill Institute

The Transportation & Climate Initiative: Its Economic Impacts on Vermont

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Executive Summary

The Transportation and Climate Initiative of the Northeast and Mid-Atlantic States (TCI) describes itself as "a regional collaboration of 12 Northeast and Mid-Atlantic states and the District of Columbia that seeks to improve transportation, develop the clean energy economy and reduce carbon emissions from the transportation sector." Vermont is a participating state.[1]

The founding document for TCI is a "Declaration of Intent," issued in 2010 and signed by transportation and environmental officials in 11 states. The declaration states that the purpose of TCI is "to reduce greenhouse gas emissions, minimize our transportation system's reliance on high-carbon fuels, promote sustainable growth, address the challenges of vehicle-miles traveled and help build the green energy economy."[1] The Initiative is "facilitated" by the Georgetown Climate Center, which worked closely with the Obama administration in its efforts to design and implement climate change policies.[2]

The Initiative would employ a method called "cap and invest" to achieve its goals. Under the "cap and invest" method, a "program administrator" in a TCI jurisdiction would set a cap on the amount of emissions that fuel distributors may produce. The initial cap would equal current baseline emissions, but the administrator would then, over time, reduce the cap as desired to reduce the total emissions being produced.

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1 Transportation Climate Initiative, (February 3, 2020) https://www.transportationandclimate.org/content/about-us.
2 Transportation Climate Initiative Declaration, (February 3, 2020) https://www.transportationandclimate.org/sites/default/files/TCI-declaration.pdf.
3 Georgetown Climate Center, (February 3, 2020) https://www.georgetownclimate.org/.

Fuel suppliers or regulated entities would have to obtain an "allowance" for every ton of emissions produced from the fuel it distributes into a participating jurisdiction. Allowances would be put up for auction and provided to the highest bidder.

The reduction in greenhouse gas (GHG) emissions under the various emissions cap scenarios proposed under TCI would confer economic benefits by abating the adverse effects of climate change. The logic follows that the more stringent the emissions cap imposed, the greater the environmental and economic benefits from mitigating GHG emissions. Potential benefits from such mitigation include avoiding crop and livestock losses, stopping property damages from climate-change-induced flooding, and other impacts caused by climate change. [4]

The Beacon Hill Institute estimated the costs and benefits to Vermont of participating in TCI. We report our results for three emissions cap scenarios from 2022 through 2026 to capture the short-term economic impacts on the Vermont economy. The scenarios are caps set at 20, 22.5, and 25 percent of baseline emissions. Table 1 displays the results of a cap set at 22.5 percent.

If Vermont were to set a 22.5 percent emissions cap on finished gasoline and on-road diesel, emissions would be reduced by .058 million metric tons of carbon dioxide or equivalent (MMTCO2E) by 2022 and .098 MMT of CO2E by 2026. The widely-used "DICE" model projects the social cost of CO2E at $36.95 per metric ton in 2022, increasing to $42.52 by 2026. Using the social costs of CO2E from 2022 through 2026, we project total social benefits of $2.14 million in 2022 and increasing to $4.17 million by 2026 in the 22.5 percent scenario.

[4] U.S. Environmental Protection Agency, Environmental Economics, Economics of Climate Change, https://www.epa.gov/environmental-economics/economics-climate-change.

The price of finished gasoline would increase by 20 cents per gallon and the price of on-road diesel would increase by 42 cents per gallon as a result of the 22.5 percent emissions cap. In 2022, the first year of implementation, business investment would fall by $36 million, disposable income by $237 million, and private employment by 1,180 jobs. The cost per average Vermont household would be $913.

By 2026, the cap would reduce business investment by $38 million, disposable income by $255 million, and private employment by 1,068 jobs. The cost per average Vermont household would increase to $984.

Table 1: The Costs and Benefits of a 22.5% Cap on Gasoline and Diesel Emissions

Variable	2022	2023	2024	2025	2026
Revenue changes from other state taxes ($, mil.)	-7	-7	-8	-8	-8
Private employment (jobs)	-1,180	-1,157	-1,135	-1,113	-1,068
Investment ($, mil.)	-36	-36	-37	-37	-38
Disposable income, real ($, mil.)	-237	-241	-246	-250	-255
Cost per household ($)	913	928	948	963	984
Total social cost of TCI ($, mil.)	123	121	115	109	104
Total social benefits of TCI ($, mil.)	2	3	3	4	4
Net benefits (-cost) of TCI ($, mil.)	-121	-118	-112	-105	-100

The total loss of output (measured in real GDP) due to the emissions cap would be $123 million in 2022 and $104 million in 2026. This loss represents the total social cost of the emissions cap imposed on Vermont. When adding the benefits from the reduction of GHG, the net cost of the emissions cap would be $121 million in 2022 and fall to $100 million by 2026.

The costs of Vermont's participation in TCI largely outweigh the benefits from the abatement of emissions. While benefits from the reduction of GHG would materialize under an emissions cap, Vermont and other cooperating jurisdictions would bear the costs, while all global citizens reap the benefits. Vermont lawmakers should keep this in mind when considering the state's participation in TCI.

Introduction

The Transportation and Climate Initiative of the Northeast and Mid-Atlantic States (TCI) Framework for a Draft Regional Policy Proposal, released on October 1, 2019, proposes a "Cap and Invest" system in which fuel suppliers would be required to purchase carbon allowances through an auction-based system.[5] The "cap" or limit for carbon emissions is determined through the use of a "combination of baseline emissions for three recent years, and projected emissions estimated through modeling." The cap would be set at a level that then declines every year at a rate chosen by TCI jurisdictions to support their emissions reduction goals. Analysis of the program's impact would also inform the cap level.

After determination of the cap, carbon allowances (designated allowances of carbon emissions from the combustion of the fossil fuel component of finished motor gasoline and on-road diesel fuel in the region) would be auctioned off to the highest bidder. Accompanying the auction process and new market for carbon allowances, a "regional organization would conduct carbon market monitoring, auction administration, and allowance tracking. This would include the establishment and maintenance of a system to collect and manage reported emissions-related data from

[5] Transportation Climate Initiative, Framework for a Draft Regional Policy Proposal, (February 3, 2020) https://www.transportationandclimate.org/sites/default/files/TCI-Framework_10-01-2019.pdf.

regulated entities and track allowance accounts." TCI will also monitor emission allowances and transportation fuel markets.

According to the TCI Framework for a Draft Regional Policy Proposal, "Fuel suppliers would be required to report emissions to TCI jurisdictions, plus supporting information. Compliance obligations would be calculated based on the emissions that occur when the affected fuel is combusted, using standard emission factors developed by the United States Environmental Protection Agency (US EPA), California, or other similar sources." To monitor emissions, "TCI Jurisdictions," most likely individual states or regional enforcement bodies, would have to create an electronic monitoring system. Reports would be required monthly or quarterly and would either be verified by a third-party, a government agency, or self-verified.

As the debate over policy responses to climate change intensifies, economists have generally advocated carbon taxes or suggested cap-and-trade laws as possible solutions.[6] Economists view greenhouse gas emissions (GHG) as a negative externality. GHG can be viewed as a negative externality when one considers the effects of the greenhouse gases on crop yields, ocean levels, ocean acidification levels, and a plethora of other areas directly affected by a rise in temperature caused by the greenhouse effect.

One way to curb an externality (GHG emissions) is to put a price on the harm it causes (shoreline destruction, decreased fishing, etc.). The most common instrument is a tax, which is intended to create a true market price for the externality (in this case, GHG emissions). As with all taxes, the increase in price resulting from a tax is supposed to decrease the consumption of the goods being taxed. An example of taxes with similar

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[6] National Bureau of Economic Research, Carbon Taxes vs. Cap and Trade: A Critical Review, (August 1, 2013) https://www.nber.org/papers/w19338.pdf.

goals is those levied on cigarettes and other so-called "sin taxes." Proponents claim that a carbon tax would give consumers an incentive to decrease their consumption of fossil fuels, which contribute to GHG emissions.

Cap-and-trade systems also impose an additional cost on carbon emissions, albeit in a very different way. The "cap" part of a cap-and-trade system entails establishing a cap of allowable emissions for a region, country, state, or locality. The emissions under the cap are partitioned into pre-determined allowances, which are then either allocated by need or auctioned off to the highest bidder. Those firms or individuals in possession of the allowances are free to trade or purchase the allowances from each other, hence the "trade" in cap-and-trade.

Existing Cap-and-Trade Systems

The European Union, the state of California, and China have instituted cap-and-trade systems akin to the TCI.

The European Union

The European Union instituted the world's first major carbon market and cap-and-trade system in 2005, called the EU Emissions Trading System (EU ETS).[7] As of today, 31 countries in the European Economic Area (EEA) are subject to emissions caps, but each country is granted a different quantity of emissions allowances.[8] Under the EU ETS, companies receive or buy emission allowances that they can trade with one another as

[7] The EU Emissions Trading System, (February 3, 2020) https://ec.europa.eu/clima/sites/clima/files/docs/0005/registered/9825553393-31_friends_of_the_earth_europe_en.pdf.

[8] Imperial College, "Evaluating the EU Emissions Trading System: Take it or leave it? An assessment of the data after ten years" (October 1, 2016) https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/publications/briefing-papers/Evaluating-the-EU-emissions-trading-system_Grantham-BP-21_web.pdf.

needed. They can also buy limited amounts of international credits from emission-saving projects around the world. Emission-saving projects include carbon-capture systems and other mechanisms that remove carbon emissions from the atmosphere.

The EU ETS regulates carbon dioxide (CO_2) emissions from power and heat generation, energy-intensive industry sectors including oil refineries, steelworks and the production of iron, aluminum, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals, commercial aviation, nitrous oxide (N_2O) from the production of nitric, adipic, and glyoxylic acids, and glyoxal, perfluorocarbons (PFCs) from aluminum production.[9]

The environmental impact from EU ETS has been studied in detail by the EU and outside entities.[10] According to most recent estimates, during the same period the EU ETS has been in place, total carbon emissions increased, not decreased, in the countries regulated by the system during the initial years the cap-and-trade system was implemented (2005-2007). The EU was reluctant to stymie economic growth, especially in countries struggling in the aftermath of the 2008 global recession. To assist these countries in their recoveries, the EU increased the quantity of emissions allotments permitted under the cap to keep the price of carbon-producing products low. The market price of carbon under EU ETS reached a record-low of €0.03 in 2007 and did not begin to rise until the EU transitioned ETS from its "Pilot Phase" to "Phase I" in 2008.[11]

Phase I resolved the issues with reducing emissions from the Pilot Phase. Researchers at Imperial College in London, UK concluded that EU ETS led to an

[9] Ibid, 8.
[10] Ibid, 8.
[11] Ibid, 8.

estimated 100-200-million-ton reduction (2.4-4.7% reduction) in CO_2 emissions during the first two years of Phase I alone.[12] From the beginning of the EU ETS to 2015, revenue collected from the auctioning of allowances totaled €4.9 billion.

California

California launched its cap-and-trade system in 2013.[13] According to the Center for Climate and Energy Solutions, "The cap-and-trade rule applies to large electric power plants, large industrial plants, and fuel distributors (e.g., natural gas and petroleum). Around 450 businesses responsible for about 85 percent of California's total greenhouse gas emissions must comply." The California Air Resources Board (CARB) is the entity responsible for enforcing the cap. The cap-and-trade rules first applied to electric power plants and industrial plants that emitted 25,000 tons of carbon dioxide or equivalent per year or more. In 2015, the program was extended to fuel distributors meeting the 25,000-metric ton threshold. In addition to the freely allocated emissions allowances from the state government, allowances are also sold to the highest bidder via auction. Between 2013 and 2018, California's cap-and-trade auction system generated $9.3 billion in revenue.[14]

Through 2016, the price of gasoline per gallon in California is estimated to have risen by 11 cents and the price of diesel fuel per gallon by 13 cents as a result of California's cap-and-trade system.[15] It is also estimated that since the implementation of

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[12] Ibid, 8.
[13] Article 5, California Cap on Greenhouse Gas Emissions, (April 1, 2019) https://ww3.arb.ca.gov/cc/capandtrade/capandtrade/ct_reg_unofficial.pdf.
[14] California Air Resources Board, (March 19, 2019) https://ww2.arb.ca.gov/news/report-cap-and-trade-spending-doubles-14-billion-2018.
[15] Legislative Analyst's Office, (March 4, 2016) https://lao.ca.gov/reports/2016/3438/LAO-letter-Tom-Lackey-040716.pdf.

a cap-and-trade, motorists spend about $2 billion more annually for transportation fuel.[16]

China

In December of 2017, China formally launched its nationwide emission trading system (ETS).[17] China set the initial price of carbon at $10 per ton, with the cap regulating 1,700 carbon-intensive sectors including energy production. China instituted its cap-and-trade system with the goal of decreasing carbon emissions by a quarter or more by 2030.[18] According to Reuters, the nationwide ETS aims to cover 8 billion tons of carbon dioxide emissions per annum from around 100,000 industrial plants when the trading scheme is fully launched.

Trading of carbon on the Chinese ETS market has yet to commence, as China has been developing the necessary regulations and technical infrastructure for the market since 2017. The Chinese expect the first trades in ETS to take place sometime in 2020.[19]

Vermont Climate Policy

Vermont's Governor Jim Douglas, along with nine other New England Governors, signed a memorandum of understanding officially joining the Regional Greenhouse Gas Initiative (RGGI) in 2006. RGGI is a regional cap-and-invest agreement between nine Northeastern states. Under the rules of the initiative, Vermont receives CO2 allowances in proportion to the number of electric power plants in the state. Those

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[16] Ibid, 15.
[17] "The China Carbon Market Just Launched, And It's the World's Largest. Here's How It Can Succeed" (December 19, 2017) https://www.forbes.com/sites/energyinnovation/2017/12/19/the-china-carbon-market-just-launched-and-its-the-worlds-largest-heres-how-it-can-succeed/#2671f2a37ce6.
[18] China Energy Policy Solutions, (July 1, 2017) https://china.energypolicy.solutions/docs/20160704_ExecutiveSummary_EN--FINAL.pdf.
[19] Ibid, 18.

allowances are invested in "consumer benefit programs", including energy efficiency, renewable energy, direct energy bill assistance, and other greenhouse gas reduction programs.[20]

As members of RGGI, Vermont and the participating states agreed to eliminate 10 percent of power sector GHG emissions by 2018. As of 2019, Vermont and the participating RGGI states have reduced GHG emissions from the power sector by nearly 50%, surpassing the initial emissions reduction goal. This cut eclipses the median national figure by approximately 90%.[21]

Much of climate change legislation in Vermont since joining RGGI has consisted of various adjustments to taxes and fees on the sale of fossil fuels. The goal of these taxes is to disincentivize fossil fuel consumption, thus reducing carbon emissions and slowing climate change.

As of 2020, taxes on gasoline in Vermont consist of: (1) a fixed 12.1 cents-per-gallon Transportation Fund tax, (2) a 4% percentage-of-price Transportation Fund assessment with a minimum and maximum cents-per-gallon equivalent of 13.4 cents and 18 cents respectively, (3) a 2% percentage-of-price Transportation Infrastructure Bond (TIB) Fund assessment with a minimum cent-per-gallon equivalent of 3.90 cents, and (4) a 1 cent-per-gallon petroleum clean-up fund fee. State levies on diesel fuel consist of: (1) a fixed 28 cents-per-gallon Transportation Fund tax, (2) a fixed 3 cents-per-gallon TIB Fund assessment, and (3) a 1 cent-per-gallon petroleum clean-up fund fee.

[20] State of Rhode Island Office of Energy Resources (Accessed October 29, 2020). http://www.energy.ri.gov/policies-programs/programs-incentives/rggi.php
[21] Sarah Shemkus, "How much credit does RGGI deserve for the Northeast's progress on emissions?", *energynews.us*, (October 25, 2019). https://energynews.us/2019/10/25/northeast/how-much-credit-does-rggi-deserve-for-the-northeasts-progress-on-emissions/

The Vermont legislature passed landmark climate change legislation this September in the Global Warming Solutions Act (H.688). H.688 requires reductions in Vermont's greenhouse gas emissions tied to three time periods: 2025, 2030, and 2050.[22] Reductions come in three stages. By January 1, 2025, Vermont must reduce GHG emissions by no less than 26% below 2005 emissions. By January 1, 2030, it must reduce GHG emissions by no less than 40% below 1990 emissions. By January 1, 2050, it must reduce GHG emissions by no less than 80% below 1990 emissions.[23]

The Global Warming Solutions Act also creates a "Vermont Climate Council" tasked with formulating set the specific programs and strategies required to achieve the GHG emissions reduction goals. The Climate Council is required to submit its plans by December 1, 2021. Every four years, the Climate Council will reconvene to update the plan and ensure the state is on track to reach the required reduction in GHG emissions.

Though passed by the House and Senate, the Global Warming Solutions by large majorities, the bill was vetoed by Governor Phil Scott on September 16, 2020. According to the Associated Press, "Scott said in his veto letter on [September 16] that he "shares the Legislature's commitment to reducing greenhouse gas emissions and enhancing the resilience of Vermont's infrastructure and landscape in the face of a changing climate" but had problems with three areas of the bill, including one that "could lead to costly litigation and delay."[24] Governor Scott also vetoed the legislation because he believed it would empower unelected officials to make decisions about the action of climate change without the consent of the citizens of Vermont. The House and the Senate

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[22] Global Warming Solutions Act H.688, (Accessed October 31, 2020). https://legislature.vermont.gov/Documents/2020/Docs/ACTS/ACT153/ACT153%20Act%20Summary.pdf.
[23] Ibid.
[24] "Vermont governor vetoes global warming solutions act," *The Associated Press*, (September 16, 2020). https://apnews.com/article/legislature-climate-climate-change-vermont-82e23db1d42da82c646fcfdeac2c180c

overrode the Governor's veto on September 22, and the Global Warming Solutions Act is now law.[25]

Vermont Carbon Emissions History

If Vermont were to participate in the region-wide Transportation Climate Initiative, GHG emissions from the combustion of finished gasoline and on-road diesel destined for final consumption would be capped between 20-25 percent. The Vermont economy produces GHG emissions by burning fossil fuels. As a result, the transportation, electricity generation, residential, commercial heating, and industrial sectors produce the vast majority of GHG emissions in Vermont. Vermont GHG emissions from the transportation sector comprise 35.7 percent of gross GHG emissions.[26] Table 2 displays emissions produced from on-road gasoline and diesel for the years 2013 through 2018.

Table 2: Vermont Gasoline and Diesel Fuel GHG Emissions for Selected Years (MMTCO2E)

Emissions	2013	2014	2015	2016	2017	2018
CO2E by Fuel						
Finished Motor Gasoline	2.4	2.4	2.4	2.5	2.5	2.5
On-Road Diesel	1.1	1.0	1.1	1.0	1.0	1.0
Total Emissions	3.5	3.4	3.5	3.5	3.5	3.5

The total emissions from finished gasoline and on-road diesel in Table 2 establish the baseline GHG emissions that would be affected by the cap outlined in TCI.

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[25] Kevin McCallum, "Lawmakers Override Scott's Veto of Global Warming Solutions Act," *Seven Days VT*, (September 22, 2020). https://www.sevendaysvt.com/OffMessage/archives/2020/09/22/lawmakers-override-scotts-veto-of-global-warming-solutions-act.

[26] Rhode Island Department of Environmental Management, (Accessed October 20, 2020) http://www.dem.ri.gov/programs/air/ghg-emissions-inventory.php

The Costs and Benefits of Vermont's Participation in TCI

Each participating jurisdiction, in this case, Vermont would set a cap on emissions from finished motor gasoline and on-road diesel. We assume that Vermont, if it were to participate, would set emissions caps of between 20-25 percent. In our analysis, we consider the period 2022 to 2026, to allow for the implementation of the program.

Emissions subject to the cap would be 3.5 MMTCO2E in 2018, the latest data available. We project Vermont emissions from finished gasoline and on-road diesel through 2026 using the compound annual growth rate (CAGR) from 2008 to 2018. Table 3 contains the results.

Table 3: Vermont Baseline Gasoline and Diesel GHG Emissions Projections

Emissions	2022	2023	2024	2025	2026
CO2E from Fossil Fuel Combustion (Baseline)					
Finished Gasoline	2.4	2.4	2.3	2.3	2.3
On-Road Diesel	1.0	1.0	1.1	1.1	1.1
Total Emissions	**3.4**	**3.4**	**3.4**	**3.4**	**3.4**
CO2E from Fossil Fuel Combustion (20%)					
Finished Gasoline	2.4	2.3	2.3	2.3	2.2
On-Road Diesel	1.0	1.0	1.0	1.0	1.0
Total Emissions	**3.4**	**3.3**	**3.3**	**3.3**	**3.2**
CO2E from Fossil Fuel Combustion (22.5%)					
Finished Gasoline	2.4	2.3	2.3	2.2	2.2
On-Road Diesel	1.0	1.0	1.0	1.0	.9
Total Emissions	**3.4**	**3.3**	**3.3**	**3.2**	**3.1**
CO2E from Fossil Fuel Combustion (25%)					
Finished Gasoline	2.4	2.3	2.2	2.2	2.1
On-Road Diesel	1.0	1.0	1.0	.9	.9
Total Emissions	**3.4**	**3.3**	**3.2**	**3.1**	**3.0**

We project that baseline emissions subjected under TCI will fall to 3.4 MMTCO2E by 2022 and will remain at 3.4 MMTCO2E by 2026. Under a 20 percent cap scenario, we project that emissions will fall to 3.4 MMTCO2E in 2022 and fall to 3.2 MMTCO2E by 2026. In a scenario whereby a 22.5 percent emissions cap is imposed, we project emissions to fall to 3.4 MMTCO2E in 2022 and decrease to 3.1 MMTCO2E by 2026. And in the scenario where a 25 percent emissions cap is set, we project emissions in 2022 would be 3.4 MMTCO2E and decrease to 3.0 MMTCO2E by 2026.

The law of supply states that if the quantity of a good supplied goes down, which occurs under an emissions cap, then the price will be driven up. Therefore, as a cap on emissions from the combustion of finished gasoline and on-road diesel is enforced, the prices of each product will increase.

We account for this by calculating the percentage decrease in the quantity of both finished gasoline and on-road diesel provided and projecting the resulting change in price of each product to 2022. This allows us to calculate the increase in the price of each product due to the various emissions cap scenarios. The Appendix contains the details of these calculations.

The TCI emissions cap would apply only to Vermont emissions from the combustion of gasoline and on-road diesel destined for final sale. Both products have very low responses, or elasticities, to changes in price. As a result, the proposed emissions cap scenarios would have a significant impact on prices in Vermont. In the 20 percent emissions cap scenario, the price of finished gasoline would increase by 17 cents per gallon and the price of on-road diesel by 36 cents per gallon. If a 22.5 percent emissions cap were imposed, the price of finished gasoline would increase by 20 cents per gallon and the price of on-road diesel by 42 cents per gallon. And in a scenario whereby a 25 percent emissions cap is enforced, the price of finished gasoline would increase by 25 cents per gallon and the price of on-road diesel by 52 cents per gallon.

To analyze the economic and global temperature effects of greenhouse gas (GHG) emission reduction policies, BHI utilized the 2017 Dynamic Integrated model of Climate and the Economy (DICE).[27] As the name of the model indicates, the DICE 2017 model integrates an economic model with a climate model. A thorough description of the DICE 2017 model, as well as results related to different policy guidelines, like the Kyoto Protocol or the Stern Review, is available in Nordhaus (2008).[28] We use the DICE 2017 model to calculate the social cost of CO2E and, in turn, the social benefits of carbon reductions resulting from the various emissions cap scenarios laid out in the TCI modeling.

BHI used the DICE model to calculate the social cost of CO2E for each year of our analysis. We applied the social cost of carbon from the DICE model to our estimate of the reduction in CO2E resulting from the different emissions cap scenarios. Table 5 displays the results.

If Vermont participated in TCI, BHI projects emissions would be reduced by .047 MMT of CO2E by 2022 and .060 MMT of CO2E by 2026 in a 20 percent emissions cap scenario. In a 22.5 percent emissions cap scenario, emissions would fall by .058 MMT of CO2E by 2022 and .098 MMT of CO2E by 2026. And in a 25 emissions cap scenario, emissions would decrease by .069 MMT of CO2E by 2022 and .14 MMT of CO2E by 2026.

The DICE model projects the social cost of CO2E to be $36.95 per metric ton of CO2E in 2022, increasing to $42.52 per metric ton of CO2E in 2026. As a result, in a 20

[27] The latest version of the DICE 2017 model is available online at http://nordhaus.econ.yale.edu/DICE2007.htm. We downloaded the model for the runs reported here on April 1, 2019.
[28] Nordhaus, William, *A Question of Balance: Weighing the Options on Global Warming Policies*, 1. ed., New Haven, CT: Yale University Press, May 2008.

percent emissions cap scenario, the reduction in emissions would provide $1.75 million in social benefits in 2022 and $2.57 million in social benefit in 2026. A 22.5 percent emissions cap scenario would result in $2.14 million in social benefits in 2022 and $4.17 million in 2026. In a 25 percent emissions cap scenario, total social benefits would be $2.55 million in 2022 and rise to $5.80 million by 2026.

To estimate the economic effects of Vermont participating in TCI, BHI has developed a Computable General Equilibrium (CGE) model. The purpose of the BHI model, called STAMP (State Tax Analysis Modeling Program), is to identify the economic effects of tax changes on a state's economy.[29] Using the STAMP model, we find that the increase in the price of finished gasoline and on-road diesel resulting from various emissions caps would generate a less competitive business environment, resulting in slower economic growth, lower employment, disposable income, and investment.

BHI modified the STAMP model to accommodate the increase in price in both finished gasoline and on-road diesel. The Appendix contains the details of this procedure.

Table 5 shows that a 20 percent emissions cap would reduce investment by $27 million, disposable income by $178 million, and private employment by 920 jobs in 2022. The cost per average Vermont household would be $687 in 2022. The net cost of the emissions cap, that is the total social benefits minus the total social cost (loss of state gross domestic product) would be $100 million. Under a 20 percent emissions cap scenario, the adverse economic effects of the emissions cap would reduce other tax revenues by $5 million.

As time passes, a 20 percent emissions cap would reduce investment by $29 million, disposable income by $196 million, and private employment by 851 jobs in 2026.

[29] For a description of the model see www.beaconhill.org.

The cost imposed per average Vermont household would be $755 in 2026. The net cost of the emissions cap to the economy would be $86 million. Under a 20 percent emissions cap scenario, the adverse economic effects of the emissions cap would reduce other tax revenues by $6 million.

Table 5: The Costs and Benefits of a 20% Emissions Cap on Vermont

Variable	2022	2023	2024	2025	2026
Revenue changes other state taxes ($, mil.)	-5	-5	-5	-6	-6
Private employment (jobs)	-920	-904	-888	-872	-851
Investment ($, mil.)	-27	-28	-28	-29	-29
Disposable income, real ($, mil.)	-178	-184	-188	-192	-196
Cost per household ($)	687	708	724	739	755
Total social cost of TCI ($, mil.)	102	99	95	92	89
Total social benefits of TCI ($, mil.)	2	2	2	2	3
Net benefits (-cost) of TCI ($, mil.)	-100	-97	-93	-90	-86

Table 6 shows that a 22.5 percent emissions cap would reduce investment by $36 million, disposable income by $237 million, and private employment by 1,180 jobs in 2022. On average, Vermont households would incur a cost of $913. The net cost of the emissions cap would be $121 million. The adverse economic effects of the emissions cap would reduce other tax revenues by $7 million.

By 2026, a 22.5 percent emissions cap would reduce investment by $38 million, disposable income by $255 million, and private employment by 1,068. The average Vermont household would incur a cost of $984. The net cost imposed on the economy from the emissions cap would be $100 million. The adverse economic effects of the emissions cap would reduce other tax revenues by $8 million.

Table 6: The Costs and Benefits of a 22.5% Emissions Cap on Vermont

Variable	2022	2023	2024	2025	2026
Revenue changes from other state taxes ($, mil.)	-7	-7	-8	-8	-8
Private employment (jobs)	-1,180	-1,157	-1,135	-1,113	-1,068
Investment ($, mil.)	-36	-36	-37	-37	-38
Disposable income, real ($, mil.)	-237	-241	-246	-250	-255
Cost per household ($)	913	928	948	963	984
Total social cost of TCI ($, mil.)	123	121	115	109	104
Total social benefits of TCI ($, mil.)	2	3	3	4	4
Net benefits (-cost) of TCI ($, mil.)	-121	-118	-112	-105	-100

Table 7 shows that a 25 percent emissions cap would reduce investment by $44 million, disposable income by $294 million, and private employment by 1,480 jobs in 2022. The cost per average Vermont household would be $1,133. The net cost of the emissions cap would be $141 million. The adverse economic effects of the emissions cap would reduce other tax revenues by $9 million.

As time passes, a 25 percent emissions cap would reduce investment by $46 million, disposable income by $315 million, and private employment by 1,366 jobs in 2026. The total cost per average Vermont household would be $1,215. The net cost imposed on the economy would be $119 million. The adverse economic effects of the emissions cap would reduce other tax revenues by $6 million.

Table 7: The Costs and Benefits of a 25% Emissions Cap on Vermont

Variable	2022	2023	2024	2025	2026
Revenue changes other state taxes ($, mil.)	-9	-9	-9	-10	-4
Private employment (jobs)	-1,480	-1,448	-1,421	-1,393	-1,366
Investment ($, mil.)	-44	-45	-45	-46	-46
Disposable income, real ($, mil.)	-294	-299	-303	-310	-315
Cost per household ($)	1,133	1,153	1,166	1,194	1,215
Total social cost of TCI ($, mil.)	144	143	137	131	125
Total social benefits of TCI ($, mil.)	3	3	4	5	6
Net benefits (-cost) of TCI ($, mil.)	-141	-140	-133	-126	-119

Conclusion

Vermont lawmakers have been aggressive in enacting policies to combat climate change. Cap and trade schemes, such as the one outlined in TCI, are, however, a problematical tool to address climate change, with consequential costs that directly hit household's disposable income.

Vermont's participation in TCI would confer benefits to the global community from the reduction of GHG emissions. However, we suspect that such a large increase in the price of gasoline will force gasoline entering the state to be formulated with a larger amount of ethanol. Wherever the ethanol production process takes place, the creation of additional GHG emissions could offset the emissions reduction in Vermont or other TCI jurisdictions as a result. If this were to happen, there could also be significant unforeseen costs for car owners and fuel suppliers due to a lack of sufficient infrastructure to handle higher blends of ethanol. It is important to note that our analysis does not capture additional regulatory costs to fuel suppliers that would result under TCI.

Also, while transportation emissions represent a large portion of total emissions in the TCI region, any emissions cap on finished gasoline and on-road diesel in Vermont and other TCI jurisdictions would have unnoticeable effects on global emissions. The Vermont emissions subject to the proposed emissions caps are but a fraction of global emissions. Global GHG emissions were 50.9 gigatons of CO2E in 2017, compared to Vermont emissions subjected to emissions caps under TCI of 3.5 MMTCO2E.[30] Nonetheless, the reduction in Vermont GHG emissions and other TCI jurisdictions would provide an economic benefit against the baseline case of no emissions reduction.

[30] Netherland Environmental Assessment Agency, "Trends in global CO2 and total greenhouse gas emissions: 2018 report," (May 12, 2018), https://www.pbl.nl/en/publications/trends-in-global-co2-and-total-greenhouse-gas-emissions-2018-report.

Vermont GHG emissions subjected under TCI are only 0.007 percent of global GHG emissions.

The Vermont economy would suffer if it were to participate in TCI. An emissions cap, while providing negligible benefits, would cost thousands of jobs, millions in investment, and millions of dollars in lower incomes and real GDP by 2026.

The costs of Vermont partaking in the TCI far outweigh the benefits. Moreover, citizens of Vermont along with other TCI jurisdictions would face the burden of the costs, while all citizens of the world share the small benefits.

Appendix

BHI used a generic multisector STAMP model to estimate the economic cost of a proposed cap and investment of finished gasoline and on-road diesel in Vermont. The existing models provide fields in which we can enter changes in the state income, corporate, sales, and motor fuels tax.

BHI then forecasted the baseline emissions from the combustion of finished gasoline and on-road diesel within the TCI region, using a compound annual growth rate (CAGR). BHI estimated that baseline emissions in the region will fall by 8 percent over the period 2022 through 2032. BHI next estimated scenarios whereby CO2E emissions from the consumption of on-road diesel and finished motor gasoline destined for final sale were capped at 20 percent, 22.5 percent, and 25 percent, leading to an increase in the price in subjected motor fuels. We subtracted the annual cap in emissions by the baseline fall in emissions to find our annual price increase for both products in Vermont. To accomplish this, BHI (1) estimated the price elasticities of demand for the different fuels specified in the Transportation and Climate Initiative MOU, (2) forecasted the price of fuels for the time period, and (3) estimated the price change for each fuel that would result from the various emissions cap scenarios.

BHI utilized data for on-road diesel and finished motor gasoline and consumption from the U.S. Department of Energy's Energy Information Administration (EIA) for New England to calculate price elasticities of demand for each product.[31] We calculated price elasticities of demand for the finished gasoline and on-road diesel portion of the transportation sector. We used a log-log model to calculate the elasticities using the following equation:

$$\log(consumption) = \beta + \log(price) + \varepsilon,$$

where β is the intercept, α is the elasticity, and ε is the error term.

Table A1: Elasticities of Demand for Finished Gasoline and On-Road Diesel in Vermont

Fuel	Transportation
On-Road Diesel	-0.112
Gasoline	-0.197

The EIA provides historical price data for each motor fuel in the transportation sector. However, we need to estimate the future prices of the motor fuels for our period. We used a five year average of gasoline and diesel prices as our future prices using data on monthly average posted prices for fuel from the State of Vermont Agency of Transportation.

[31] U.S. Department of Energy, Energy Information Administration, Rhode Island State Profile and Energy Estimates, More Data & Analysis in Rhode Island by Source, (accessed March 2019), https://www.eia.gov/state/search/#?1=79&2=220&r=false

The EIA provides carbon dioxide emissions coefficients by fuel per unit of volume and per million BTU. We converted the emissions coefficients into metric tons for motor fuels to match the measure used in the EIA price data.

Using our price elasticity of demand we calculated the price change that would result from the cap in carbon emissions for on-road diesel and gasoline. The EIA provides data on emissions by motor fuel in the transportation sector.

We assume that the emissions reduction under the cap would fall in line with the reduction in the supply of on-road diesel and gasoline. Thus, we divide the percentage decrease in quantity by the elasticity under the carbon emissions cap for on-road diesel and gasoline and then multiply that result by the forecasted price without the cap to get our estimate of the price increase. For example, we multiplied the decrease in the quantity of gasoline (1.38 percent) by the elasticity for gasoline (-0.197) to calculate the increase in the price of gasoline of 17 cents in 2022. Once again, this process was repeated for on-road diesel fuels.

Next, we insert the increase in the price of on-road diesel and gasoline that would result under the proposed emissions cap into our models. We also use obtained estimates of the resulting revenue figures from the proceeds of auctions allowances as inputs to the STAMP models.

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