The Transportation & Climate Initiative: Its Economic Impacts on Virginia

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Foreword

It has been said all models are wrong, but some models are useful. At our request, and in response to similar requests from stakeholders in other states, the Beacon Hill Institute for Public Policy (BHI) has completed modeling on the potential climate and economic impacts of the proposed Transportation and Climate Initiative (TCI).

The TCI compact of 12 states and the District of Columbia proposes to cap, tax, and trade allowances for CO2 emissions and gradually reduce the use of fossil fuels for transportation within the Virginia to Maine region. Our participation starting in 2022 will be decided by the 2021 Virginia General Assembly.

The results from Beacon Hill's review differ dramatically from the modeling produced by advocates for the regional compact and point to some major flaws in the assumptions behind arguments for TCI. It projects higher costs for on-road motor fuels, major economic downsides, and negligible environmental benefits. A previous analysis in 2019 disputed the claimed health benefits from reduced fuel usage.

The cap and trade scheme could force up retail gasoline prices by 33 cents per gallon in Virginia, substantially higher than the initial 17 cents per gallon projected by the advocates, with the impact even greater on the cost of diesel fuel in some states. One oversight in the analysis done by TCI advocates was failing to recognize diesel will respond differently than gasoline to the rationing imposed. BHI expects an increase of 28 cents per gallon to diesel costs in Virginia.

These will, of course, be in addition to the Virginia gasoline and diesel tax hikes already approved by the 2020 Virginia General Assembly, scheduled to basically double those taxes by next July for much of Virginia. TCI's carbon tax could nearly double them again.

Even with the substantially higher allowance prices that BHI expects, the 12-state region will struggle to achieve the targeted 25% reduction in transportation fuel use and thus CO2 emissions over the years.

As with any proposed tax increase on a basic and crucial economic commodity such as motor fuels, the economic impact ripples through the entire economy.

Virginians will pay more at the pump but also pay more for all the goods and services dependent on transportation, adding hundreds of dollars of cost per household per year. BHI also projects lower investment, job creation and household income because of the taxes and fuel rationing.

The economic costs of TCI dwarf by orders of magnitude any potential benefit from reduced emissions, even using the Dynamic Integrated Climate-Economy (DICE) model used by the U.S. Environmental Protection Agency to calculate a social cost of carbon. If TCI does exactly what it promises, the reduction in CO2 produced is small even for the region, and infinitesimal on the global scale.

The Transportation and Climate Initiative will not do what it promises. Other efforts to cap emissions in this manner have not lived up to their projections.

TCI is based on unrealistic assumptions about the ability of the economy to move quickly away from fossil fuels toward electric vehicles, especially commercial activity dependent upon diesel. It is based on unrealistic assumptions about future demand. As to the actual retail cost of these fuels in years to come, with or without the added carbon taxes, history even before this recession showed they defy prediction. Projecting five years out is unreliable and projecting ten years out is futile. But the outcome of the TCI models depend on such long term projections.

Stripped of its pretenses, this is just a tax increase – but one that is unpredictable and unreliable. The money collected by damaging our economy in this way will not produce improved transportation, better health, better economic outcomes, or lower future air temperatures. A General Assembly that directs the tax revenue to be spent one way can be reversed by a future General Assembly, which spends it somewhere else.

Virginia should decline to join this compact.

Christian N. Braunlich
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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." Virginia is a potential participating state.[1]

The founding document of the 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 the 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."[2] 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.[3]

The Initiative would employ a method called "cap and invest" to achieve its goals. Under this 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 of the Northeast and MidAtlantic States, (February 3, 2020) https://www.transportationandclimate.org/content/about-us.
[2] Ibid, 1.
[3] Georgetown Climate Center, (February 3, 2020) https://www.georgetownclimate.org/.

A fuel distributor would have to obtain an "allowance" for every ton of emissions produced from the fuel it distributes. 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 the 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]

TCI would, however, impose costs by raising the cost of motor fuels, and the costs would far outweigh the benefits. In the study, the Beacon Hill Institute estimates the costs and benefits to Virginia of participating in the Transportation Climate Initiative. To capture the short-term economic impacts on the Virginia economy, we report our results for three emissions cap scenarios from 2022 through 2026. The scenarios are caps set at 20, 22.5, and 25 percent of baseline emissions. For example, a 25 percent emissions cap would reduce the baseline emissions from the combustion of motor fuels by 25 percent. ES-Table 1 displays the results of a cap set at 25 percent.

If Virginia were to set a 25 percent emissions cap on finished gasoline and on-road diesel, we project emissions in 2022 would fall to 39.0 million metric tons of carbon dioxide equivalent (MMTCO2E) and to 36.0 MMTCO2E by 2026.

The often-used Dynamic Integrated model of Climate and the Economy (DICE), which integrates an economic model with a climate model, allows us to estimate the

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

social cost of CO2E. It is important to note, however, the DICE model may overestimate the social cost of carbon as it fails to include the fertilization benefit of carbon dioxide.[5] Nevertheless, because it is so widely recognized for its validity, we use the DICE model to measure the benefits of GHG reductions in Virginia.

The model projects the social cost of CO2E at $39.53 per metric ton in 2022, increasing to $45.81 by 2026. Using the social costs of CO2E from 2022 through 2026, total social benefits of avoiding these costs would be $31.62 million in 2022 and $33.79 million by 2026 if a 25 percent emissions cap were set.

Under a 25 percent cap on emissions from finished gasoline and on-road diesel, the adverse economic effects of the emissions cap would reduce other tax revenues by $48 million in 2022. By 2026, the adverse economic effects of the emissions cap would reduce other tax revenues by $43 million.

Under a 25 percent cap, the price of finished gasoline would increase by 33 cents per gallon and the price of on-road diesel by 28 cents per gallon. In 2022, the first year of implementation, business investment would fall by $165 million, disposable income by $2,307 million, and private employment by 12,884 jobs. The cost per average Virginia household would be $737.

By 2026, the cap would reduce business investment by $187 million, disposable income by $2,449 million, and private employment by 11,424 jobs. The cost per average Virginia household would increase to $782.

[5] Dayaratna, Kevin and McKitrick, Ross and Kreutzer, David, Empirically-Constrained Climate Sensitivity and the Social Cost of Carbon (April 5, 2016).

ES-Table 1: The Costs and Benefits of a 25% Cap on Virginia Gasoline and Diesel Emissions

Variable	2022	2023	2024	2025	2026
Revenue changes other state taxes ($, mil.)	-48	-46	-44	-42	-43
Private employment (jobs)	-12,884	-12,567	-12,233	-11,860	-11,424
Investment ($, mil.)	-165	-171	-175	-181	-187
Disposable income, real ($, mil.)	-2,307	-2,342	-2,379	-2,414	-2,449
Cost per household ($)	737	749	760	771	782
Total social cost of TCI ($, mil.)	1,083	1,068	1,052	1,035	1,017
Total social benefits of TCI ($, mil.)	32	32	33	33	34
Net benefits (-cost) of TCI ($, mil.)	-1,051	-1,036	-1,019	-1,002	-983

The total loss of output (measured in real GDP) due to the emissions cap would be $1,083 million in 2022 and $1,017 million in 2026. This loss represents the total social cost of the emissions cap imposed on Virginia. When subtracting the benefits of GHG reduction, the net cost of the emissions cap would be $1,051 million in 2022 and fall to $983 million by 2026.

The costs of Virginia participating in TCI largely outweigh the benefits from the abatement of emissions. While benefits from the reduction of GHG would materialize under an emissions cap, Virginia and other cooperating jurisdictions would bear the costs, while all global citizens reap the benefits. Virginia 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.[6] 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 determining 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 be used to 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 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,

[6] 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.

> 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 create electronic monitoring systems. Reports would be required monthly or quarterly and would either be verified by a third-party or a government agency or self-verified by individual jurisdictions.

As the debate over policy responses to climate change intensifies, economists have generally advocated carbon taxes or suggested cap-and-trade regimes as possible solutions.[7] Economists view GHG as a negative externality. When one considers the effects of the greenhouse gases on crop yields, sea levels, ocean acidification, and a plethora of other areas directly affected by a rise in temperature caused by the greenhouse effect, it becomes clear that GHG is a negative externality.

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 consumption of the goods being taxed. An example of taxes with similar goals are those levied on cigarettes and other so-called "sin taxes." Similarly, proponents claim that a carbon tax would give consumers an incentive to decrease their consumption of fossil fuels, which contribute to GHG emissions.

[7] Lawrence H. Goulder & Andrew R. Schein, "Carbon Taxes Versus Cap and Trade: A Critical Review," *Climate Change Economics*. V4N3, (2013). https://www.worldscientific.com/doi/abs/10.1142/S2010007813500103.

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 and the state of California have instituted cap-and-trade systems akin to TCI, with China soon to be implementing a similar system.

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).[8] 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.[9] Under the EU ETS, companies receive or buy emission allowances that they can trade with one another as 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 (CO2) 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 (N2O) from the production of nitric, adipic, and glyoxylic acids, and glyoxal, perfluorocarbons (PFCs) from aluminum production.[10]

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[8] Friends of the Earth. "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.

[9] Grantham Institute, Imperial College, "Evaluating the EU Emissions Trading System: Take It or Leave It? An Assessment of the Data after Ten Years." *Briefing Paper 21*. (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.

[10] Ibid, 8.

The environmental impact from EU ETS has been studied in detail by the EU and independent institutions.[11] According to most recent estimates, 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 goods and services 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.[12]

Phase I largely resolved the issues with reducing emissions from the Pilot Phase. Researchers at Imperial College in London, UK concluded that EU ETS led to an estimated 100-200-million-ton reduction (2.4-4.7% reduction) in CO2 emissions during the first two years of Phase I alone.[13] 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.[14] 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).

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[11] Ibid, 8.
[12] Ibid, 8.
[13] Ibid, 8.
[14] California Air Resources Board, "Article 5: California Cap on Greenhouse Gas Emissions and Market-based Compliance Mechanisms," (April 1, 2019), https://ww3.arb.ca.gov/cc/capandtrade/capandtrade/ct_reg_unofficial.pdf.

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 were 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.[15]

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.[16] It is also estimated that since the implementation of a cap-and-trade, motorists spend about $2 billion more annually for transportation fuel.[17] From 2013 to 2017, California has seen a reduction of 3 percent in statewide greenhouse gas emissions, although not all of the decline in emissions is attributable to the state's cap-and-trade program.[18] As a result of the COVID-19 pandemic, demand for motor fuels has plummeted.[19] In May 2020, California's cap-and-trade program only generated $25 million in auction revenues.[20]

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[15] California Air Resources Board, "Report: Cap-and-trade spending doubles to $1.4 billion in 2018," (March 19, 2019) https://ww2.arb.ca.gov/news/report-cap-and-trade-spending-doubles-14-billion-2018.
[16] Mac Taylor, Legislative Analyst's Office, (March 4, 2016) https://lao.ca.gov/reports/2016/3438/LAO-letter-Tom-Lackey-040716.pdf.
[17] Ibid, 15.
[18] GHG Current California Emission Inventory Data, https://ww2.arb.ca.gov/ghg-inventory-data (August 22, 2020)
[19] California re-evaluating its landmark climate strategy, https://calmatters.org/environment/2020/06/california-climate-strategy-cap-trade/ (August 22, 2020)
[20] Ibid, 18.

China

In December of 2017, China formally launched its nationwide emission trading system (ETS).[21] 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.[22] 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 and monitoring mechanisms since 2017. The Chinese expect the first trades in ETS to take place sometime in 2020.[23]

[21] Hal Harvey and Hu Min, "The China Carbon Market Just Launched, And It's the World's Largest. Here's How It Can Succeed," *Forbes*, (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.

[22] Liu Quiang, Tian Chuan, et al, "Climate and Energy Policy Solutions for China: Quantitative Analysis and Policy Recommendations for the 13th Five-Year Plan," (July 2016), https://china.energypolicy.solutions/docs/20160704_ExecutiveSummary_EN--FINAL.pdf.

[23] Ibid, 18.

Virginia Climate Policy

Much of Virginia's climate change policy originates from the 2008 Climate Action Plan. The 2008 Climate Plan was the result of the Governor's Commission on Climate Change (GCCC), which was spearheaded by Governor Tim Kaine in 2007. After examining the Commonwealth of Virginia's economy and projecting the impacts of climate change on the state, the 2008 Climate Action Plan made nine general recommendations to reduce Virginia's greenhouse gas emissions (listed below).[24] Under these recommendations, Virginia will:

1. Reduce GHG emissions by increasing energy efficiency and conservation.
2. Advocate for federal actions that will reduce net GHG emissions.
3. Reduce GHG emissions related to vehicle miles traveled through expanded commuter choice, improved transportation system efficiency, and improved community designs.
4. Reduce GHG emissions from automobiles and trucks by increasing efficiency of the transportation fleet and use of alternative fuels.
5. Reduce GHG emissions through accelerated research and development.
6. Reduce GHG emissions by increasing the proportion of energy demands that are met by renewable sources.
7. Reduce GHG emissions by increasing the proportion of electricity generation provided by emissions-free sources of energy.

[24] Virginia Institute of Marine Science, "Virginia Accomplishments Since the 2008 Climate Action Plan Release," (December 2014) http://ccrm.vims.edu/Report_FINAL_ExeSum.pdf.

8. Reduce net GHG emissions by protecting/enhancing natural carbon sequestration capacity and researching/promoting carbon capture and storage technology.
9. Implement practices that will reduce GHG emissions.

Virginia has taken steps to accomplish each of these goals, but as detailed in a study by the Virginia Institute of Marine Science, major progress on many of the 2008 Climate Action Plan's goals has been hard to come by.

Starting on January 1, 2021, Virginia will join the Regional Greenhouse Gas Initiative (RGGI).[25] RGGI is a carbon dioxide cap-and-trade agreement between nine Northeastern states.[26] RGGI, Inc. is the entity responsible for managing the goals of the law. RGGI imposes a limit on the amount of carbon dioxide (CO2) emitted by all of the regulated electric power plants in the region. Each state agrees to issue a fixed amount of allowances corresponding to this limit, proportional to the number of power plants in the state.

Though Virginians have been reluctant to join regional initiatives and accords, the Commonwealth of Virginia has devoted a significant amount of legislative effort to climate prevention efforts, mostly at the local level. For example, in 2018 the city of Norfolk, Virginia made massive changes to building codes in flood-prone areas (which are projected to increase in their likelihood of flooding due to climate change) and took steps to purchase homes and property in flood-prone areas. At an estimated cost of $112 million, Norfolk plans to construct additional berms, basins, and other water dispersion

[25] RGGI States Welcome Virginia as Its CO2 Regulation Is Finalized, (Accessed October 25, 2020), https://www.rggi.org/sites/default/files/Uploads/Press-Releases/2020_07_08_VA_Announcement_Release.pdf
[26] Ibid, 24.

mechanisms to quell rising sea levels. Norfolk is expecting two and a half feet of sea-level rise over the next 50 years.[27]

In September 2019, Virginia Governor Ralph Northam signed an executive order setting a goal for the state to produce 100% of its electricity from carbon-free sources by 2050. With the executive order, the Governor also set intermediate goals of powering 30% of the state's electric system with carbon-free sources by 2030 and procuring 30% of electricity from renewable sources by 2022.[28]

In April 2020, the Virginia Clean Economy Act was signed into law, furthering the ambitious goals set by the executive order signed by Governor Northam in 2019.[29] The Act requires the majority of the Virginian coal power plants to be shuttered by 2030.[30] Additionally, the Act mandates that electric and gas plants that produce GHG emissions be shut down by 2045.[31] Also required under the law, Virginia must reach 41 percent renewable power by 2030 and 100 percent renewable power by 2045.[32] The "Clean Economy Act" and other measures passed by the General Assembly to reduce carbon emissions in the power sector and signed into law are estimated to eventually cost Virginians between $771.24 and $807.84 per year in additional residential electricity costs.[33]

Passed on April 22, 2020, House Bill (H.B) 1541 creates the Central Virginia Transportation Authority (VCTA).[34] The bill establishes a wholesale tax on gasoline of

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[27] Ryan Murphy, "Norfolk's $112 million Flooding Plan Will Fortify One Neighborhood and Test Other Solutions," *The Virginia Pilot*, (January 14, 2019), https://www.pilotonline.com/news/environment/article_6266e882-1819-11e9-99ff-23a687267a29.html.
[28] Sarah Rankin, "Virginia Governor Sets Renewable Energy Goal: 100% by 2050," Associated Press, (September 17, 2019), https://apnews.com/eb973425398f4eb4b4d368b21d7a45c3
[29] Virginia Clean Economy Act, https://lis.virginia.gov/cgi-bin/legp604.exe?201+sum+HB1526 (October 5, 2020)
[30] Ibid, 28.
[31] Ibid, 28.
[32] Ibid, 28.
[33] Summary of the pe-filed testimony of Carol B. Myers, Customer Bill Impacts, https://www.baconsrebellion.com/app/uploads/2020/10/PUR-2020-00035-Myers-Testimony-FINAL.pdf
[34] House Bill 1541, https://lis.virginia.gov/cgi-bin/legp604.exe?201+sum+HB1541 (October 5, 2020)

7.6 cents per gallon and 7.7 cents per gallon of diesel fuel in Virginia.[35] The tax would then be indexed for inflation each year after the first year of the imposition of the tax.[36] The bill requires "a local maintenance of effort for transit funding of at least 50 percent of what was provided on July 1, 2020, with such amount to be indexed beginning in 2023." The Authority will oversee the direction of funds generated under the new tax.[37]

A separate transportation bill, HB 1414, was also passed on April 22, 2020. The bill makes a variety of changes to transportation laws in Virginia.[38] Under the bill, a regionwide wholesale tax on gasoline and diesel fuel will be imposed on a statewide basis.[39] Additionally, the bill establishes a cents per gallon tax on motor fuels and stipulates that the tax will no longer be imposed as a percentage of the wholesale price of gasoline and diesel.[40] According to the bill, "Most transportation revenues are directed to a new Commonwealth Transportation Fund and the existing Highway Maintenance and Operating Fund. Funds are then disbursed, based on codified formulas, to sub-funds established to meet the varying transportation needs of different modes of transportation."

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[35] Ibid, 32.
[36] Ibid, 32.
[37] Ibid, 32.
[38] House Bill 1414, https://lis.virginia.gov/cgi-bin/legp604.exe?201+sum+HB1414 (October 5, 2020)
[39] Ibid, 36.
[40] Ibid, 36.

Virginia Carbon Emissions History

If Virginia 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 and 25 percent. The Virginia economy produces GHG emissions when fossil fuels are burned in the production process. As a result, the transportation, electricity generation, residential, commercial heating, and industrial sectors produce the vast majority of the GHG emissions in Virginia. Table 2 displays the emissions, calculated by vehicle miles traveled and produced from the combustion of gasoline in addition to on-road diesel for the years 2012 through 2017.

Table 2: Gasoline and Diesel Fuel GHG Emissions for Selected Years (MMTCO2E)[41]

Emissions	2012	2013	2014	2015	2016	2017
CO2E by Fuel						
Finished Motor Gasoline	26.9	26.7	26.9	27.4	29.0	29.0
On-Road Diesel	11.8	12.0	12.0	12.0	11.1	11.1
Total Emissions	38.7	38.7	38.9	39.4	40.1	40.1

Finished gasoline and on-road diesel emissions are 40.1 MMTCO2E out of the total emissions from the transportation sector. 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.

[41] Environmental Protection Agency, Summary of Mobile Combustion Emissions, https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool

The Costs and Benefits of Virginia Participating in TCI

Each participating jurisdiction, in this case Virginia, would set a cap on emissions from finished motor gasoline and on-road diesel, accomplished by capping and reducing the supply available for sale. We assume that Virginia, 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 40.1 MMTCO2E in 2017, according to the latest data available. We project Virginia emissions from finished gasoline and on-road diesel through 2026 using the compound annual growth rate (CAGR) from 2007 to 2017. Table 3 contains the results.

Table 3: Baseline Gasoline and Diesel GHG Emissions Projections (MMTCO2E)

Emissions	2022	2023	2024	2025	2026
CO2E from Fossil Fuel Combustion (Baseline)					
Finished Gasoline	28.9	28.9	28.9	28.9	28.9
On-Road Diesel	11.0	10.9	10.9	10.8	10.8
Total Emissions	**39.9**	**39.8**	**39.8**	**39.7**	**39.7**
CO2E from Fossil Fuel Combustion (20%)					
Finished Gasoline	28.5	28.1	27.7	27.4	27.0
On-Road Diesel	10.8	10.7	10.5	10.3	10.2
Total Emissions	**39.3**	**38.8**	**38.2**	**37.7**	**37.2**
CO2E from Fossil Fuel Combustion (22.5%)					
Finished Gasoline	28.4	28.0	27.6	27.1	26.7
On-Road Diesel	10.8	10.6	10.4	10.2	10.1
Total Emissions	**39.2**	**38.6**	**38.0**	**37.3**	**36.8**
CO2E from Fossil Fuel Combustion (25%)					
Finished Gasoline	28.3	27.8	27.2	26.7	26.1
On-Road Diesel	10.7	10.5	10.3	10.1	9.9
Total Emissions	**39.0**	**38.3**	**37.5**	**36.8**	**36.0**

We project that baseline emissions subjected under TCI will fall to 39.9 MMTCO2E by 2022 and fall to 39.7 MMTCO2E by 2026. Under a 20 percent cap scenario, we project that emissions will fall to 39.3 MMTCO2E in 2022 and to 37.2 MMTCO2E by 2026. In a scenario whereby a 22.5 percent emissions cap is imposed, we project emissions to fall to 39.2 MMTCO2E in 2022 and to 36.8 MMTCO2E by 2026. And in the scenario where a 25 percent emissions cap is set, we project emissions in 2022 would fall to 39.0 MMTCO2E and to 36.0 MMTCO2E by 2026.

The law of demand 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, calculating the responsiveness of each product to changes in quantity, and applying the resulting change in price of each product to project its price for 2022. This allows us to calculate the increase in the price of each product due to the various emissions cap scenarios. The Appendix provides the details of these calculations.

The TCI emissions cap would apply to Virginia 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 quantity. As a result, the proposed emissions cap scenarios would have a significant impact on prices in Virginia.

In the 20 percent emissions cap scenario, the price of finished gasoline would increase by 23 cents per gallon and the price of on-road diesel by 19 cents per gallon. If a 22.5 percent emissions cap were imposed, the price of finished gasoline would increase by 27 cents per gallon and the price of on-road diesel by 23 cents per gallon. And in a scenario whereby a 25 percent emissions cap is enforced, the price of finished gasoline would increase by 33 cents per gallon and the price of on-road diesel by 28 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).[42] 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).[43] We use the DICE 2017 model to calculate the optimal 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 optimal 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.

If Virginia participated in TCI, BHI projects that emissions would be reduced by .549 MMT of CO2E by 2022 and .519 MMT of CO2E by 2026 in a 20 percent emissions cap scenario. In a 22.5 percent emissions cap scenario, emissions would fall by .648 MMT of CO2E by 2022 and .607 MMT of CO2E by 2026. And in a 25 emissions cap scenario, emissions would decrease by .800 MMT of CO2E by 2022 and .738 MMT of CO2E by 2026.

The DICE model projects the social cost of CO2E at $39.53 per metric ton of CO2E in 2022, increasing to $45.81 per metric ton of CO2E in 2026. As a result, in a 20 percent emissions cap scenario, the reduction in emissions would provide $21.70 million in social

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[42] The latest version of the DICE 2017 model is available online at https://sites.google.com/site/williamdnordhaus/dice-rice. We downloaded the model for the runs reported here on April 1, 2019.

[43] Nordhaus, William, *A Question of Balance: Weighing the Options on Global Warming Policies*, 1. ed., New Haven, CT: Yale University Press, May 2008.

benefits in 2022 and $23.79 million in social benefit in 2026. A 22.5 percent emissions cap scenario would result in $25.60 million in social benefits in 2022 and $27.88 million in social benefits by 2026. In a 25 percent emissions cap scenario, total social benefits would be $31.62 million in 2022 and $33.79 million by 2026.

To estimate the economic effects ofVirginia's participation in the TCI, BHI has utilized a Computable General Equilibrium (CGE) model. The purpose of the BHI model, called VA-STAMP (Virginia State Tax Analysis Modeling Program), is to identify the economic effects of tax changes on a state's economy.[44] Using the STAMP model, we found 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 ran the VA-STAMP model to determine the increase in price in both finished gasoline and on-road diesel. The Appendix contains the details of this procedure.

Table 4 shows that a 20 percent emissions cap would reduce investment by $103 million, disposable income by $1,439 million, and private employment by 8,033 jobs in 2022. The cost per average Virginia household would be $460 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 $653 million. Under a 20 percent emissions cap scenario, the adverse economic effects of the emissions cap would reduce state tax revenues by $30 million.

As time passes, a 20 percent emissions cap would reduce private investment by $116 million, disposable income by $1,634 million, and private employment by 7,116 jobs

[44] For a description of the model see www.beaconhill.org/how-stamp-works.

in 2026. The cost imposed per average Virginia household would be $523 in 2026. The net cost of the emissions cap to the economy would be $572 million. Under a 20 percent emissions cap scenario, the adverse economic effects of the emissions cap would reduce state tax revenues by $26 million.

Table 4: The Costs and Benefits of a 20% Emissions Cap on Virginia

Variable	2022	2023	2024	2025	2026
Revenue changes other state taxes ($, mil.)	-30	-29	-27	-26	-26
Private employment (jobs)	-8,033	-7,834	-7,625	-7,390	-7,116
Investment ($, mil.)	-103	-107	-110	-113	-116
Disposable income, real ($, mil.)	-1,439	-1,500	-1,544	-1,596	-1,634
Cost per household ($)	460	479	493	511	523
Total social cost of TCI ($, mil.)	675	657	632	611	596
Total social benefits of TCI ($, mil.)	22	22	23	23	24
Net benefits (-cost) of TCI ($, mil.)	-653	-635	-609	-588	-572

Table 5 shows that a 22.5 percent emissions cap would reduce investment by $121 million, disposable income by $1,691 million, and private employment by 9,444 jobs in 2022. On average, Virginia households would incur a cost of $540. The net cost of the emissions cap would be $767 million. The adverse economic effects of the emissions cap would reduce state tax revenues by $35 million.

Table 5: The Costs and Benefits of a 22.5% Emissions Cap on Virginia

Variable	2022	2023	2024	2025	2026
Revenue changes other state taxes ($, mil.)	-35	-34	-32	-30	-31
Private employment (jobs)	-9,444	-9,211	-8,966	-8,691	-8,370
Investment ($, mil.)	-121	-125	-129	-133	-137
Disposable income, real ($, mil.)	-1,691	-1,735	-1,780	-1,824	-1,866
Cost per household ($)	540	554	570	584	597
Total social cost of TCI ($, mil.)	793	778	764	747	733
Total social benefits of TCI ($, mil.)	26	26	27	27	28
Net benefits (-cost) of TCI ($, mil.)	-767	-752	-737	-720	-705

By 2026, a 22.5 percent emissions cap would reduce investment by $137 million, disposable income by $1,866 million, and private employment by 8,370 jobs. The average Virginia household would incur a cost of $597. The net cost imposed on the economy from the emissions cap would be $705 million. The adverse economic effects of the emissions cap would reduce state tax revenues by $31 million.

Table 6 shows that a 25 percent emissions cap would reduce investment by $165 million, disposable income by $2,307 million, and private employment by 12,884 jobs in 2022. The cost per average Virginia household would be $737. The net cost of the emissions cap would be $1,051 million. The adverse economic effects of the emissions cap would reduce state tax revenues by $48 million.

As time passes, a 25 percent emissions cap would reduce investment by $187 million, disposable income by $2,449 million, and private employment by 11,424 jobs in 2026. The total cost per average Virginia household would be $782. The net cost imposed on the economy would be $983 million. The adverse economic effects of the emissions cap would reduce state tax revenues by $43 million.

Table 6: The Costs and Benefits of a 25% Emissions Cap on Virginia

Variable	2022	2023	2024	2025	2026
Revenue changes other state taxes ($, mil.)	-48	-46	-44	-42	-43
Private employment (jobs)	-12,884	-12,567	-12,233	-11,860	-11,424
Investment ($, mil.)	-165	-171	-175	-181	-187
Disposable income, real ($, mil.)	-2,307	-2,342	-2,379	-2,414	-2,449
Cost per household ($)	737	749	760	771	782
Total social cost of TCI ($, mil.)	1,083	1,068	1,052	1,035	1,017
Total social benefits of TCI ($, mil.)	32	32	33	33	34
Net benefits (-cost) of TCI ($, mil.)	-1,051	-1,036	-1,019	-1,002	-983

Conclusion

Cap and trade schemes are a problematical tool to address climate change, with consequential costs that directly impact households' disposable income. Virginia'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. If this were to happen, whichever state produces the ethanol could create enough emissions to offset the reduction in emissions in Virginia or other TCI jurisdictions. Also, many customers could be inclined to purchase motor fuels at a lower price across borders in neighboring states such as West Virginia, Kentucky, Tennessee, and North Carolina.

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 Virginia and other TCI jurisdictions would have unnoticeable effects on global emissions. The Virginia emissions subject to the proposed emissions caps are but a small fraction of global emissions. Global GHG emissions were 50.9 gigatons of CO2E in 2017, compared to Virginia emissions subjected to emissions caps under TCI of 40.1 MMTCO2E.[45] Nonetheless, under the DICE model the reduction in Virginia GHG emissions and other TCI jurisdictions would provide an economic benefit against the baseline case of no emissions reduction.

Virginia GHG emissions subject to the proposed carbon taxes are only 0.08 percent of global GHG emissions, which grew at a rate of 1.2 percent between 2016 and

[45] J.G.J. Olivier, J.A.H.W. Peters, "Trends in Global CO2 and Total Greenhouse Gas Emissions: 2018 report," Netherlands Environmental Assessment Agency, (May 12, 2018), https://www.pbl.nl/en/publications/trends-in-global-co2-and-total-greenhouse-gas-emissions-2018-report

2017. A reduction of Virginia emissions would result in 0.0001 degrees Centigrade reduction in global warming.[46]

The Virginia economy would suffer under the proposed emissions cap scenarios. 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 Virginia partaking in the TCI far outweigh the benefits. Moreover, citizens of Virginia along with other TCI jurisdictions would face the burden of the costs, while all citizens of the world share the small benefits.

[46] IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_SPM_FINAL.pdf

Appendix

BHI used its multisector STAMP model to estimate the economic cost of a proposed cap and investment of finished gasoline and on-road diesel in Virginia. The STAMP model provides fields in which we can enter changes in the state income, corporate, sales, and motor fuels tax. We modified the model adding separate taxes on gasoline and diesel.

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 eight 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 of 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 Virginia. 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 Virginia to calculate price elasticities of demand for each product.[47] We calculated price elasticities of demand for the finished gasoline and on-road diesel portion of the

[47] U.S. Department of Energy, Energy Information Administration, "Virginia State Profile and Energy Estimates, More Data & Analysis in Virginia by Source," (Accessed February 2020), https://www.eia.gov/state/search/#?1=79&2=200.

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

Fuel	Transportation
On-Road Diesel	-0.243
Gasoline	-0.135

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. The CME Group provides futures prices for gasoline (RB) and fuel oil products (MF).[48] We used the percentage change in the futures prices to project motor fuel prices for 2022.

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 EPA provides data on mobile combustion 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 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

[48] Chicago Mercantile Exchange, https://www.cmegroup.com/

gasoline (1.38 percent) under a 20 percent cap by the elasticity for gasoline (-0.135) to calculate the increase in the price in gasoline of 23 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.

About the Authors

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