Reducing Greenhouse Gas Emissions from Transportation

Opportunities in the Northeast and Mid-Atlantic

GEORGETOWN CLIMATE CENTER
A Leading Resource for State and Federal Policy

November 2015

Gabe Pacyniak, Kathryn Zyla, Vicki Arroyo, and Matthew Goetz, Georgetown Climate Center

Christopher Porter and David Jackson, Cambridge Systematics

With additional research help by Suseel Indrakanti, Cambridge Systematics

GEORGETOWN CLIMATE CENTER
A Leading Resource for State and Federal Policy

Reducing Greenhouse Gas Emissions from Transportation:

Opportunities in the Northeast and Mid-Atlantic

Gabe Pacyniak, Kathryn Zyla, Vicki Arroyo, and Matthew Goetz, Georgetown Climate Center
Christopher Porter and David Jackson, Cambridge Systematics
With additional research help by Suseel Indrakanti, Cambridge Systematics

November 2015

Georgetown Law | 600 New Jersey Ave. NW | Washington, DC 20001 | 202.661.6566 | georgetownclimate.org

About this Report

This report presents analysis of the potential for greenhouse gas (GHG) emission reductions from the transportation sector, and the resulting benefits and costs for the 11 northeast and mid-Atlantic states and the District of Columbia that participate in the Transportation and Climate Initiative (TCI). The analysis finds that the region can significantly cut GHG emissions, while also bringing billions of dollars in cost savings, improving public health, growing the economy, and creating jobs.

The TCI is a collaboration of the agency heads of the transportation, energy, and environment agencies of 11 states and the District of Columbia, who in 2010 committed to work together to improve efficiency and reduce greenhouse gas emissions from the transportation sector throughout the northeast and mid-Atlantic region.[1] More information on TCI is available at http://www.georgetownclimate.org/state-action/transportation-and-climate-initiative.

The Georgetown Climate Center serves as the facilitator of the TCI, and commissioned this analysis in response to state requests. The analysis was designed by the Georgetown Climate Center, and quantitative aspects of the analysis were conducted by Cambridge Systematics. The Georgetown Climate Center and Cambridge Systematics have jointly developed this synthesis report.

The Georgetown Climate Center is a non-partisan, non-profit institute based at Georgetown University Law Center that serves as a resource to states to advance climate and energy policies and seeks to inform the federal dialogue with the lessons of the states.

Cambridge Systematics is an independent firm specializing in the development and implementation of innovative policy and planning solutions, objective analysis, and technology applications in the transportation sector. Cambridge Systematics has provided detailed analysis to the United States Department of Transportation, as well as to more than 44 states and 60 MPOs.

Senior agency officials from states participating in TCI provided input throughout the process. However, the analysis reflects the work of the Georgetown Climate Center and Cambridge Systematics and does not necessarily represent the views of any particular state participants. The Georgetown Climate Center would like to thank state staff who provided data and methodological input to this analysis.

The Georgetown Climate Center and Cambridge Systematics would also like to thank the following experts for their review of this analysis: David L. Greene, Senior Fellow, Howard H. Baker, Jr. Center for Public Policy, University of Tennessee Knoxville; Paula Hammond, Senior Vice President, Parsons

Brinckerhoff; Roland Hwang, Transportation Program Director, Natural Resources Defense Council; and Robert B. Noland, Director of the Alan M. Voorhees Transportation Center, Rutgers University. We are grateful for their thoughtful review that helped improve this report, although the views expressed in this report and any errors are the authors' alone.

The authors also thank Georgetown Climate Center Communications Director Chris Coil for his dedicated work designing this report and Institute Associate Benjamin VanGessel for his assistance in review. The Georgetown Climate Center is also grateful to John Carey for his editorial contributions.

We would like to thank the Barr Foundation and Rockefeller Brothers Fund, whose generous support for this analysis and related convenings in New York and Boston helped launch and sustain this TCI work. We also thank the Rockefeller Brothers Fund for generously providing the use of The Pocantico Center in July 2013 for the inaugural meeting of the TCI Policy Committee and discussions of preliminary analyses that inspired this study. Support for our work on this analysis was also generously provided by the New York Community Trust, the Town Creek Foundation, the Oak Foundation, and the Surdna Foundation. We thank them and all of our funders who have supported the Transportation and Climate Initiative over the past five years, including the Rockefeller Foundation, the Emily Hall Tremaine Foundation, the John Merck Fund, and the U.S. Department of Energy, as well as the other funders who make Georgetown Climate Center's work possible: http://www.georgetownclimate.org/support.

Contents

Figures and Tables

Figures

Tables

Executive Summary

Five years ago, the leaders of the transportation, energy, and environment agencies of 11 northeast and mid-Atlantic states and the District of Columbia joined to form the Transportation and Climate Initiative (TCI). These jurisdictions committed to work together to promote a cleaner and more efficient transportation system that reduces emissions of greenhouse gases and criteria air pollutants. The Georgetown Climate Center serves as the facilitator of the TCI.

This report summarizes analysis designed by the Georgetown Climate Center in response to state requests for better information on transportation-sector greenhouse gas (GHG) emissions trends and opportunities to reduce emissions in the region. Quantitative aspects of the analysis were conducted by Cambridge Systematics. The Georgetown Climate Center and Cambridge Systematics have jointly developed this synthesis report.

FIGURE ES1: *The TCI Region*

11 northeast and mid-Atlantic states and the District of Columbia are the focus of the analysis.

The report includes a bottom-up assessment of current and future transportation-sector emissions based in large part on the U.S. Environmental Protection Agency's (EPA)MOVES model; an analysis of emission reduction potential, economic impacts, and other impacts of diverse clean transportation strategies implemented at different levels of investment; and a macroeconomic analysis of two scenarios conducted using the REMI model. State officials in the TCI region provided detailed input and review to inform the work.

The report examines the potential reductions that could be achieved by 2030 in the northeast and mid-Atlantic region through existing federal and state policies, as well as through implementation of additional clean transportation investments and policies. The analysis also looks at the potential public health improvements and other benefits of such investment, as well as the costs, savings, and net economic benefits to the region from two comprehensive policy bundles. The report finds that existing federal and state policies are projected to cut greenhouse gas emissions 29 percent by 2030 in the region from 2011 levels. Additional strategies analyzed in the report could further those reductions, achieving total cuts of 31 to 40 percent by 2030 while also resulting in significant public health improvements. Economic analysis finds that a comprehensive implementation of state clean transportation policies could bring net cost savings of $32.3 billion to $72.5 billion over 15 years to the region's businesses and consumers, while at the same time adding $11.7 billion and 91,000 new jobs or more to the regional economy in 2030.

Regional Emissions Background and Context

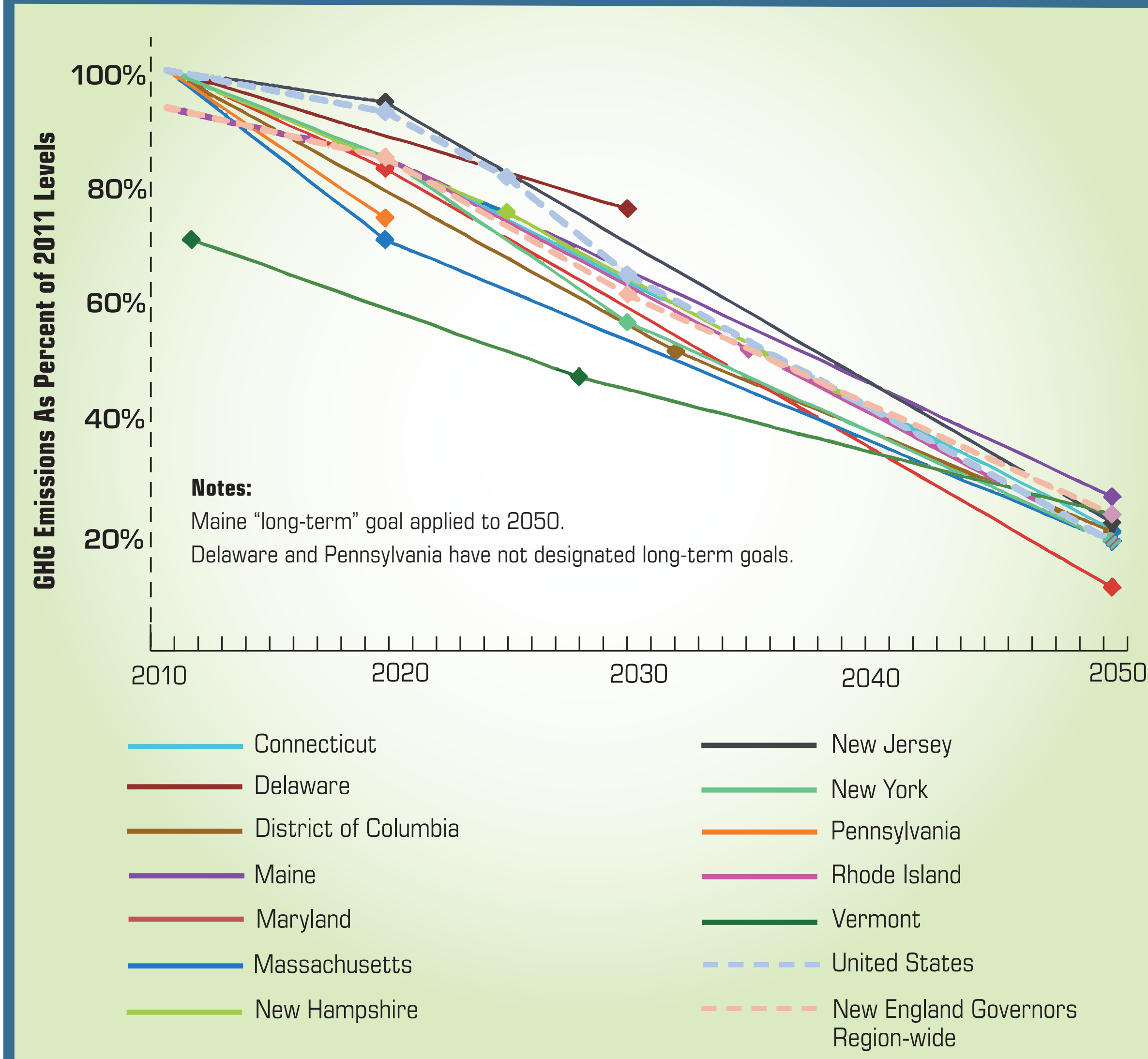
Residents in the TCI region are already experiencing the effects of climate change including rising seas, heatwaves, and extreme weather events like Hurricanes Irene and Sandy that result in loss of life, significant community disruptions, and tremendous damage to transportation and other infrastructure.

Most states in the region, as well as the District of Columbia, have set economy-wide GHG reduction goals through statute, executive order, or in climate change or energy plans. These goals are generally consistent with achieving an 80 percent reduction by 2050 from 1990 levels, which reflects the scientific consensus of the scale of action needed internationally to avoid the worst effects of climate change.

In the northeast and mid-Atlantic states, direct emissions from the transportation sector represent the largest source of greenhouse gas emissions—approximately 35 percent of regional emissions in 2011 (the most recent year for which data was available). Therefore, states will have to achieve significant GHG emission reductions from the transportation sector to meet the long-term economy-wide goals they have identified. At the same time, states will also need to prepare the transportation system for the impacts of climate change—including more extreme weather and sea-level rise—which will require growing levels of investment and reevaluation of investment priorities.

Federal and state policies already in place are beginning to promote shifts in energy use and reductions in emissions. These policies include federal fuel economy and GHG standards for cars and trucks, which will effectively double the fuel economy of new light-duty vehicles by model year 2025. Ten U.S. states have put in place Zero Emission Vehicle (ZEV) programs that require manufacturers to increase the percentage of ZEVs sold through 2025. State policies and initiatives also include transit service expansions, upgrades to cleaner bus fleets, programs that promote investment in compact development or infill, and a focus on "fix-it-first" transportation investment, among other strategies, as well as the states' collective efforts through the TCI. As this report's findings show, these existing policies will make important progress in reducing emissions, but will not be sufficient to achieve the magnitude of reductions needed.

FIGURE ES2: *State Economy-Wide GHG Goals Relative to TCI Region's 2011 Transportation Emissions*

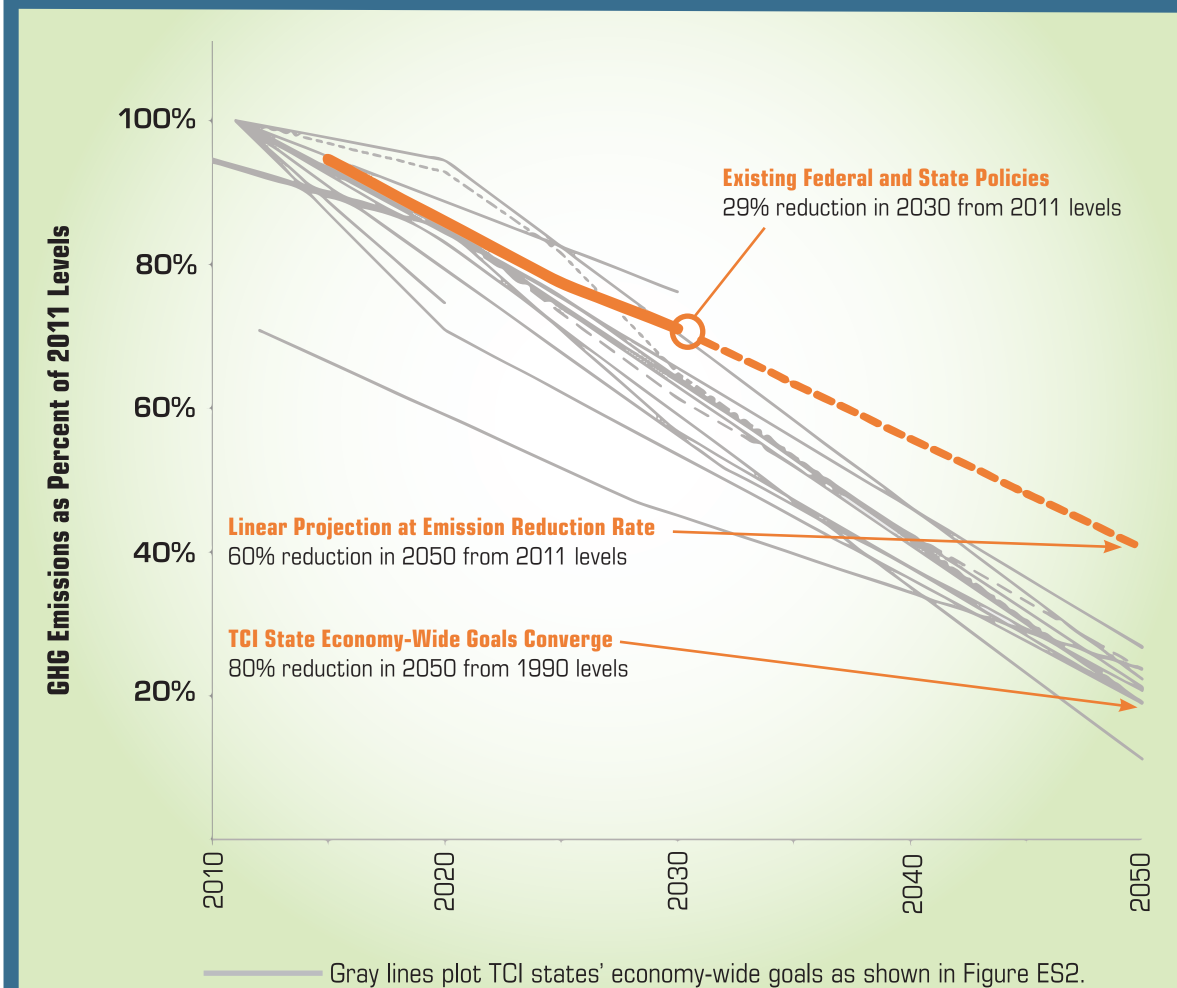


Source: Georgetown Climate Center; see Appendix State Goals for detailed analysis

State strategies that support a cleaner, more efficient, and more resilient transportation system can provide benefits to states and their residents beyond reducing greenhouse gas emissions, including public health, environmental, and economic benefits. Increasing use of transportation alternatives such as cleaner vehicles, transit, and active transportation such as walking and cycling reduces harmful air pollutants, including toxic pollutants like benzene and pollutants that contribute to formation of ozone and fine particulate matter. Increasing the use of electric vehicles and other alternative fuel vehicles will increase energy diversity and reduce dependence on petroleum fuels, which are largely produced outside the northeast and mid-Atlantic. Strategies like increasing transit options, promoting compact development, and enhancing transportation efficiency increase quality of life, reduce congestion and travel time, and provide cost savings to businesses and residents. At the same time, state transportation agencies also face a severe funding crisis due to reduced revenue and purchasing power from federal and state gasoline and diesel taxes, deteriorating infrastructure, and increasing demand on transportation systems. Federal and state reliance on fixed motor fuel taxes to fund transportation also creates a structural challenge for meeting states' energy and climate goals, since transportation revenues decrease as consumption of fuels decreases (caused, for example, by increasing vehicle fuel efficiency). Preparing for the impacts of climate change by investing in more resilient transportation infrastructure will also increase costs.

In the context of these various factors, this report examines the potential for clean transportation policies to further reduce greenhouse gas emissions in the region, provide other health and economic benefits, and potentially help address the transportation funding crisis.

FIGURE ES3: *Projected TCI Region Transportation GHG Emission Reductions from Existing Federal and State Policies Compared to Economy-Wide Goals*

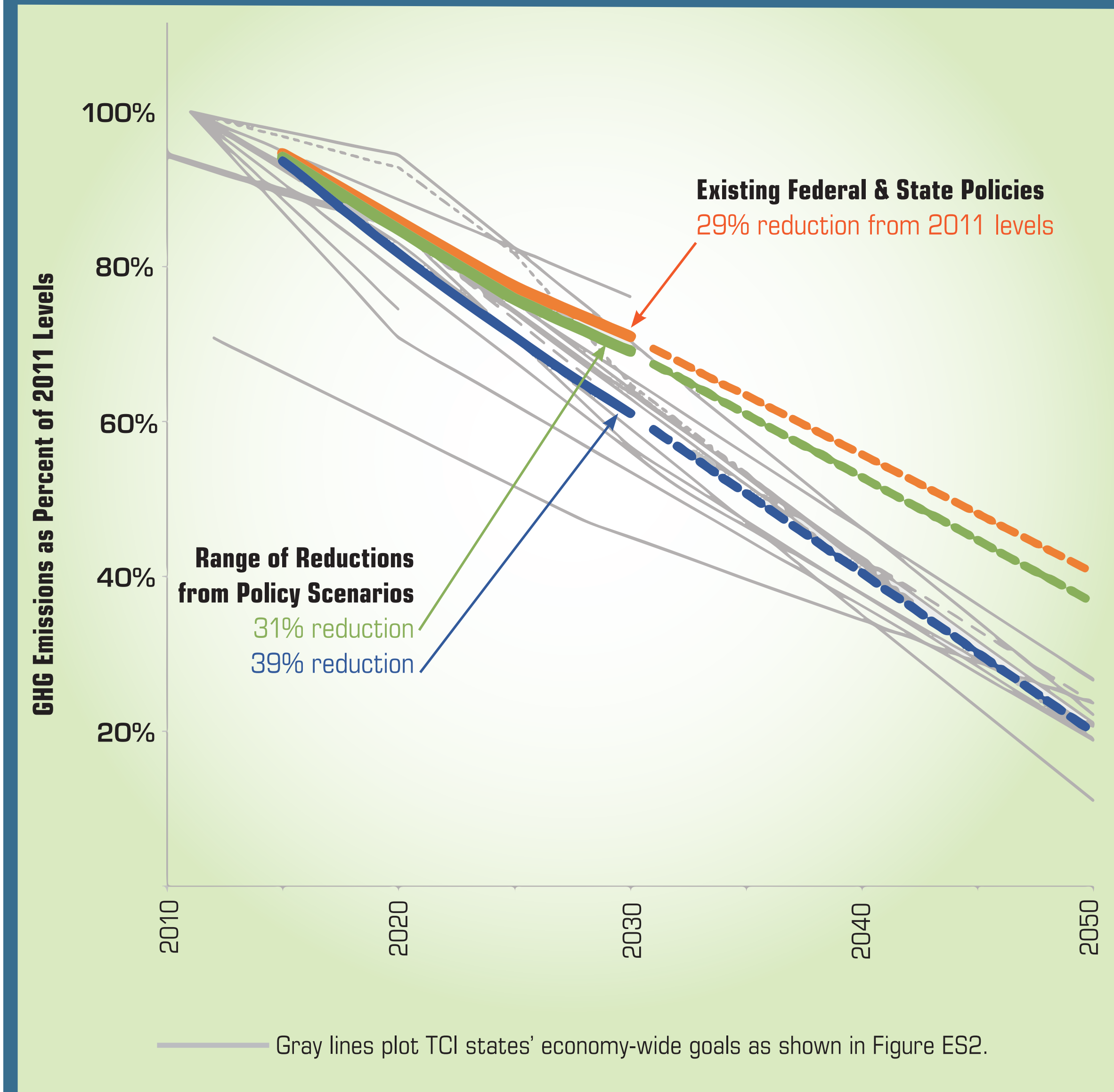


Source: Cambridge Systematics, see Appendix Emission Reduction Analysis; WRI, CAIT 2.0; see Appendix State Goals

Key Findings

- Existing federal and state policies will achieve significant reductions in transportation-sector greenhouse gas emissions of about 29 percent by 2030 from 2011 levels (the most recent year for which data was available). However, existing policies will not be sufficient to put states on the path needed to meet the mid-century economy-wide reduction goals that most states in the region have identified and that reflect the scientific consensus of the magnitude of action needed. Federal fuel economy and emissions standards will provide significant cost savings and other benefits to consumers, but reductions in petroleum consumption resulting from these standards will cause

FIGURE ES4: *Projected GHG Emission Reductions from Investment Scenarios*



Source: Cambridge Systematics; see Appendix Emission Strategy Analysis

GEORGETOWN CLIMATE CENTER

combined federal and state transportation revenues to decrease by a cumulative $35 billion from 2015 to 2030 in the region.

- Additional clean transportation investments would help states achieve their long-term economy-wide goals. This analysis modeled three levels of clean transportation investment, which reduced GHG emissions in the range of 31 to 39 percent by 2030 from 2011 levels. The investments were allocated among a suite of clean transportation strategies for the region, including support for clean vehicles, reduced traffic congestion, freight rail and shipping, transit, efficient land use policies, and cycling and walking. (See Figure ES4 on the preceeding page.)
- These investments would produce other benefits, such as reducing petroleum consumption by 4 to 27 percent beyond what would be achieved by existing federal and state policies, and achieving public health benefits, such as reductions in premature deaths and asthma cases—valued at $114 million to $463 million in 2030 in current dollars.
- One option that could be included in a suite of such strategies is a transportation pricing policy (e.g., a carbon fee, mileage-based user fee, or emissions budget program). Including a pricing policy would modestly increase the range of emission reductions achieved (i.e., 32 to 40 percent in 2030 from 2011 levels), and could generate proceeds to fund the other strategies.
- Macroeconomic analysis of two comprehensive policy bundles—which included a suite of clean transportation strategies funded by a hypothetical transportation pricing policy—found these combined policies would bring significant benefits for the region. Businesses and consumers would experience net savings over the 15-year period—$28.7 billion to $54.5 billion for businesses and $3.6 billion to $18 billion for consumers in current dollars—reflecting that savings from reduced fuel consumption, congestion, and consumer incentives would more than offset increased vehicle costs and fees. As a result of these changes, the analysis projects that in 2030 gross regional product would increase by $11.7 billion to $17.7 billion, personal disposable income would increase by $9.4 billion to $14.4 billion, and 91,000 to 125,000 new jobs would be created.

Background and Context

The Transportation and Climate Initiative

In June 2010 the leaders of the transportation, energy, and environment agencies of 11 states in the northeast and mid-Atlantic region and the District of Columbia joined to form the Transportation and Climate Initiative (TCI). These jurisdictions committed to work together to promote a cleaner and more efficient transportation system that reduces emissions of greenhouse gases and criteria air pollutants in the transportation sector throughout the northeast and mid-Atlantic region while also developing the clean energy economy. Through this work, the TCI jurisdictions seek to improve public health, lessen their contributions to climate change, save citizens and businesses money on transportation and fuel costs, and create a more diverse and resilient transportation system. Participating jurisdictions are Connecticut, Delaware, the District of Columbia, Maryland, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.[2]

For more than five years now, the TCI has been a robust partnership with a proven record of accomplishment—including launching the Northeast Electric Vehicle Network,[3] carrying out a program of research to promote sustainable communities,[4] conducting analysis of freight flows throughout the region,[5] and working to address barriers to the use of information technologies supporting clean transportation.

The TCI is directed by state agencies located within the 12 TCI jurisdictions. Each agency determines whether and how it will participate in individual projects and working groups.

The initiative is facilitated by the Georgetown Climate Center, a non-partisan, non-profit institute based at Georgetown University Law Center that since 2008 has served as a resource to states and communities on climate and energy issues.[6]

Analysis Context

The analysis was commissioned to inform the Georgetown Climate Center's work with states in the Transportation and Climate Initiative, responding to requests made in 2012 to help state leaders better understand emissions trends and opportunities for reductions in the region.

The Georgetown Climate Center partnered with Cambridge Systematics to conduct the analysis. Cambridge Systematics is an independent firm that specializes in analysis and planning in the transportation sector. Cambridge Systematics has provided detailed analysis to more than 44 states and 60 MPOs, led the analysis for the U.S. Department of Transportation's (DOT) 2010 Report to Congress on Transportation's Role in Reducing U.S. Greenhouse Gas Emissions, and authored the 2009 report *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*.[7]

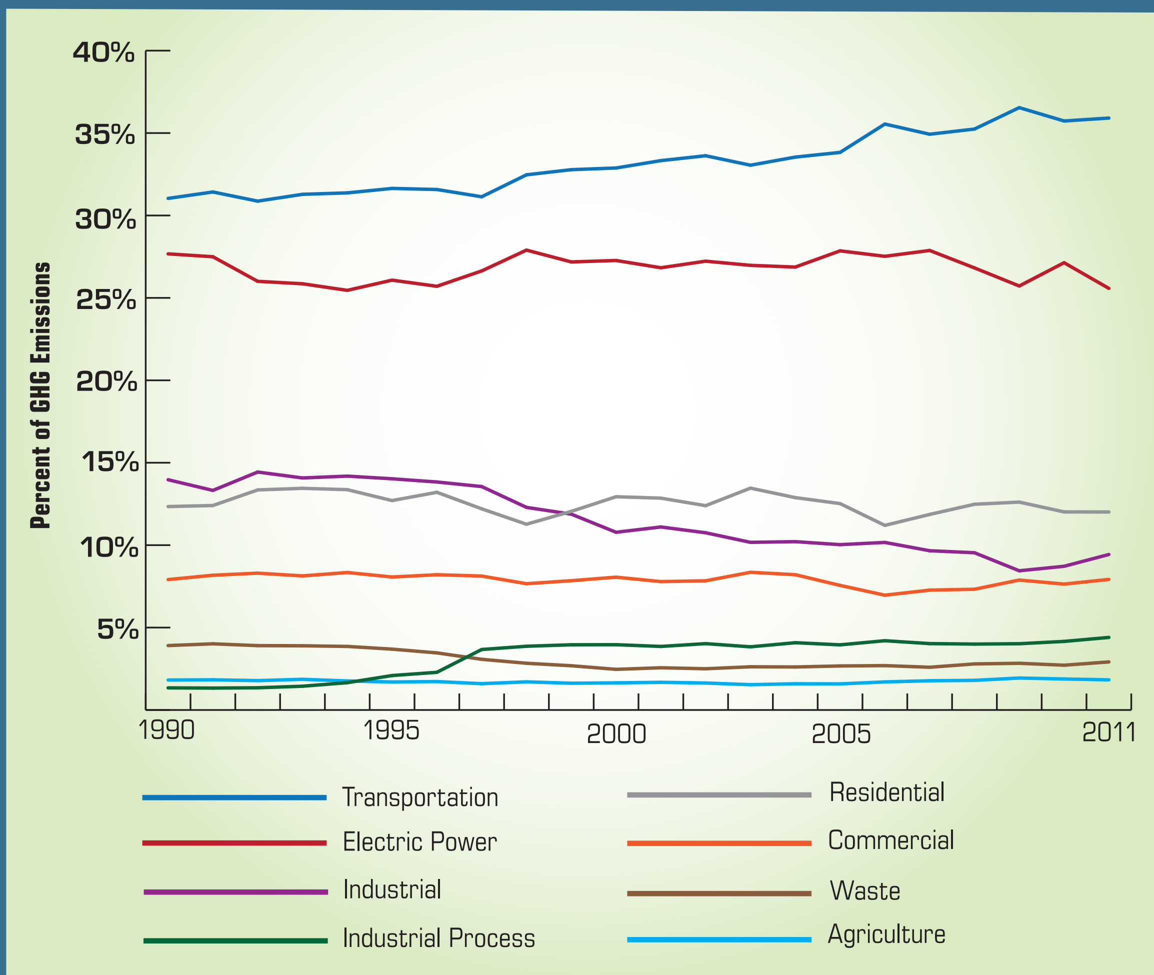
The Georgetown Climate Center designed the analysis incorporating extensive input from state agencies, and Cambridge Systematics conducted the quantitative aspects of the analysis. Analysts produced a detailed, bottom-up emissions inventory and forecast using the U.S. Environmental Protection Agency's (EPA) MOVES model (MOVES 2010b)[8] with location-specific inputs to estimate greenhouse gas emission rates within the TCI region. Effects of emissions reduction strategies were generally modeled by deriving cost-effectiveness rates for specific GHG reduction strategies from regional project-level studies as well as broader literature, and applying these cost-effectiveness rates to specific levels of investment. Additionally, analysts conducted macroeconomic modeling using the Regional Economic Models, Inc. (REMI) Policy Insight (PI+) model (v1.6.8). REMI is the premier economic simulation model in the U.S. and is a dynamic model, measuring interactions among all sectors of the economy over time. REMI incorporates input-output, general equilibrium, econometric, and economic geography modeling approaches.[9] State officials in the TCI region provided detailed input to inform the analysis. The results of the analysis were presented to state agencies and leading transportation experts for review and comment. The Georgetown Climate Center and Cambridge Systematics considered these comments in jointly developing this synthesis report to present the results of the analysis.

Given the scope and complexity of the analysis, the results should be considered "order of magnitude" findings rather than precise estimates. A more detailed overview of the methodology is presented at the end of this synthesis report document. Full descriptions of the methods, assumptions, and results are presented in the appendices, including results of several sensitivity analyses conducted on key assumptions.

Transportation-Sector Emissions in the TCI Region

In the northeast and mid-Atlantic, direct emissions from the transportation sector represent the largest source of greenhouse gas emissions—approximately 35 percent of regional emissions in 2011.[10] This is in contrast to the United States as a whole, for which the power sector is the largest source of GHG emissions. In the TCI region, the share of electric power sector emissions has declined over time, largely due to state carbon pollution reduction programs, clean energy programs, and energy efficiency programs, as well as shifts in energy markets. These state programs include the Regional Greenhouse Gas Initiative, a CO_2 emission budget program for the power sector in which nine states in the region participate, as well as state renewable portfolio standards and energy efficiency programs.[11]

FIGURE 1: *Share of GHG Emissions by Sector in the TCI Region*[12]

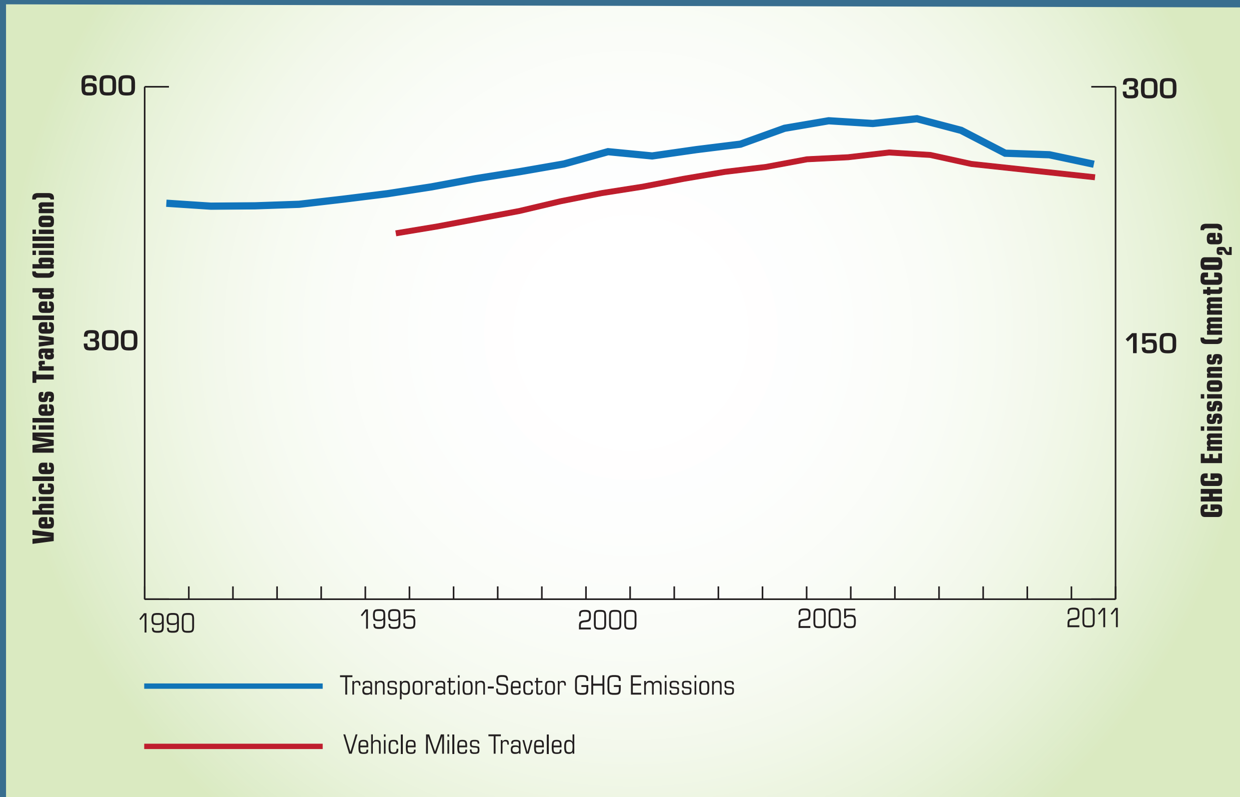


Source: WRI, CAIT 2.0, 2014.

This region's transportation-sector GHG emissions grew steadily from 1990 to the mid-2000s, peaking in 2007. Transportation emissions fell nine percent from 2007 to 2011, due in significant part to decreasing vehicle miles traveled (VMT) during the economic downturn.[13]

In comparison to the United States as a whole, the TCI region has lower vehicle miles traveled per capita, a greater number of hours of delay per auto commuter, a higher portion of commuters using non-single-occupancy vehicles, and significantly higher public transportation trips per capita.[14]

FIGURE 2: *Transportation-Sector GHG Emissions and Vehicle Miles Traveled in the TCI Region*[15]



Sources: U.S. EIA, SEDS; U.S. Federal Highway Administration

TABLE 1: *Comparison of Transportation Indicators Between the TCI Region and the United States*

	Northeast and Mid Atlantic	United States
Amount of Travel (Annual Vehicle Miles Traveled Per Capita)	7,940	9,570
Congestion (Average Hours of Delay Per Auto Commuter)	58 hours	53 hours
Commuting (Non Single-Occupancy Vehicle Mode Share)	32%	23%
Public Transportation (Annual Unlinked Trips Per Capita)[16]	90	33

Sources: 2012 National Transit Database, 2012 American Communities Survey, and 2012 Urban Mobility Report

This report includes a bottom-up inventory of greenhouse gas emissions (measured in million metric tons of carbon dioxide equivalent, or mmtCO_2e) from on-road mobile sources, passenger rail and ferry, freight rail, and intra-region marine sectors. These four sub-sectors are chosen because they are most likely to be affected by existing or potential state clean transportation policies. The analysis found that 2011 GHG emissions for these sectors totaled 261.39 mmtCO_2e.[17]

TABLE 2: *TCI Region 2011 GHG Emissions and Mileage Estimates from Analysis*[18]

Emissions Source[19]	Direct Emissions	Mileage Estimates
On-Road	**mmtCO_2e**	**Vehicle Miles Traveled (VMT, millions)**
Passenger Cars/Trucks	194.48	434,994
Commercial Trucks	47.06	53,274
Buses (Public and Private)	14.75	9,187
Passenger Rail and Ferry	**mmtCO_2e**	**Passenger Miles Traveled (PMT, millions)**
Light Rail/Streetcar	0.10	448
Ferry	0.09	148
Heavy Rail	0.94	12,794
Commuter Rail	1.24	7,838
Amtrak	0.30	2,067
Freight Rail	**mmtCO_2e**	**Ton Miles (millions)**
Intra-region	0.47	16,795
Outside-region	1.89	67,607
Commercial Marine	**mmtCO_2e**	**Ton Miles (millions)**
Intra-region	0.07	4,066
Total	**261.39 mmtCO_2e**	

Source: Cambridge Systematics; see Appendix Emission Inventory & Forecast

GHG Emission Reduction Goals of States in the Region

Residents in the TCI region are already experiencing the effects of climate change including rising seas, heatwaves, and extreme weather events like Hurricanes Irene and Sandy that result in loss of life, significant community disruptions, and tremendous damage to transportation and other infrastructure.

Most states in the region, as well as the District of Columbia, have set economy-wide emission reduction goals, including long-term goals generally consistent with achieving an 80 percent reduction by 2050 from 1990 levels.[20] This level reflects the scientific consensus of the scale of action needed internationally to avoid the worst effects of climate change.[21]

Most states' economy-wide goals do not include sector-specific emission targets, and not all sectors will contribute equally to emission reductions. However, as the transportation sector is the largest source of emissions in the TCI region, shifting to a cleaner transportation system is one critical component of the action needed to meet economy-wide goals and to avoid further catastrophic harms of climate change.

The states' economy-wide goals, which vary with regard to the target and baseline years, have been set through statute, executive order, or in climate or energy plans.

- Seven states have established goals in legislation or through executive action required by legislation: Connecticut, Massachusetts, Maryland, Maine, New Jersey, Rhode Island, and Vermont.
- Delaware, the District of Columbia, New Hampshire, New York, and Pennsylvania have articulated goals in climate or energy plans or frameworks.
- In addition, the New England states and eastern Canadian provinces have collectively established an economy-wide GHG reduction goal through a resolution passed by the New England Governors and Eastern Canadian Premiers.[22]

The state goals appendix provides detailed information about these state goals.

Figure 3 on the following page shows the TCI states' economy-wide goals normalized to a 2011 baseline year and assuming a linear path between goal milestones (i.e., a constant rate of reduction between a 2020 goal and a 2050 goal).[23] The graph shows that the states' goals, along with goals established by the United States and by the New England Governors and Eastern Canadian Premiers, generally converge at reductions of 80 percent from 1990 levels in 2050.

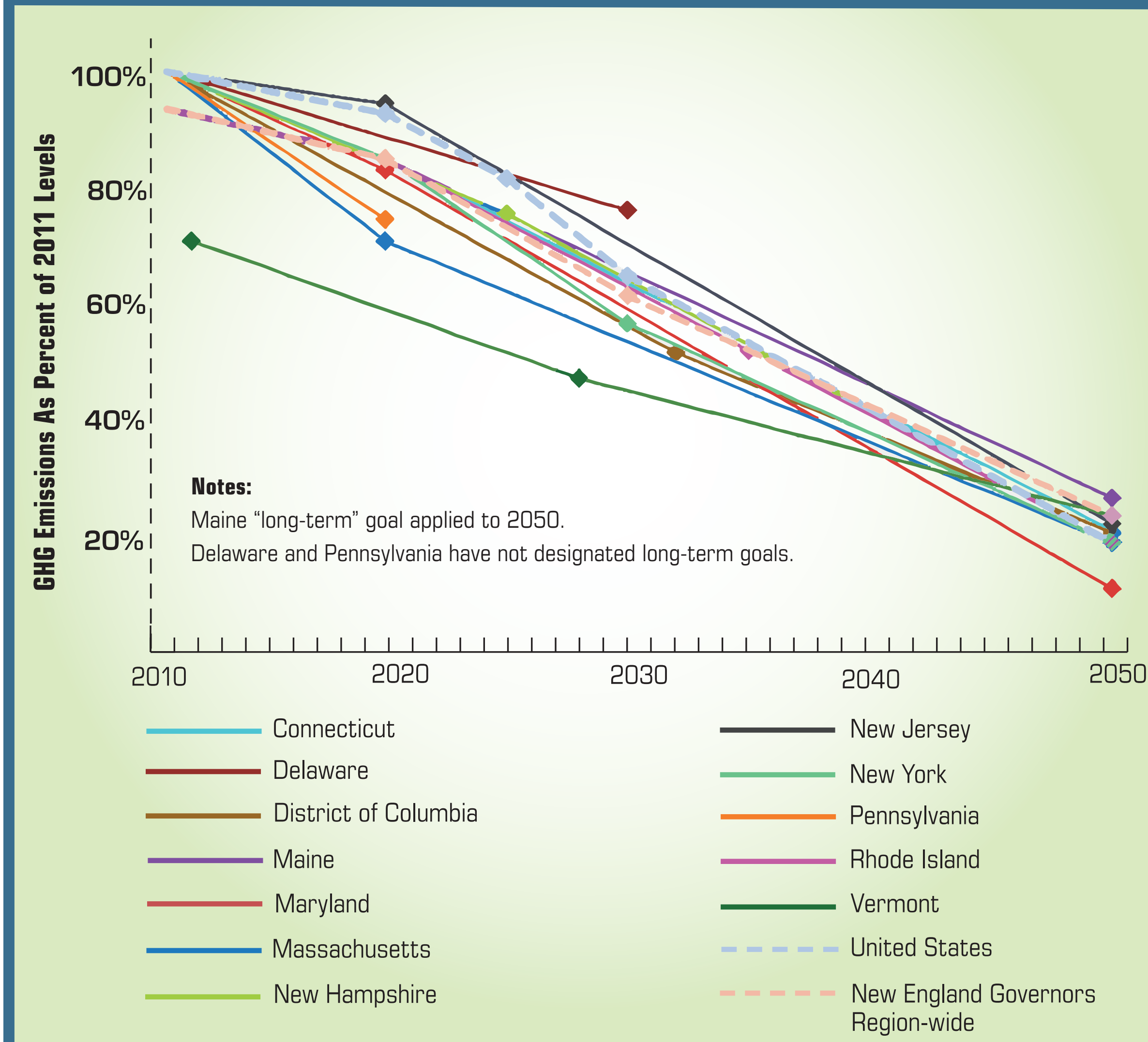
Federal GHG Standards for Vehicles and Existing State Clean Transportation Programs

Federal and state policies already in place will reduce GHG emissions in the transportation sector in the northeast and mid-Atlantic region.

The federal National Highway Traffic Safety Administration (NHTSA) and the EPA have finalized two rounds of combined fuel economy and GHG standards for new light-duty vehicles that will require improvements in fuel economy and reductions in greenhouse gas emissions through model year 2025.[24] EPA and NHTSA have also finalized one round of fuel economy and GHG standards for new medium-duty and heavy-duty trucks and engines for model years 2014-2018,[25] and have recently proposed a second round of joint truck standards for model years 2019-2027.[26]

Other federal standards, including Tier III standards for sulfur in gasoline (which regulate both the fuel and vehicle as an integrated system)[27] and criteria pollutant emissions standards for diesel locomotives and marine engines[28] will also contribute to reducing GHG emissions from the transportation sector.[29]

FIGURE 3: *State Economy-Wide GHG Goals Relative to TCI Region's 2011 Transportation Emissions*



Source: Georgetown Climate Center; see Appendix State Goals for detailed analysis

States in the northeast and mid-Atlantic region have a number of programs and initiatives in place that are already reducing GHG emissions in the transportation sector. For example, the TCI states collectively account for more than half of the nation's transit ridership and passenger miles, and provide significant support for continued transit system operations. The TCI states also accounted for more than 50 percent of total nationwide intercity rail ridership in FY 2014, and Amtrak's Northeast Corridor Service served more than 11.6 million riders.[30]

In addition, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont have adopted California's Zero Emission Vehicle (ZEV) program, which requires vehicle manufacturers to achieve ZEV sales equal to a specified percentage of all vehicle sales each year.[31] In 2013, the governors of California, Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island, and Vermont signed a memorandum of understanding committing to work together to increase deployment of electric vehicles,[32] and in 2014 they released a ZEV Action Plan (citing ongoing TCI work to support electric vehicles) with a goal of achieving a collective deployment of 3.3 million ZEVs by 2025.[33]

As described above, all of the states in this region have worked together to reduce GHG emissions and energy use through the Transportation and Climate Initiative for more than five years, including through changes in administrations and leadership in the relevant agencies. TCI achievements already include the establishment of the Northeast Electric Vehicle Network and the development of resources to promote electric vehicle deployment, the sharing of best practices and development of resources to measure progress on sustainable communities, an analysis of freight movement in the region, and work to mitigate legal barriers to the deployment of real-time transit information.[34]

States have individually taken on a number of other programs and initiatives that either directly or indirectly contribute to GHG reductions, including transit service expansions and continued system maintenance and operations support, investments in cleaner bus fleets, programs that promote investment in compact development or infill, and a focus on "fix-it-first" transportation investment, among other strategies.[35]

Clean Transportation Investments Provide Significant Benefits

Shifting to a cleaner, more efficient, and more resilient transportation system can also provide multiple public health, environmental, and economic benefits to states and their residents. Increasing use of transportation alternatives such as cleaner vehicles, transit, and active transportation such as walking and cycling reduces harmful air pollution, including toxic pollutants like benzene and other pollutants that contribute to the formation of ozone and fine particulate matter. Increasing the use of electric vehicles and other alternative fuels will increase energy diversity and reduce dependence on petroleum fuels, which make up 96 percent of transportation fuels used in TCI states and are almost entirely produced outside the TCI region.[36] Strategies examined in this analysis, such as increasing transit options, promoting compact development, and enhancing transportation efficiency can improve quality of life, reduce congestion and travel time, and provide cost savings to businesses and residents.

Federal GHG and fuel economy standards and state programs are already producing significant benefits. For example, the EPA estimates that consumers purchasing a 2025 light-duty passenger vehicle will save more than $8,000 in fuel costs over that vehicle's lifetime (compared to a pre-GHG standards vehicle). On a national level, the combined light-duty standards are projected to reduce petroleum consumption by more than 2 million barrels per day.[37]

States Also Face Transportation Revenue Shortfalls

At the same time, states in the northeast and mid-Atlantic region, and throughout the country, face serious current and future transportation funding shortfalls. According to the U.S. Department of Transportation, funding for capital improvements in the most recent year analyzed was between $24 billion and $46 billion short of the level required to achieve a state of good repair for roads and bridges, and $2.75 billion short to achieve a state of good repair for transit infrastructure.[38] As vehicles become more fuel efficient—due in significant part to federal fuel economy and GHG standards—and as growth in vehicle travel slows or is even reversed, fuel consumption is also reduced and, consequently, federal and state motor fuel tax ("gas tax") revenues decrease. In addition, the fixed nature of federal motor fuel taxes (i.e., 18.4 cents per gallon for gasoline and 24.4 cents per gallon for diesel fuel),[39] as well as most state motor fuel taxes, means that these funds do not maintain their buying power as inflation increases. Even as greater levels of investment are needed, state investments are harder to sustain as revenues from federal and state motor fuel taxes decrease and purchasing power is lost.

The federal government accounts for a major share of funding for state transportation. The majority of federal transportation programs are funded through the Highway Trust Fund, which is capitalized by receipts from federal motor fuel taxes and other user fees.[40] The shortfall of fuel tax revenues has already resulted in a near-insolvency of the federal Highway Trust Fund since 2008, prevented only through Congressionally-authorized transfers totaling $77.3 billion as of October 2015, the vast majority from the general fund of the U.S. Treasury.[41] While many commentators and legislators have acknowledged the need to reform federal transportation funding to address revenue shortfalls, such reforms would require passage of legislation. At the current time, however, no political consensus has emerged around a funding mechanism that could provide long-term, sustainable funding for transportation. For example, even though the federal MAP-21 transportation funding authorization expired at the end of Fiscal Year 2014, it has only been succeeded by temporary extensions. Recent discussions around multi-year transportation reauthorization legislation have generally been focused on one-time funding mechanisms, not on establishing a funding approach that would provide dedicated and sustainable funding for the foreseeable future.[42] If no such transportation funding mechanism is passed into law, it is likely that states will receive less federal funding in the future as traditional highway gas tax funds decline.

Many states also rely on state motor fuel taxes as the major source of state funding for transportation.[43] As with federal motor fuel tax revenue, the combined factors of increasing fuel economy, inflation, and decreases in vehicle miles traveled all contribute to reductions in the revenue from—and purchasing power of—state motor fuel taxes and result in decreasing transportation funding across the TCI region and the country.

A number of states have responded to decreasing federal and state transportation revenues by passing legislation to raise additional funds. In the northeast and mid-Atlantic, Delaware, Maryland, Massachusetts, New Hampshire, Pennsylvania, Rhode Island, and Vermont have all passed some form of transportation funding measure since 2012.[44] In total, twenty-one states have enacted transportation funding measures in that time.[45]

Given that most current transportation revenue mechanisms depend upon petroleum consumption, even states that have passed gas tax increases or other funding measures recently will likely have to address transportation funding challenges over the medium- and long-term as vehicles become more fuel efficient, and if vehicle travel continues to slow. Additionally, states will have to evaluate how transportation funds are allocated, to support changing needs and priorities in building a cleaner and more resilient transportation system. States will also have to grapple with the additional costs of preparing for the impacts of climate change. For example, Hurricanes Irene and Sandy caused tremendous damage to the transportation sector, with Irene causing an estimated $175 million to $250 million in damage to Vermont's state roads and bridges, and Sandy causing an estimated $7.5 billion and $2.9 billion in damage to New York's and New Jersey's transportation infrastructure, respectively.[46] These natural disasters have underscored the need for greater infrastructure investment to prepare for increased extreme weather events and sea-level rise.

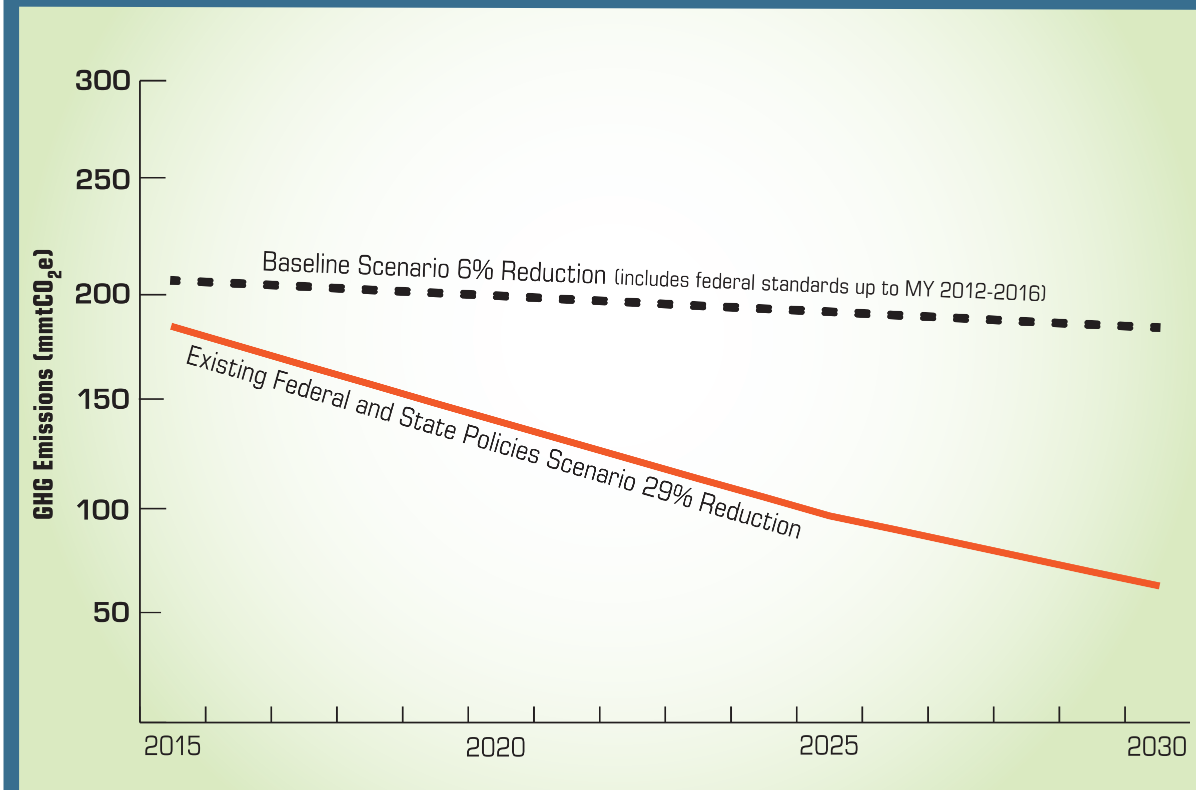
Key Findings

Federal Standards Are Projected to Achieve Significant GHG Reductions, But Are Not Sufficient to Meet Long-Term Goals

Federal fuel economy and greenhouse gas standards for model year 2012 and later vehicles, along with state ZEV programs, will help curb greenhouse gases in the region—reducing direct transportation-sector emissions approximately 29 percent below 2011 levels by 2030.[47]

These policies provide significant reductions compared to the Baseline Scenario, which would achieve a six percent emission reduction from 2011 levels by 2030. The Baseline Scenario used in the analysis includes the model year 2012-2016 light-duty vehicle standards, but does not include the most recent federal and state policy actions, which were not included in the version of the MOVES model used in this analysis.[48]

FIGURE 4: *Projected GHG Emission Reductions from Existing Federal and State Standards*



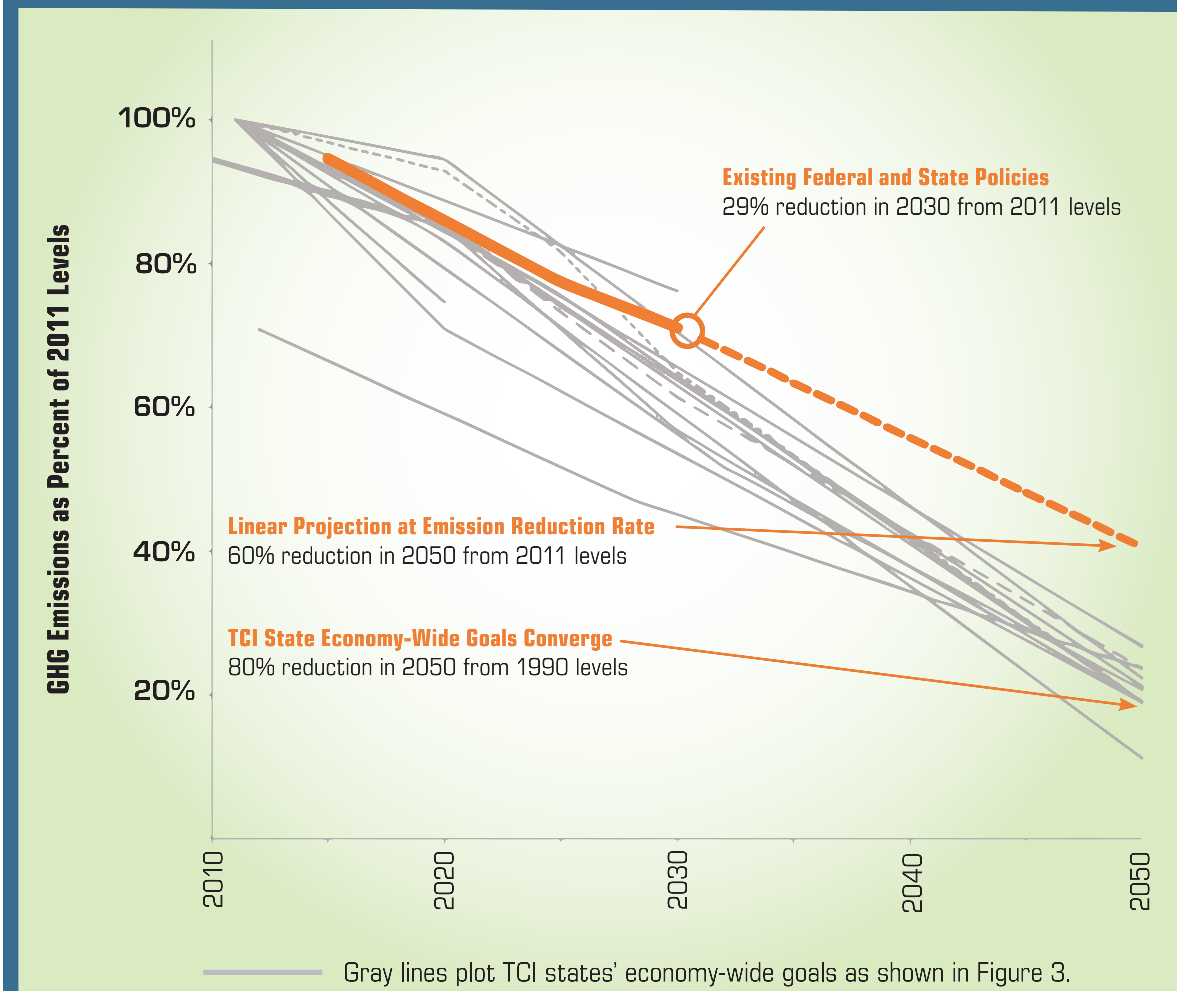
Source: Cambridge Systematics; see Appendix Inventory and Forecast

GEORGETOWN CLIMATE CENTER

The Existing Federal and State Policies Scenario includes reductions from model year 2012-2016 light-duty vehicle standards, as well as more recent federal and state policy actions, including:

- model year 2017-2025 light-duty vehicle standards,
- model year 2014-2018 medium- and heavy-duty vehicle standards,
- the federal Renewable Fuel Standard (RFS),[49] and
- the Zero-Emission Vehicle MOU, in which six TCI states participate.[50]

FIGURE 5: *Projected TCI Region Transportation GHG Emission Reductions from Existing Federal and State Policies Compared to Economy-Wide Goals*



Source: Cambridge Systematics, see Appendix Emission Reduction Analysis; WRI, CAIT 2.0; see Appendix State Goals

The Existing Federal and State Policies Scenario only includes those standards that have been finalized, and therefore does not include the proposed post-2018 medium- and heavy-duty vehicle standards.[51]

The existing policies in place in this region move the TCI states' transportation-sector emissions closer to the goals these states have identified for economy-wide reductions, but are not sufficient to achieve the level of reductions required in the long term. If continued at the same rate of reduction beyond 2030, the states would reduce transportation-sector emissions 56 percent from 1990 levels in 2050, significantly shy of the states' economy-wide 80 percent reduction goals.[52]

The 2030 to 2050 trajectory of projected TCI region transportation-sector emissions depicted in Figure 5 is a linear extension based on the rate of change of emission reductions projected through 2030. Federal and state policies were not modeled beyond 2030 in this analysis because they have yet to be determined. Many states in the TCI region have adopted California's more stringent vehicle emissions standards, and California and other states will play a role in the determination of the next round of federal fuel economy and greenhouse gas standards.[53]

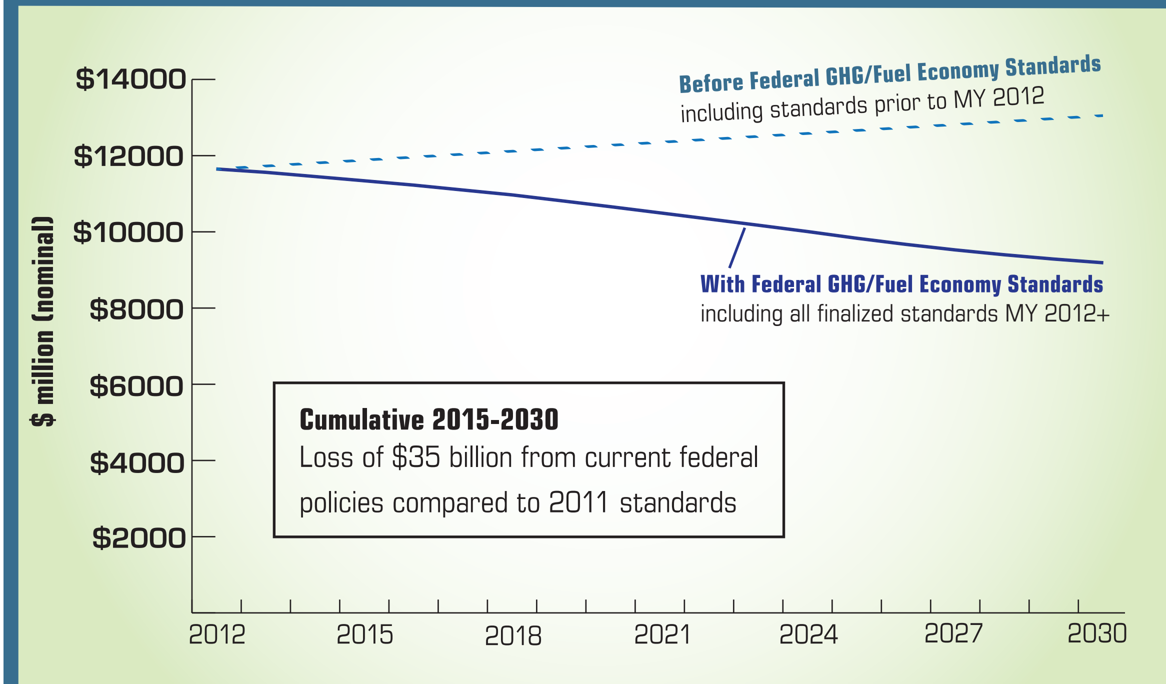
Existing Federal Standards Will Significantly Reduce Transportation Funding under Current Federal and State Revenue Mechanisms

The existing federal fuel economy and GHG standards will have the effect of making the overall fleet of vehicles more fuel efficient over time. As a result, emission and petroleum reliance will decrease as drivers purchase less motor fuel. As described in more detail below, this will result in significant net cost savings to consumers and businesses in the region, as well as significant public health benefits. At the same time, reductions in fuel consumption will also cause revenues from federal and state motor fuel taxes to decrease.

The analysis finds that as a result of the federal and state GHG and fuel economy standards identified above, combined federal and state transportation revenues will decrease by a cumulative $35 billion in current dollars[54] from 2015 to 2030 in the northeast and mid-Atlantic region compared to what revenues would have been in the absence of these standards.[55]

The analysis uses projections of motor fuel prices from the Energy Information Administration's 2014 Annual Energy Outlook (AEO) reference case. For example, for motor gasoline, the AEO reference case projected fuel costs of $3.18 per gallon in 2015 and $3.43 per gallon in 2030 in current dollars.[56]

FIGURE 6: *Federal and State Motor Fuel Tax Revenues in the TCI Region*



Source: Cambridge Systematics; see Appendix Emission Reduction Strategy Analysis

Modest Additional GHG Reductions by 2030 Would Help States Achieve Their Long-Term Economy-Wide Goals

The analysis modeled three hypothetical investment scenarios to show the emissions impact of a portfolio of clean transportation policies at varying levels of implementation. (A subsequent section of this report discusses comprehensive policy bundles that include pricing policies that could generate proceeds to fund implementation of such strategies.)

The three investment scenarios were as follows:

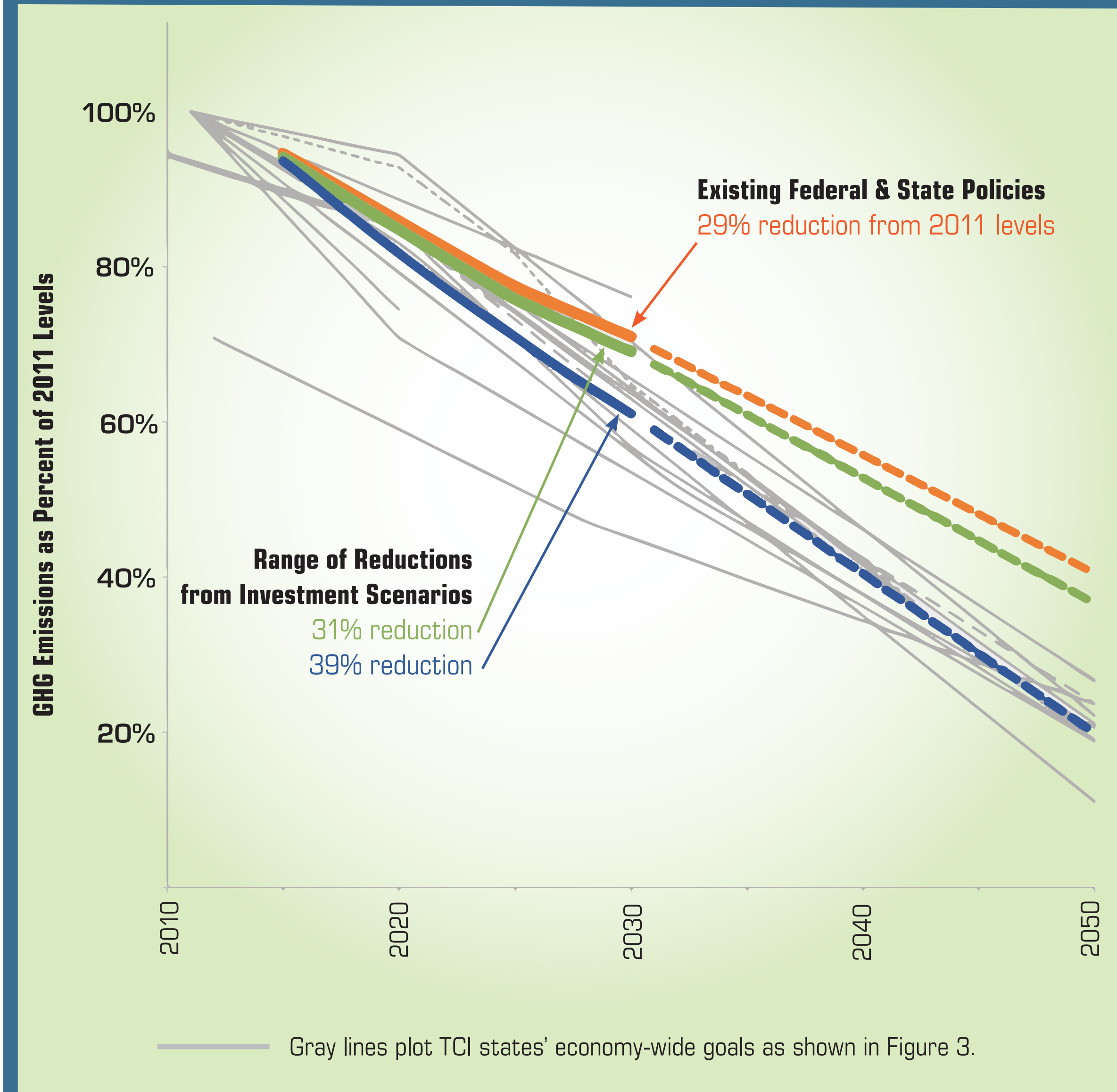
- ***Modest Investment Scenario*** assumes $1.5 billion in average annual funding over the region;
- ***Moderate Investment Scenario*** assumes $3 billion in average annual funding over the region; and
- ***Aggressive Investment Scenario*** assumes $6 billion in average annual funding over the region.

Investing at these levels in a suite of clean transportation strategies reduced GHG emissions in the range of 31 to 39 percent by 2030 from 2011 levels.[57] For translation of emissions reductions to additional baseline years (including 1990 and 2005 baselines), see Table 4.

Emissions reductions in this range would help states achieve their long-term economy-wide goals.

For example, continuing emission reductions at the same rate as the modest investment scenario—31 percent reduction by 2030—would achieve a reduction in the transportation sector of 60 percent in 2050 compared to 1990 levels. Continuing at the same rate as the aggressive investment scenario—39 percent reduction by 2030—would achieve a 78 percent reduction in transportation GHGs in 2050 from 1990 levels.[58]

FIGURE 7: *Projected GHG Emission Reductions from Investment Scenarios Compared to Economy-Wide Goals*



Source: Cambridge Systematics; see Appendix Emission Strategy Analysis

This analysis finds that such levels of reduction are achievable through a suite of clean transportation policies in the region. The clean transportation strategies include:

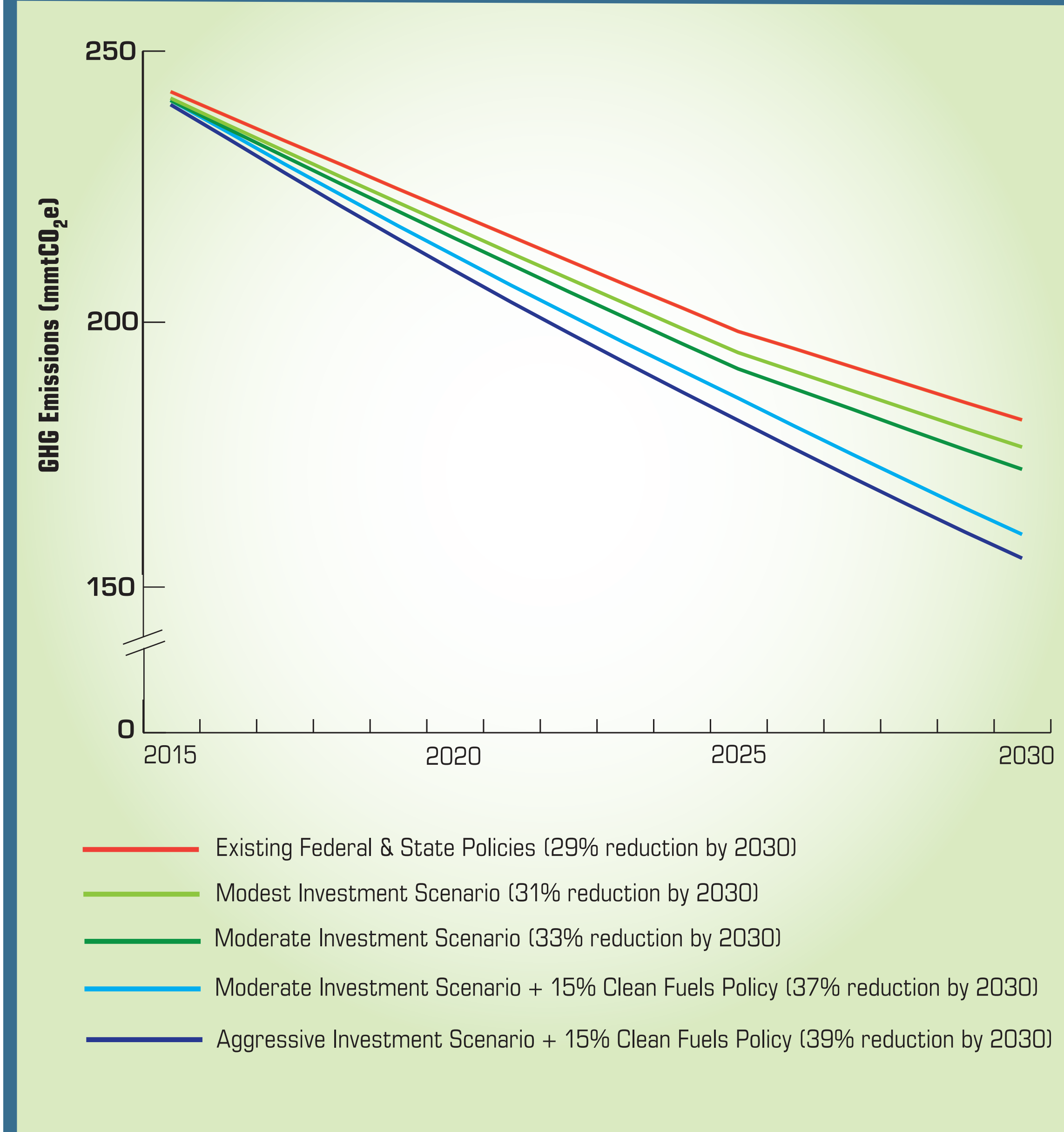
- financial incentives for purchase of clean vehicles including full battery electric and plug-in hybrid electric light-duty vehicles, and heavy-duty vehicles running on compressed natural gas or liquefied natural gas;
- investment in transit expansion, such as bus rapid transit, light rail, and heavy rail;
- promotion of urban infill and other compact land use;
- investment in bicycle infrastructure in urban areas;
- additional support for travel demand management strategies;
- additional investment in system operations efficiency technologies; and
- investment in infrastructure to support rail and short-sea freight shipping and intermodal connections.[59]

The analysis assumes that at each level of investment, funds are allocated to the different strategies according to the percentages shown in Table 3. This allocation was chosen based on input from states.

TABLE 3: *Modeled Investment Scenarios: Percent Allocation to GHG Reduction Strategies*[60]

GHG Strategy	Percent of Total Investment
Electric Vehicle / Alternative Fuel Infrastructure and Incentives	20%
Urban and Intercity Transit	25%
Land Use / Smart Growth	7.5%
Active Transportation	7.5%
Travel Demand Management (TDM) and Ecodriving	10%
System Operations / Efficiency	15%
Freight / Intermodal Infrastructure / Operations	15%
Total	**100%**

FIGURE 8: *Projected GHG Emission Reductions from Investment Scenarios*



Source: Cambridge Systematics; see Appendix Emission Strategy Analysis

The three levels of implementation analyzed are consistent with "modest" to "aggressive" levels of implementation (but not a "maximum" level of implementation) that Cambridge Systematics modeled in its Moving Cooler analysis.[61] In addition, the analysis examined the effect that a hypothetical regional clean fuels policy—for example, a requirement that fuel suppliers reduce carbon intensity 15 percent over 15 years—could have when implemented together with the policies above.[62]

Figure 8 shows the emission reductions possible at these three levels of implementation, with and without a clean fuel standard.[63]

TABLE 4: *Modeled Investment Scenarios: 2030 Emission Reductions Relative to Different Baselines*[64]

	1990 Baseline	2005 Baseline	2011 Baseline
Existing Federal and State Policies	22%	35.4%	29%
Modest Investment Scenario	24.1%	37.2%	30.9%
Moderate Investment Scenario	25.8%	38.6%	32.5%
Moderate Investment Scenario + 15% CFS	31%	42.9%	37.2%
Aggressive Investment Scenario + 15% CFS	33%	44.5%	39%

Emission Reductions Would Benefit Public Health and Reduce Fuel Consumption

In addition to moving states closer toward the pathway needed to achieve long-term economy-wide emissions reduction goals, reductions in the range of 31 to 39 percent would achieve significant energy independence and public health benefits, including the following benefits when compared to existing federal and state policies:

- ***Reduction in petroleum fuel consumption***—ranging from 4 to 27 percent by 2030—would promote energy diversity and keep more money within the region.[65]
- ***Reductions in conventional air pollution*** would improve public health. This includes preventing between 19 and 65 premature deaths and between 1,099 and 3,728 asthma cases in 2030. These public health improvements translate to $152 million to $463 million in benefits in 2030.[66]

- ***Travelers would spend less personal time in traffic*** due to reduced congestion, saving between 385 million to 1.36 billion hours in the region in 2030.[67]
- ***Reduced vehicle travel*** would result in fewer traffic accidents and reduced wear on transportation infrastructure.[68]
- ***Increased walking and cycling*** as a result of investments in pedestrian and bicycle infrastructure is also expected to result in public health improvements.[69]

The Emission Reduction Strategy Appendix provides additional details on these benefits in Table 2.5 and in Section 6.[70]

Pricing Policies Could Reduce Emissions, Fund Clean Transportation Strategies, and Address Transportation Revenue Shortfalls

One potential policy mechanism for achieving these levels of reductions would be to implement a transportation pricing policy, which could both achieve GHG reductions and generate proceeds that could be used to fund clean and resilient transportation solutions.

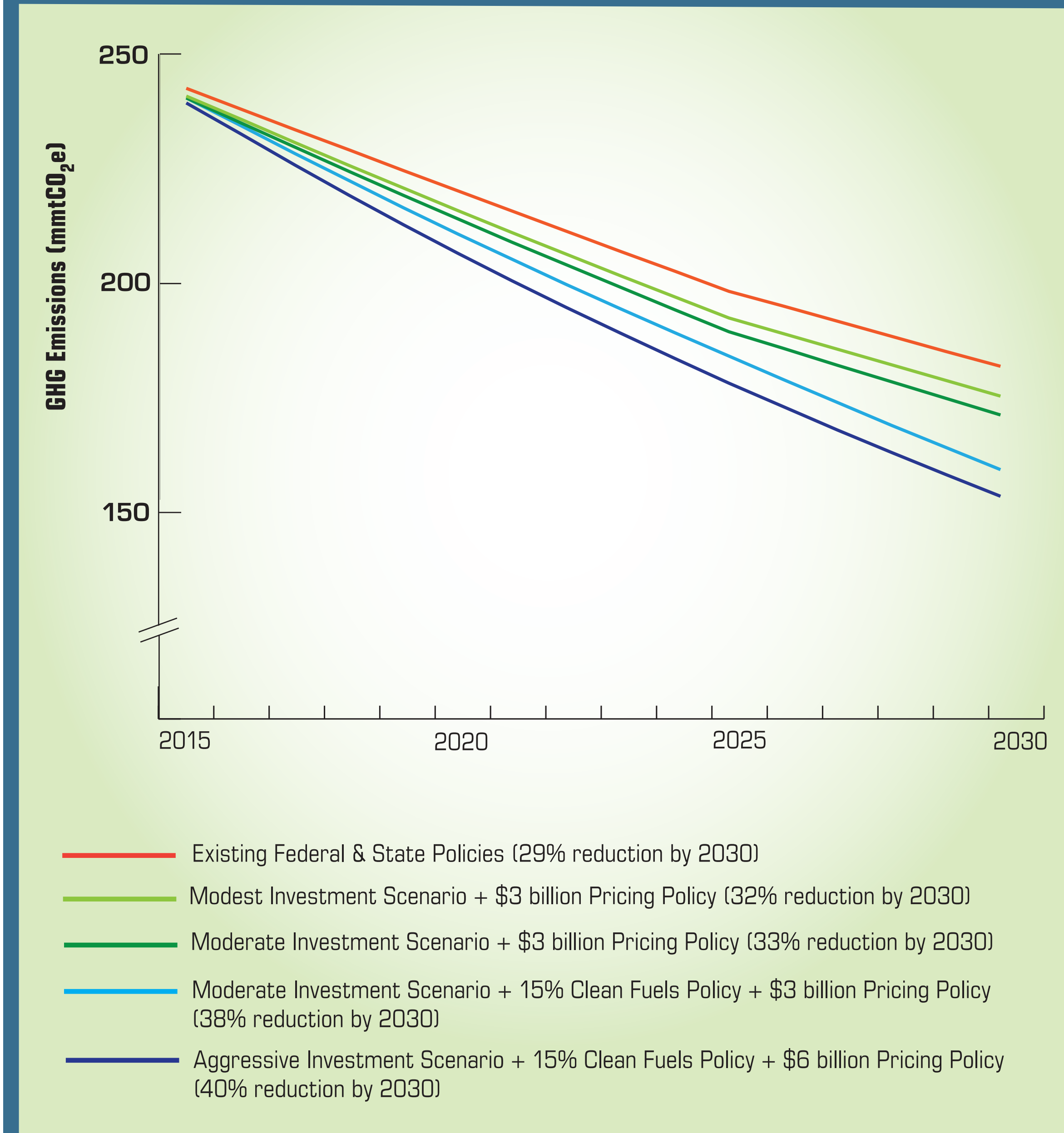
In the current transportation funding debate, mileage-based user fees, fuel fees indexed to inflation, carbon-content-based fees, and additional petroleum-based pricing policies have been discussed as potential options to reduce GHG emissions and raise proceeds for clean transportation policies.[71]

This report looks at the potential effects of a hypothetical pricing policy on both GHG emissions and funding. The analysis modeled carbon-content-based fees, mileage-based user fees, and motor-fuel taxes at levels of implementation that would generate an average of $1.5 billion to $6 billion annually in the region. At these levels of implementation, the analysis found that the differences in emission impacts between the different policies were minor, and therefore refers to a generic “pricing policy.”

A pricing policy that generated approximately $3 billion per year for the region would create a price signal that would promote alternatives to single-occupancy vehicle travel and result in modest additional emission reductions.[72] It would also raise a cumulative $41 billion to $46 billion for the region during 2015-2030.[73]

Proceeds from this $3 billion per year pricing policy would be sufficient to fund the implementation of a suite of clean transportation policies at the Moderate Investment Scenario level. The clean transportation policy investments combined with the pricing policy would reduce transportation-sector direct emissions approximately 33 percent from 2011 levels by 2030. Figure 9 shows that if the pricing policy were added to the three investment scenarios, emission reductions could be achieved in the range of 32 to 40 percent.[74]

FIGURE 9: *Projected GHG Emission Reductions from Investment Scenarios With Pricing Policies Included*

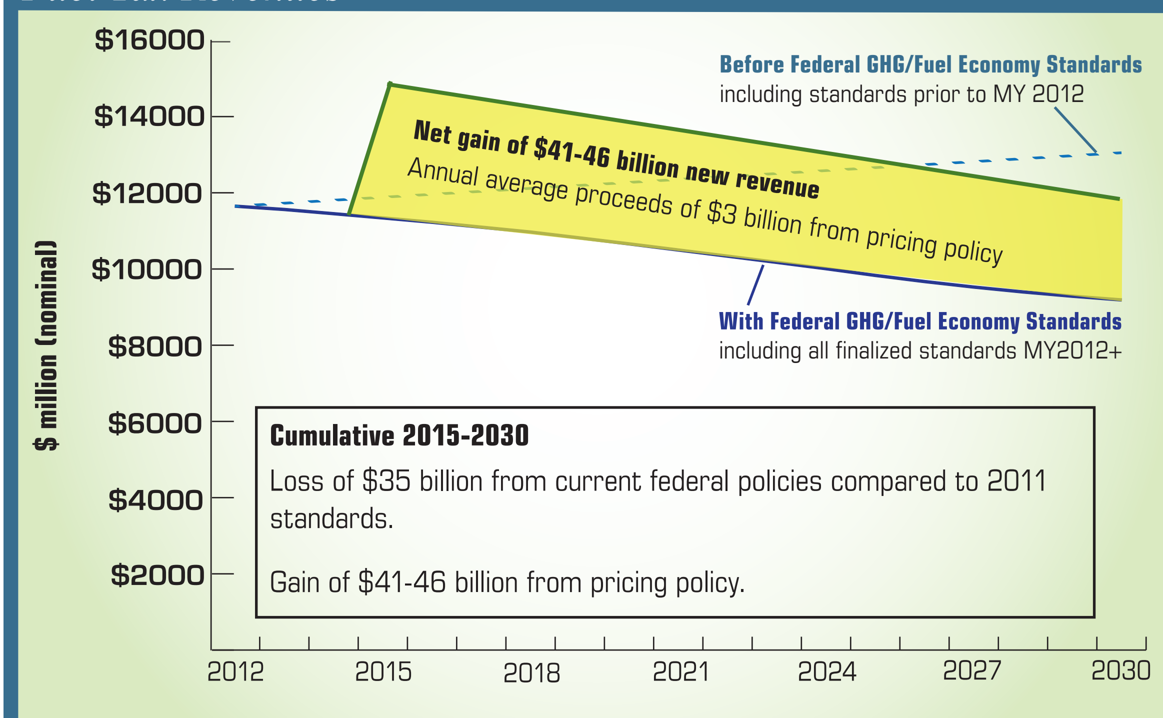


Source: Cambridge Systematics; see Appendix Emission Strategy Analysis

Funds raised through a pricing policy would also offset declines from existing federal and state gas taxes. The net gain of $41 billion to $46 billion takes into account the impact on federal and state revenue of clean energy strategies that reduce petroleum consumption, including the new pricing policy. As seen in Figure 10, the new funds would more than offset the $35 billion loss that is projected to result from existing federal fuel economy standards.

States could use proceeds from the pricing policy to invest in a broad range of transportation strategies, including strategies that achieve additional greenhouse gas reductions and strategies that do not achieve additional reductions but are still critical to supporting a clean and resilient transportation system (e.g., maintaining existing transit operations and system preservation). Each state would have the opportunity to determine these public policy and investment priorities for itself.

FIGURE 10: *Potential Proceeds from Pricing Policy Relative to Fuel Tax Revenues*



Source: Cambridge Systematics; see Appendix Emission Reductions Strategy Analysis

Figure note: A $3 billion per year pricing policy would provide revenue of between $41 billion to $46 billion depending on the type of pricing policy, as clean transportation investments would have different effects on revenue under different pricing policies. See Appendix Emission Reductions Strategy Analysis.

A Bundle of Pricing and Investment Policies Could Reduce Costs for Businesses and Consumers, Help Fund Transportation Investments, and Generate Economic Benefits for the Region

This analysis explores the macroeconomic effects of two policy bundles that include pricing policies and investment scenarios. These bundles include a suite of clean transportation strategies and assume that a pricing policy provides funds to support these strategies. The First Policy Bundle assumes that 100 percent of the revenue is invested in policies that achieve emission reductions. The Second Policy Bundle assumes that half of the revenue is invested in those policies, and the other half is invested in transportation system preservation and transit operations. Both analyses project significant benefits for the region, including net cost savings for consumers and businesses and net macroeconomic benefits to the region. To model the economic effects of this approach, the analysis uses a generic pricing policy that generates approximately $3 billion per year of proceeds for the TCI region.

The two policy bundles modeled are as follows:

- ***The First Policy Bundle*** assumes a Moderate Investment Scenario of $3 billion per year, plus a transportation pricing policy raising approximately $3 billion per year.[75] The combined policies are projected to achieve a 33 percent reduction in GHG emissions below 2011 levels by 2030.[76] At this rate of reduction, transportation-sector emissions would be reduced 65 percent by 2050 from 1990 levels.[77]
- ***The Second Policy Bundle*** assumes a Modest Investment Scenario of $1.5 billion per year, plus a transportation pricing policy raising approximately $3 billion per year. In the Second Policy Bundle, the remaining $1.5 billion is assumed to be invested in clean transportation programs such as funding existing transit operations and maintaining the existing transportation system.[78] The combined polices are projected to achieve approximately 31.5 percent reductions in GHG emissions below 2011 levels by 2030.[79] At this rate of reduction, transportation-sector emissions would be reduced 61 percent by 2050 from 1990 levels.[80]

Under both scenarios, consumers and businesses would see net cost savings.

TABLE 5: *Comprehensive Policy Bundle Investment Allocations*[81]

Strategy	Investment Allocation		New Average Annual Funding 2015-2030 ($ million)	
	First Bundle	Second Bundle	First Bundle	Second Bundle
Greenhouse Gas Mitigation	The Second Policy Bundle invests half as much in greenhouse gas mitigation strategies as the First Policy Bundle.			
EV/ Alternative Fuel Infrastructure and Incentives	20%	10%	$613	$311
Urban and Intercity Transit	25%	12%	$767	$388
Land Use/ Smart Growth	7.5%	3.75%	$230	$116
Active Transportation	7.5%	3.75%	$230	$116
TDM and Ecodriving	10%	5%	$307	$155
System Operations/ Efficiency	15%	7.5%	$460	$233
Freight/ Intermodal Infrastructure/ Operations	15%	7.5%	$460	$233
Other Sustainable Transportation	The Second Bundle invests the remaining half of funds in other transportation measures.			
Highway Preservation		32.5%		$544
Transit Operations		16.5%		$1,010
Total	**100%**	**100%**	**$3,067**	**$3,106**
Cumulative, 2015 2030			**$49,064**	**$49,702**

Table note: The Second Policy Bundle generates slightly more cumulative revenue because a lower level of investment in GHG reduction strategies in the Second Policy Bundle results in a higher level of fuel consumption or VMT, which leads to higher proceeds from the pricing policy. TDM is Travel Demand Management and includes measures such as ridesharing and vanpools.

Net Consumer Cost Savings

In both bundles, consumers would initially experience cost increases as they purchase more advanced clean vehicles and pay the cost of the pricing policy, but these increases would be more than offset in a short time by cost savings from reduced fuel use (because consumers are driving more fuel-efficient vehicles and driving less), reduced vehicle maintenance costs (also because they are driving less), and incentives and discounts (to promote clean vehicles).[82] Consumers would begin to see net cost savings by either 2019 or 2021, depending on the scenario, and the net savings would continue to increase until the end of the analysis period in 2030.[83]

TABLE 6: *Consumer Costs and Savings from Policy Bundles*

Ranges reflect results from First and Second Policy Bundles.

	2015	2030	Cumulative 2015 2030
Consumer Costs ($ million)			
Vehicle Purchase Differential[84]	$188 - $376	$201 - $393	$2,981 - $5,880
Electricity	$2 - $5	$77 - $151	$512 - $1,012
Fees/ Taxes	$2,780 - $2,775	$2000 - $1,948	$38,280 - $37,795
Total New Costs	**$2,970 - $3,156**	**$2,278 - $2,492**	**$41,773 - $44,687**
Consumer Savings ($ million)			
Fuel (Petroleum)	$522 - $622	$1,830 - $2,801	$20,413 - $29,068
Vehicle Maintenance/ Repair	$561 - $430	$1,701 - $2,274	$19,161 - $22,653
Incentives and Discounts	$413 - $824	$320 - $623	$3,641 - $11,530
Total New Savings	**$1,496 - $1,876**	**$3,851 - $5,698**	**$45,413 - $63,251**
Net Consumer Savings $ (million) *Parentheses indicate net costs*	**($1,475) ($1,278)**	**$1,573 - $3,206**	**$5,840 - $18,563**

Source: Cambridge Systematics; see Appendix Emission Strategy Analysis

Net Business Cost Savings

Much like individual consumers, businesses would experience initial cost increases due to higher vehicle prices and the pricing policy, but these increases would quickly be more than offset by savings from reduced fuel use and vehicle maintenance costs, as well as reductions in labor costs due to relieved congestion and the availability of more cost-effective freight options.[85] Businesses would begin to see net cost savings by either 2016 or 2017, depending on the scenario, and the net benefits would continue to increase until the end of the analysis period in 2030.[86]

TABLE 7: *Business Costs and Savings from Policy Bundles*

Range reflects results from First and Second Policy Bundles.

	2015	2030	Cumulative 2015 2030
Business Costs ($ million)			
Vehicle Purchase Differential	$121 - $242	$333 - $649	$4,952 - $9,759
Fees, Taxes, Tolls, Fares	$734 - $733	$720 - $702	$11,422 - $11,269
Total New Costs	**$855 - $975**	**$1,053 - $1,351**	**$16, 374 - $21,028**
Business Savings ($ million)			
Time (Productivity)	$500- $572	$2,791 - $4,613	$27,557 - $42,940
Fuel (Petroleum)	$46 - $65	$542 - $1,014	$4,860 - $8,853
Vehicle Maintenance/ Repair	$49 - $29	$124 - $153	$1,461 - $1,522
Transportation Services (Shipping)	$90 - $179	$1,267 - $2,502	$11,254 - 22,304
Total New Savings	**$685 - $845**	**$4,724 - $8,282**	**$45,132 - $75,619**
Net Business Savings $ (million) *Parentheses indicate net costs*	**$(170) $(130)**	**$3,671 $6,931**	**$28,758 $54,591**

Source: Cambridge Systematics; see Appendix Emission Strategy Analysis

Changes in Government Expenditures

State governments would receive just over $3 billion annually (averaged over the 2015-2030 period) in new funds from the pricing policy. This amount considers decreased fuel use due to the GHG reduction strategies, which reduces the new proceeds by about $75 million to $141 million per year on average (depending on the pricing mechanism) compared to what it would be without the strategies. The analysis assumes that the new funds would be reinvested in transportation policies.[87]

Net Macroeconomic Benefits

As a result of these changes in costs and cost savings, the macroeconomic analysis projects that within the TCI region in 2030, gross regional product would increase by an amount in the range of $11.7 billion to $17.7 billion relative to business as usual, personal disposable income in the region would increase in the range of $9.4 billion to $14.4 billion in 2030, and 91,000 to 125,000 new jobs would be created.[88]

TABLE 8: *Macroeconomic Analysis Results Summary*

Range reflects results from First and Second Policy Bundles.

	2030	2030 (% of Region)	Cumulative 2015 2030
Change in Regional Employment (job years)[89]	91,000 - 125,000	0.22% - 0.31%	794,000 - 1,167,000
Change in Gross Regional Product ($ Billion, 2009)	$11.7 - $17.7	0.25% - 0.38%	$92 - $144
Change in Disposable Personal Income ($ Billion, 2009)	$9.9 - $14.4	0.19% - 0.28%	$71 - $109

Source: Cambridge Systematics; see Appendix Emission Strategy Analysis

Conclusion

Shifting to a cleaner, more efficient, and more resilient transportation system would provide multiple public health, environmental, and economic benefits to states and their residents. At the same time, states will need to achieve significant GHG reductions from the transportation sector if they are to meet the reductions that scientists say are required by mid-century, as well as the long-term economy-wide goals that most states in the northeast and mid-Atlantic region have articulated. State transportation agencies are also facing a funding crisis, due in part to the fact that fixed cent-per-gallon gas taxes will receive less revenue as vehicle fuel efficiency improves.

This analysis shows that existing federal and state policies will achieve significant GHG reductions, approximately 29 percent from 2011 levels by 2030, but that this will not be sufficient to put states on the path to meeting the scale of economy-wide reductions that will be required. Additional greenhouse gas reductions by 2030—in the range of 31 to 40 percent—could move states closer to the path needed to achieve these long-term goals. This range of reductions could be achieved through modest to aggressive implementation of a suite of clean transportation strategies in the region. Implementation of these strategies would produce significant benefits, for example significantly reducing petroleum consumption and achieving public health benefits such as reducing premature deaths and asthma cases. One option that could be included in a suite of such strategies would be a transportation pricing policy (e.g., a carbon fee or mileage-based user fee), which could modestly increase the range of emission reductions achieved and also generate proceeds to fund the other strategies in the suite.

The analysis also shows that a comprehensive bundle that includes clean transportation strategies funded by a transportation pricing policy could generate significant net macroeconomic benefits for the region over a 15-year period—increasing gross regional product and personal disposable income, as well as creating new jobs.

A more detailed summary of the methodology used in this analysis follows on the next several pages. Full descriptions of the methodology, assumptions, and analysis results, including additional sensitivities, are included in the three technical appendices to this report that respectively cover the inventory and forecast analysis, the emission reduction strategy analysis, and the state energy and climate goals analysis.

Summary of Methodology

The methodology used in this report is detailed in the appendices, and described here at a high level.

Inventory and Forecast

The analysis included a bottom-up emissions inventory and forecast for the multi-state region using state and county-level data inputs. This inventory and forecast covered on-road, passenger rail and ferry, freight rail, and intra-region marine sectors.

On-Road Vehicle Inventory and Forecast

The EPA's Motor Vehicle Emission Simulator model[90] was used to estimate greenhouse gas emission rates (grams CO_2e per mile) by vehicle type and road type for five representative "place types" within the TCI region. The resulting emission rates were then applied to estimated county-level vehicle miles traveled (VMT) by vehicle type and road type for 2011 and 2030, resulting in estimated and projected CO_2 emissions.[91]

The five place types—core, high urban, medium urban, suburban, and rural—were defined based on population density by county within the region. MOVES was run in inventory mode for the entire year for two representative counties for each of four place types (and for five urban counties identified as the "core" place type), using county-specific inputs provided by states for 2011 and 2030. The model produced composite running emission rates (CO_2e emissions per VMT) for each county, averaging emission rates for different vehicle and road types, and an average emission rate for each of the place types.[92]

Since the MOVES version available at the time of this analysis did not include federal GHG standards for light-duty vehicles for model years 2017 to 2025, or medium- and heavy-duty vehicle standards for model years 2014 to 2018, post-MOVES adjustments were made to the average emission-rate factors to reflect the projected improvement in fuel efficiency of these standards by vehicle type.[93] The Baseline Scenario shows the emissions reductions from the pre-2012 federal standards. The Existing Federal Policies Scenario reflects this adjustment to the MOVES model.[94]

The calculated emission rates were then applied to estimated or projected VMT for 2011 and 2030 for each county in the region based on the county's place type, resulting in emissions for each county. For 2011, county-level state VMT data from the Highway Performance Monitoring System was used, in most cases broken down by place type and vehicle type. For 2030, a regional average VMT growth rate was calculated for each place-type based on state VMT projections.[95] These VMT estimates and projections were then applied to the emission rates calculated for vehicle- and road-type for each representative county, generating the 2011 on-road inventory and 2030 forecast.[96]

The inventory and forecast outcomes were consistent with an earlier phase of analysis that developed estimated current and future emissions based on a simpler methodology that examined fuel sales in the region.

Passenger Rail and Ferry Inventory and Forecast

The passenger rail and ferry analysis includes all fixed guideway transit systems in the TCI region (light rail, streetcar, heavy rail, and commuter rail), ferry, and Amtrak.

The 2011 inventory is based on publicly accessible data from the National Transit Database (revenue miles, passenger miles, and energy consumption by operator and mode), and the Amtrak Northeast Corridor Infrastructure Master Plan.[97] Emissions were calculated by applying a CO_2 emissions coefficient to the diesel fuel consumed or based on the carbon intensity of the electricity generated in the electricity grid subregion where the transit agency resides.[98]

For 2030, the analysis projects passenger-mile growth based on data from the National Transit Database, and where available, ridership projections from operator-specific long-range plans. For the 2030 Baseline Scenario, per-passenger mile CO_2 rates are assumed to be constant. For the 2030 Existing Federal and State Policies Scenarios, emission rates are adjusted annually consistent with Tier IV locomotive standards, full achievement of Renewable Portfolio Standard (RPS) goals in each state, and RGGI target reductions.[99]

Freight Rail Inventory and Forecast

The analysis uses ton-mile and other freight rail data for the region from the Federal Highway Administration's (FHWA) Freight Analysis Framework (FAF). 2011 emissions were estimated by applying average emission factors for locomotives operating on Class I railroads, analyzed by Cambridge Systematics as part of the U.S. DOT Report to Congress on Transportation's Role in Reducing U.S. Greenhouse Gas Emissions.[100] The 2030 projection assumes that most line-haul locomotives would meet Tier IV standards and/or the best technology available, and therefore a lower emission rate is applied.[101]

Intra-Region Marine Inventory and Forecast

The analysis uses data from the U.S. Army Corps of Engineers Waterborne Commerce Statistics Center and the FHWA's FAF to produce annual state-to-state flows by commodity and tonnage. Ton-miles were estimated by calculating marine distances between major ports in each state and using an online tool that calculates nautical shipping distances. Intrastate shipments were assumed to be 50 miles, representing a combination of some short-sea and some intra-terminal shipments. In order to estimate emissions, an average efficiency factor was applied from the literature (576 ton-miles per gallon), and then an emission factor for barges was applied based on EPA reports.[102]

A detailed explanation of all the inventory and forecast methodology, assumptions, and findings is presented in Appendix 1: Emission Inventory & Forecast.

Emission Reduction Analysis

The emission reduction analysis derived cost-effectiveness rates for specific GHG reduction strategies based on regional project-level studies as well as broader literature. The cost-effectiveness rates were then used to derive GHG reductions that would be achieved at specific levels of implementation (calculated as a quantity of investment into the specific policy).

This general cost-effectiveness methodology builds on Cambridge Systematics' analyses in Moving Cooler, the federal Department of Transportation's 2010 Report to Congress on Transportation's Role in Reducing U.S. Greenhouse Gas Emissions, and several analyses conducted for state departments of transportation or metropolitan planning organizations.[103]

The levels of implementation chosen are consistent with what Cambridge Systematics has found to be "modest" to "aggressive" levels of implementation of GHG reduction strategies, but less than a "maximum" level of implementation, in an earlier phase of analysis and in other Cambridge Systematics GHG reduction analyses. The three levels of implementation were modeled as specific levels of investment in a combined suite of policies.

It is beyond the scope of this analysis to consider the potential effects of additional federal fuel economy and greenhouse gas emissions standards beyond those currently finalized. The emission reductions achieved by additional federal standards could be significant, however, and states in the TCI region may have a role in the establishment of such standards.

The three emission reduction scenarios tested the following policies at three different levels of implementation, using the following general sources to arrive at ratios of emission reduction per dollar invested:

- ***Electric and alternative fuel vehicles:*** The analysis examines the impact of hypothetical financial incentives provided to reduce the cost of full battery electric (BEV) and plug-in hybrid electric (PHEV) light-duty vehicles, and heavy-duty vehicles running on compressed natural gas (CNG) or liquefied natural gas (LNG), therefore increasing consumer adoption. BEV and PHEV cost projections are based on California Air Resources Board projections; CNG and LNG cost projections are based on a review conducted by Cambridge Systematics for the Oregon Department of Energy. For the six states participating in the zero-emission vehicle memorandum of understanding, the investment is assumed to help the state meet the level of vehicle deployment identified as that state's MOU target (i.e., it is not assumed to be supplemental to the MOU target).[104] The analysis notes that there would be overlap in the GHG reductions driven by federal fuel economy standards and the reductions driven by regional efforts to promote electric and alternative fuel vehicles, however analyzing the interaction was beyond the scope of this analysis.[105]

- ***Transit:*** The analysis examines the impact of hypothetical expansions of transit service. Capital costs and GHG benefits were reviewed for a sample of proposed transit projects in the northeast and mid-Atlantic regions for which data were available from project studies (including bus rapid transit, light rail, and heavy rail), and compared with broader literature.[106]
- ***Land use and smart growth:*** The analysis examines the impact of hypothetical incentives that promote shifts in population or activity into more transportation-efficient locations, using as a benchmark the Commonwealth of Massachusetts' Chapter 40R program (Smart Growth Zoning Overlay District Act), which since 2005 has offered cities and towns an incentive of up to $3,500 per new built dwelling unit in areas rezoned as "smart growth" districts meeting certain criteria.[107] The analysis uses census-tract specific population data to examine the impact of hypothetical incentives to shift a fraction of population from lower-density to higher-density place types.[108]
- ***Active transportation:*** The analysis examines the impact of hypothetical investments in bicycle infrastructure in different place types. The approach is to assume an increase in bicycle mode share (percent of trips) between current conditions and full build-out of a robust bike network. The assumed mode share varies by place type and is highest in core/high density areas. A mix of facility types is assumed in each place type to achieve a complete, fully built-out network of facilities appropriate to that place type, and a cost per mile is associated with each facility type.[109]
- ***Travel demand management:*** The analysis examines the impact of hypothetical annual expenditures on travel demand strategies such as rideshare and vanpool programs, subsidized transit passes, and neighborhood trip reduction programs to generate emission reductions based on evidence from the literature. However, unlike capital intensive strategies where a dollar invested now brings continuing returns in the future, TDM is assumed to have short-term effects, therefore it is assumed that a dollar invested in Year X also brings returns only in Year X.[110]
- ***System efficiency and operations:*** The analysis examines the impact of hypothetical investments into signal timing and coordination, adaptive signal control, ramp metering, incident response, traveler information, advanced traffic management systems, and integrated corridor management based on evidence from the literature.[111]
- ***Freight and intermodal infrastructure and operations:*** The analysis examines the impact of hypothetical investment into infrastructure that encourages freight modal shift from truck to rail or water. The basic approach to analyzing this strategy is similar to the analysis of transit investment. Examples include relieving capacity constraints at critical freight rail bottlenecks;

addressing rail infrastructure constraints such as low clearance bridges and low railcar weight limits; and improving accessibility to intermodal facilities. Cost-effectiveness data were taken from the national literature and from project studies conducted in the TCI region to estimate a GHG tons per dollar value of capital investment.[112]

In addition, bundles of the above strategies were tested together with a hypothetical clean fuels policy and a pricing policy.

- ***Clean fuels policy:*** The clean fuels policy scenario assumed a required improvement in the carbon fuel intensity of transportation fuels in the region. Two policy scenarios were tested, one that assumed a carbon-intensity improvement of 10 percent over ten years, one that assumed a carbon intensity improvement of 15 percent over 15 years. It was assumed that this policy had an overlap with strategies to promote electric vehicles (i.e., electric fuels were treated as a fuel for the purposes of the clean fuel standard to avoid double-counting).[113]
- ***Pricing policy:*** GHG reductions were projected for hypothetical pricing policies that could reflect a mileage-based user fee, a carbon fee, or a supplemental motor fuel fee, all yielding generally similar results. The impact of pricing policies on GHG emissions was analyzed based on elasticities of travel or vehicle efficiency with respect to fuel price. These were derived from the 2014 Annual Energy Outlook (AEO) published by the U.S. Department of Energy (DOE). This was done by comparing fuel prices, light-duty vehicle VMT, and light-duty vehicle stock efficiency under the "High Price" scenario with the "Reference" scenario. The percent change in VMT or stock efficiency with respect to the percent change in fuel price was used as the elasticity. Due to a lack of information available on the sensitivity of fuel carbon content to a carbon price, the carbon price option was not assumed to have an additional effect on fuel carbon content beyond what will be achieved through the Federal Renewable Fuel Standard (RFS-2) and any regionally adopted clean fuels programs.[114]

The emission reduction analysis also included several sensitivity analyses conducted to evaluate the impact of changes to key assumptions, including sensitivities related to assumptions about VMT and fuel economy,[115] as well as different approaches to treating the effects of clean transportation strategies on revenue.[116]

A detailed explanation of all the emission reduction potential analysis methodology, assumptions, and findings is presented in Appendix 2: Emission Reduction Strategy Analysis, Section 3.

Public Health/Other Benefits Analysis

Investing in transportation options that reduce GHG emissions has the potential to support a variety of other benefits that are not reflected in the economic analysis. The benefits that were quantified in this analysis include:

- ***Energy independence:*** A reduction in petroleum fuel use.[117]
- ***Time savings:*** For personal or "off-the-clock" travel.[118]
- ***Safety:*** A reduction in fatalities and injuries due to reduced motor vehicle crashes.[119]
- ***Air pollution:*** A reduction in premature deaths and respiratory illnesses associated with air pollution reductions.[120]
- ***Physical activity:*** Reduced mortality as a result of greater participation in "active" transportation options including walking and bicycling.[121]
- ***Pavement damage:*** Reduced wear and tear on the region's highways.[122]

While some of these benefits were quantified in monetary terms in this analysis (e.g., based on value of statistical life saved or health outcomes), these cost savings were not included in the macroeconomic REMI analysis since they may affect the economy in complex ways that were beyond the scope of this analysis to assess.

A detailed explanation of the methodology, assumptions, and findings of the public health and other benefits analysis is presented in Appendix 2: Emission Reduction Strategy Analysis, Sections 2 and 6.

Macroeconomic Analysis

The macroeconomic analysis estimated the costs and cost savings of implementing the GHG reduction strategies described in this report, as well as the net economic benefits to the TCI region. This analysis included calculations of costs and savings to businesses and consumers, as well as changes in expenditures by government. These were used as inputs in the macroeconomic model, the Regional Economic Models, Inc. (REMI) Policy Insight (PI+) model (v1.6.8). REMI is a dynamic model, measuring interactions among all sectors of the economy over time. Economic benefits are measured in terms of new jobs, additional gross regional product (GRP), and additional disposable income over the analysis period (2015-2030). These benefits may accrue due to factors such as travel time savings, reduced vehicle operating costs, and increasing the share of business and consumer income that is spent within the TCI region. Macroeconomic impacts were evaluated for two combined scenarios, both of which modeled a suite of clean transportation policies combined with a pricing policy that provided funds for the clean transportation policies.

A detailed explanation of all the macroeconomic methodology, assumptions, and findings is presented in Appendix 2: Emission Reduction Strategy Analysis, Section 5.

State Climate and Energy Goal Summary

A table and summary of state greenhouse gas reduction goals and other clean transportation goals is included in Appendix 3: State Climate and Energy Goals. This was compiled through a state-by-state survey of statutes, executive orders, and climate and energy plans.

Endnotes

1. Participating jurisdictions are Connecticut, Delaware, the District of Columbia, Maryland, Main, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. For more information, *see* http://www.transportationandclimate.org.

2. Transportation and Climate Initiative Declaration of Intent (2010), http://www.transportationandclimate.org/content/tci-declaration-intent. *See generally* Transportation and Climate Initiative website, http://www.transportationandclimate.org/.

2. Northeast Electric Vehicle Network, http://www.transportationandclimate.org/node/30.

4. Gabe Pacyniak, Georgetown Climate Center, Analysis of State-Level Programs and Policies Supporting Sustainable Communities within Transportation and Climate Initiative Jurisdictions (2012), http://www.georgetownclimate.org/state-level-programs-and-policies-supporting-sustainable-communities-within-transportation-and-clima; Georgetown Climate Center and Rutgers University Bloustein School of Planning and Public Policy, Analysis on Indicators to Measure Progress in Supporting Sustainable Communities (2014), http://www.transportationandclimate.org/indicators-measure-progress-promoting-sustainable-communities.

5. Freight Movement in the Northeast, Transportation and Climate Initiative website (2015), http://www.transportationandclimate.org/node/33.

6. The Georgetown Climate Center's support for the Transportation and Climate initiative has come from a range of philanthropic and government entities, including the Barr Foundation, the Rockefeller Brothers Fund, the New York Community Trust, the Town Creek Foundation, the Oak Foundation, the Surdna Foundation, the Emily Hall Tremaine Foundation, the Rockefeller Foundation, the John Merk Fund, and the U.S. Department of Energy.

7. U.S. Department of Transportation, Report to Congress, Transportation's Role in Reducing U.S. Greenhouse Gas Emissions (2010), http://climate.dot.gov/resources/presentations/html/2010_06_16.html; Cambridge Systematics, Inc., Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions (2009), http://www.camsys.com/pressreleases/pr_jul09_Moving_Cooler.htm.

8. MOVES2010b Software and Documentation, U.S. Environmental Protection Agency website, http://www3.epa.gov/otaq/models/moves/moves-docum.htm.

9. The REMI Model, Regional Economic Models, Inc. website, http://www.remi.com/the-remi-model.

10 Transportation-sector emissions in this statistic refer only to tailpipe emissions, that is direct emissions from mobile sources. This statistic is derived from World Resources Institute (WRI), Climate Analysis Indicators Tool (CAIT) 2.0., http://cait2.wri.org. All other emissions inventory and forecast analysis in the report also uses tailpipe emissions, with the only exception being the calculation of emissions reduction benefits of EV/AFVs, which uses fuel-cycle emissions. See discussion of EV/AFVs in Appendix Emission Reduction Strategy Analysis section 3.2.

11. The Regional Greenhouse Gas Initiative (RGGI) is a regional cap-and-trade program to reduce CO_2 emissions from the electric power sector formed in 2009. The nine states currently participating in RGGI are Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. Participating states set a region-wide, decreasing cap on CO_2 emissions. States allocate or sell emission allowances through an auction process and may choose to invest proceeds in energy efficiency, renewable energy, or other programs. The program has raised $2 billion in auction proceeds since its inception. *See* Regional Greenhouse Gas Initiative website, http://www.rggi.org/.

12. This statistic is derived from World Resources Institute, Climate Analysis Indicators Tool (CAIT) 2.0, http://cait2.wri.org.

13. Historic transportation-sector emissions data from U.S. Energy Information Administration (EIA), State Energy Data System (SEDS) website, http://www.eia.gov/state/seds/. Transportation-sector emissions data computed as a share of all surface transportation sector emissions as found in this analysis. *See* Appendix Emission Reduction Strategy Analysis, sub-Appendix B, Table B.1. *See also* U.S. Environmental Protection Agency, U.S. Climate Action Report 82 (2014), http://www.state.gov/documents/organization/219038.pdf ("recent trend for transportation has shown a general decline in emissions, due to recent slow growth in economic activity, higher fuel prices, and an associated decrease in the demand for passenger transportation").

14. 2012 National Transit Database, http://www.ntdprogram.gov/ntdprogram/; 2012 American Communities Survey, U.S. Census website, https://www.census.gov/programs-surveys/acs/; David Schrank et al., Texas A&M Transportation Institute, TTI's 2012 Urban Mobility Report (2012).

15. Vehicle Miles Traveled data derived from Federal Highway Administration (FHWA), Office of Highway Information Management, Annual Vehicle-Miles of Travel 1994-2011. Transportation-sector GHG emissions data calculated using U.S. Energy Information Administration (EIA), State Energy Data System (SEDS) website, http://www.eia.gov/state/seds/. *See* Appendix Emission Reduction Strategy Analysis, sub-Appendix B, Table B.1.

16. This report uses the U.S. Federal Highway Administration's (FHWA) definition of unlinked passenger trips (UPT). The FHWA defines unlinked passenger trips, or, "boardings," as "every time a person gets on an in-service transit vehicle. Each transfer to a new vehicle or route is considered another unlinked trip, so a person's commute to work may count as more than one trip if that person transferred between routes." U.S. Department of Transportation, Federal Highway Administration, 2013 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance Report to Congress ES-7 (2013).

17. Note that 2012 data was used for passenger rail, freight rail, and intra-region marine sectors, and assumed to be equivalent for 2011. This overall level of transportation-sector GHG emissions was consistent with an earlier phase of analysis conducted by Cambridge Systematics that estimated 2011 emissions based on fuel sales in the region.

18. *See* Appendix Emission Inventory & Forecast section 6.0.

19. Transit mode categories derived from National Transit Database, http://www.ntdprogram.gov/ntdprogram/Glossaries/pdf/Glossary2014.pdf.

20. *See generally* Appendix State Goals.

21. The 2009 Copenhagen Accord stated that to "prevent dangerous anthropogenic interference with the climate system...the increase in global temperature should be below 2 degrees Celsius" (3.6 degrees Fahrenheit) above pre-industrial levels. United Nations Framework Convention of Climate Change, Copenhagen Accord, http://unfccc.int/meetings/copenhagen_dec_2009/items/5262.php. The 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report concluded that limiting global temperature increase to 2 degrees Celsius would require industrialized nations to reduce GHG emissions 80 percent from 1990 levels by 2050. Intergovernmental Panel on Climate Change, IPCC Fourth Assessment Report: Climate Change (2007), https://www.ipcc.ch/report/ar4/. The IPCC Fifth Assessment Report, published in 2014, indicates that global emissions near or below zero will be needed by 2100. The Fifth IPCC report says that a 40 to 70 percent reduction in global GHG emissions from 2010 levels will be necessary by 2050 for all countries, but does not provide a specific target for developed countries. Intergovernmental Panel on Climate Change, Climate Change 2014: Synthesis Report 22 (2014), https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf.

22 For detailed information on each state goal and citations to individual statutes, regulations, and state plans, *see* Appendix State Goals.

23. To better compare the individual GHG emission reduction goals of the TCI jurisdictions, which have articulated individual state goals as reductions from different baseline years (ranging from 1990 to 2012), the state goals depicted in Figure 3 are normalized to TCI region transportation-sector emissions for 2011 using data from World Resources Institute, Climate Analysis Indicators Tool (CAIT) 2.0, http://cait2.wri.org. Goal pathways are linearly interpolated between any two state goal points. 2011 emissions were used as a starting point, with the exception of three states that had early goals articulated for years 2009-2012: Maine, Rhode Island, and Vermont.

24. The federal GHG standards extend through vehicle model year 2025; however, the parallel federal fuel economy standards are only in place until model year 2021 due to constraints in the relevant statute. Both standards—which together form the joint national GHG and fuel economy program—will be subject to a mid-term evaluation that will be completed by 2018 and which will result in promulgation of federal fuel economy standards for light-duty vehicle model years 2022 to 2025. Should the outcome of this mid-term review be to weaken the current federal GHG standards for those vehicles, the emission reduction projected from federal policies in this report would be reduced. 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed. Reg. 62,624 (Oct. 15, 2012); Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, 75 Fed. Reg. 25,324 (May 7, 2010).

25. Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles, 76 Fed. Reg. 57,106 (Sep. 15, 2011).

26. Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles - Phase 2, 80 Fed. Reg. 40,138 (proposed July 13, 2015).

27. Control of Air Pollution From Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards, 79 Fed. Reg. 23,414 (Apr. 28, 2014).

28. Control of Emissions of Air Pollution From Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder, 73 Fed. Reg. 37,096 (June 30, 2008).

29. The Tier 3 gasoline sulfur standard will make emission control systems more effective for both existing and new vehicles because lower levels of sulfur allow a vehicle's catalyst to work more efficiently. Lower-sulfur gasoline also facilitates the development of some lower-cost technologies to improve fuel economy and reduce GHG emissions. Depending on the actual design of the engine and control technology, GHG emissions could be reduced or increased in locomotive and marine engines. To the extent that federal standards along with grant programs have increased the deployment of hybrid diesel-electric switch locomotives, which use batteries to store electricity produced by a small diesel generator, these locomotives are on average 15 to 20 percent more fuel-efficient than standard switch locomotives. *See* U.S. Environmental Protection Agency, Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards Final Rule Regulatory Impact Analysis (Mar. 2014), http://www3.epa.gov/otaq/documents/tier3/420r14005.pdf; U.S. Department of Transportation, Federal Railroad Administration, Best Practices and Strategies for Improving Rail Energy Efficiency (2014), http://ntl.bts.gov/lib/51000/51000/51097/DOT-VNTSC-FRA-13-02.pdf.

30. Calculations by New York State Department of Transportation using ridership statistics from the National Transit Database and Amtrak.

31. The state of California has special authority under the Clean Air Act to set more stringent air pollution standards for motor vehicles under the waiver provision of Section 209, and other states may adopt these authorities under Clean Air Act Section 177. Clean Air Act, §§ 209, 177, 42 U.S.C. §§ 7543, 7507. California's ZEV mandate is one of the regulations that California has adopted under this authority, and that other states have adopted under Section 177 authority. California's standards certify passenger cars, light-duty trucks and medium-duty vehicles as ZEVs "if the vehicles produce zero exhaust emissions of any criteria pollutant (or precursor pollutant) under any and all possible operational modes and conditions." Cal. Code of Reg. 1962.1(a). *See also* ZEV Program, Center for Climate and Energy Solutions website, http://www.c2es.org/us-states-regions/policy-maps/zev-program.

32. State Zero-Emission Vehicles Programs Memorandum of Understanding Among Eight States (2013), http://www.nescaum.org/documents/zev-mou-8-governors-signed-20131024.pdf/.

33. ZEV Program Implementation Task Force, Multi-state ZEV Action Plan (2014), http://www.nescaum.org/topics/zero-emission-vehicles/multi-state-zev-action-plan.

34. Celebrating Five Years of Success, Transportation and Climate Initiative website, http://www.transportationandclimate.org/celebrating-five-years-success.

35. *See* Gabe Pacyniak, Georgetown Climate Center, State-Level Programs and Policies Supporting Sustainable Communities within Transportation and Climate Initiative Jurisdictions (2012), http://www.georgetownclimate.org/state-level-programs-and-policies-supporting-sustainable-communities-within-transportation-and-clima.

36. U.S. Energy Information Administration, Annual Energy Outlook, http://www.eia.gov/totalenergy/data/monthly/index.cfm#consumption (comparing petroleum production and refining in the TCI region with petroleum consumption).

37. U.S. Environmental Protection Agency, Regulatory Announcement, EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks (2012), http://www.epa.gov/oms/climate/documents/420f12051.pdf.

38. The U.S. Department of Transportation 2013 Conditions and Performance Report states that all levels of government (federal, state, and local) would need to spend between $123.7 billion and $145.9 billion per year to improve the condition and performance of roads and bridges. For comparison, in 2010, capital infrastructure spending by governments at all levels was a combined $100.2 billion (including $11.9 billion from the American Recovery and Reinvestment Act). The same spending deficit holds true for transit. Capital investment in transit in 2010 was $16.5 billion–compared to the $18.5 billion in annual average spending needed to bring existing transit assets up to a state of good repair. U.S. Department of Transportation, 2013 Status of the Nation's Highways, Bridges, & Transit: Conditions and Performance ES-1 (2013), https://www.fhwa.dot.gov/policy/2013cpr/.

39. 26 U.S.C. § 4081(a)(1).

40. Joseph Kile, Congressional Budget Office, Pub. No. 4946, Testimony Before the Committee on Finance, United States Senate, The Status of the Highway Trust Fund and Options for Financing Highway Spending 3 (May 6, 2014), https://www.cbo.gov/publication/45315.

41. Congressionally authorized transfers to maintain the solvency of the Highway Trust Fund include Pub. L. No. 110-318 ($8 billion transfer); Pub. L. No. 111-46 ($7 billion transfer); Pub. L. No. 111-147 ($14.7 billion transfer); and Pub. L. No. 114-41 ($8 billion transfer). *See* Robert Jay Dilger, Congressional Research Service, Federalism Issues in Surface Transportation Policy: Past and Present, R40431, at 29 (2012); Congressional Budget Office, Projections of Highway Trust Fund Accounts CBO's March 2015 Baseline at 4 (2015), https://www.congress.gov/114/plaws/publ41/PLAW-114publ41.pdf.

42. *See, e.g.*, Mike DeBonis and Kelsey Snell, Congress Still Paralyzed on Transportation Funding as Another Deadline Looms, Wash. Post (July 15, 2015), https://www.washingtonpost.com/politics/congress-still-paralyzed-on-transportation-funding-as-another-deadline-looms/2015/07/15/15f12196-2742-11e5-aae2-6c4f59b050aa_story.html; Keith Laing, Feds: Highway Funding Will Last Until June 2016, The Hill (Sept. 9, 2015), http://thehill.com/policy/transportation/252950-feds-highway-funding-will-last-until-june-2016; Keith Laing, House Passes $325B Highway Bill, The Hill (Nov. 5, 2015), http://thehill.com/policy/transportation/259246-house-approves-325b-highway-bill (reporting that six-year transportation authorization passed by the U.S. House of Representatives in November 2015 includes funding for only three years of the six-year period).

43. National Cooperative Highway Research Program, Synthesis 479: Forecasting Transportation Revenue Sources: Survey of State Practices (2015), http://www.trb.org/Main/Blurbs/172636.aspx.

44. Recent State Transportation Revenue Measures in TCI Region:

- Delaware (2015) HB 140 increased vehicle sales tax and license fees.
- Maryland (2013) HB 1515 indexed the gas tax to inflation and added a three percent sales tax for gasoline.
- Massachusetts (2013) H3535 raised the gas tax three percent and indexed it to inflation. This measure also dedicated additional state revenues to transportation.
- New Hampshire (2013) SB 367 raised the gas tax three cents per gallon and dedicated funding to bridge repair projects.
- Pennsylvania (2013) Act 89 eliminated a per-gallon gas tax and increased the wholesale fuels tax. The act will raise $2.3 billion per year for transit and transportation projects, provide funding for local transportation projects, and establish Multimodal Transportation Fund.
- Rhode Island (2014) H7133 raised the gas tax one cent per gallon and indexed it to inflation. This measure also dedicated vehicle fees and rental car taxes to highway fund.
- Vermont (2013) Act 12 added a two percent sales tax to gasoline and raised the diesel per-gallon tax.

See State Legislation to Raise Transportation Revenue, Transportation for America website, http://t4america.org/maps-tools/state-transportation-funding/#top.

45. Additional State Transportation Revenue Measures since 2012:

- Arkansas (2012) voter-approved constitutional amendment for sales tax increase to repay bond obligation used to fund highway network.
- Florida (2014) enacted a transportation package.
- Georgia (2015) replaced previous motor fuel taxes with a 26 cent-per-gallon gas tax and indexed the tax to vehicle fleet efficiency and CPI, established fees on heavy-duty vehicles and electric vehicles, and imposed a fee on short-term lodging.
- Idaho (2015) enacted a series of gas tax increases; increased the vehicle registration fee; established a fee for electric and alternative vehicles.
- Iowa (2015) increased the gas tax 10 cents per gallon and established a vehicle registration fee.
- Kentucky (2015) will increase wholesale fuel assessment.
- Nebraska (2015) will raise the gas tax six cents per gallon over four years.
- North Carolina (2015) changed the gas tax calculation beginning in 2017 to account for population growth and CPI (projected $400 million long-term revenue increase compared to current calculation methodology).
- Ohio (2014) enacted a toll increase to fund road construction and repair.
- South Dakota (2015) increased the gas tax six cents per gallon and increased vehicle sales tax and fees.
- Utah (2015) changed the gas tax calculation to a 12 percent assessed rate with floor and ceiling.
- Virginia (2013) raised state and local sales taxes, replaced a per-gallon gas tax with wholesale tax on gasoline and diesel, and imposed fees on alternative-fuel vehicles.
- Washington (2015) enacted a $16 billion transportation bill funded by an 11.7 cents per gallon gas tax increase.
- Wyoming (2013) enacted a 10 cents per gallon gas tax increase for highway funding.

See State Legislation to Raise Transportation Revenue, Transportation for America website, http://t4america.org/maps-tools/state-transportation-funding/#top.

46. Sascha Pealer, Vermont Agency of Natural Resources, Lessons from Irene: Building Resiliency as We Rebuild (2012), http://anr.vermont.gov/sites/anr/files/specialtopics/climate/documents/factsheets/Irene_Facts.pdf; Eric S. Blake et al.,

National Hurricane Center, Tropical Cyclone Report: Hurricane Sandy, AL182012 (2013), http://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf.

47. *See* Appendix Emission Reduction Strategy Analysis section 2.1.1.

48. *See* Appendix Emission Reduction Strategy Analysis section 2.1.1.

49. Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, 75 Fed. Reg. 25,324 (May 7, 2010); 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed. Reg. 62,624 (Oct. 15, 2012); Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles, 76 Fed. Reg. 57,105 (Sep. 15, 2011).

50. *See* Appendix Emission Reduction Strategy Analysis section 2.1.1; Appendix Emission Reduction Strategy Analysis section 3.2.

51. EPA and NHTSA issued a Notice of Proposed Rulemaking for Phase 2 standards for the Heavy-Duty National Program on June 19, 2015. Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles - Phase 2, 80 Fed. Reg. 40,138 (proposed July 13, 2015). The proposed standards have not been finalized, and are not included in this analysis. *See* Appendix Emission Reduction Strategy Analysis section 2.1.1.

52. The 2030 to 2050 trajectory of TCI region transportation-sector emissions under each scenario is an extrapolation based on the annual rate of change between the calculated 2011 baseline emissions and the 2030 projected level of emissions in each scenario. *See* Appendix Emission Reduction Strategy Analysis section 2.3. For translation of emissions to 1990 baseline, *see* Table 4.

53. California has special authority under the Clean Air Act to set more stringent air pollution standards for motor vehicles under the waiver provision of Section 209. Under Clean Air Act Section 177, other states may adopt California standards. Clean Air Act, §§ 209, 177, 42 U.S.C. §§ 7543, 7507. In recent years the U.S. Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) have coordinated with California and other states adopting California standards to create a single national program, responding to industry preferences for a unified market. As a result, California and the "177" states can be expected to play an important role in setting future standards. *See also* Light Duty Vehicle Program, Environmental Protection Agency website, http://www3.epa.gov/otaq/climate/regs-light-duty.htm.

54. All monetary figures in this report are in current or nominal dollars, i.e., not indexed to inflation. The fees and taxes are assumed constant in nominal terms and not indexed to inflation. This means that $3 billion in revenue in 2030 is worth less than $3 billion in 2015.

55. *See* Appendix Emission Reduction Strategy Analysis section 4.2.

56. Energy Information Administration, 2014 Annual Energy Outlook (2014), http://www.eia.gov/forecasts/archive/aeo14/. For a discussion of fuel price and elasticities related to fuel prices, *see* Appendix Emission Reduction Strategy Analysis section 3.1.

57. *See* Appendix Emission Reduction Strategy Analysis section 2.1.

58. *See* comment in note 52; *See* Appendix Emission Reduction Strategy Analysis section 2.3.

59. For detailed explanation of investment levels and calculation methodology, *see* Appendix Emission Reduction Strategy Analysis sections 3.2 to 3.8.

60. *See* Appendix Emission Reduction Strategy Analysis Table 1.1a.

61. In the Moving Cooler analysis, policies were evaluated at three levels of implementation: expanded current practice, aggressive implementation, or maximum implementation. In this analysis, the aggressive scenario is generally consistent with the aggressive level of implementation in Moving Cooler. The moderate and modest scenarios reflect respectively lower levels of implementation. *See* Cambridge Systematics, Inc., Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions (2009).

62. *See* Appendix Emission Reduction Strategy Analysis section 3.9.

63. For detailed explanation of investment levels and emissions reduction levels, *see* Appendix Emission Reduction Strategy Analysis section 2.

64. *See* Appendix Emission Reduction Strategy Analysis, sub-Appendix B.

65. *See* Appendix Emission Reduction Strategy Analysis section 6.1.

66. *See* Appendix Emission Reduction Strategy Analysis section 6.4.

67. *See* Appendix Emission Reduction Strategy Analysis section 6.2.

68. *See* Appendix Emission Reduction Strategy Analysis section 6.3.

69. *See* Appendix Emission Reduction Strategy Analysis section 6.5.

70. *See also* Appendix Emission Reduction Strategy Analysis, sub-Appendix C.

71. *See*, *e.g.*, U.S. Department of Transportation, Report to Congress, Transportation's Role in Reducing U.S. Greenhouse Gas Emissions (2010); Transportation Research Board of the National Academies, Special Report 307: Policy Options for Reducing Energy Use and Greenhouse Gas Emissions from U.S. Transportation (2011); D.L. Greene, What's Greener than a VMT Tax? The Case for an Indexed Energy User Fee to Finance U.S. Surface Transportation, 16 Transportation Research D-Environment 451 (2011).

72. Generating this average annual level of funding over the 15 year period would be consistent with a carbon price increasing from $5 per ton in 2015 to $10 per ton in 2020 to $30 per ton in 2030. *See* Appendix Emission Reduction Strategy Analysis Section 1.0.

73. The macroeconomic analysis is based on reinvestment into strategies where the full cost of the strategy implementation is considered. The macroeconomic analysis does not assume an external, unspecified source of funding to assist with implementing the described strategies to the described levels.

74. *See* Appendix Emission Reduction Strategy Analysis section 2.1.3.

75. *See* Appendix Emission Reduction Strategy Analysis section 5.5.1.

76. *See* Appendix Emission Reduction Strategy Analysis section 2.1.3.

77. *See* Appendix Emission Reduction Strategy Analysis Table 2.3.

78. *See* Appendix Emission Reduction Strategy Analysis section 5.5.2.

79. *See* Appendix Emission Reduction Strategy Analysis section 5.5.1.

80. *See* Appendix Emission Reduction Strategy Analysis Table 2.3.

81. *See* Appendix Emission Reduction Strategy Analysis Table 1.1a.

82. Fuel prices used in macroeconomic analysis are from the U.S. Energy Information Administration, 2014 Annual Energy Outlook (2014), Reference Case forecast.

83. *See* Appendix Emission Reduction Strategy Analysis section 5.4.3.

84. No adjustment is made for baseline future vehicle purchase costs of internal combustion engine (ICE) vehicles. The cost differential between EVs and ICEs is assumed to decline over time (based on CARB projections). *See* Appendix Emission Reduction Strategy Analysis section 3.2.

85. Even when accounting for induced demand, some congestion reduction is projected to occur. Several of the clean transportation strategies (e.g., transit, TDM) are heavily targeted to reduce peak-hour travel. The system efficiency strategy accounts for induced demand. *See* Appendix Emission Reduction Strategy Analysis section 3.7.

86. *See* Appendix Emission Reduction Strategy Analysis section 5.4.2.

87. *See* Appendix Emission Reduction Strategy Analysis section 5.4.1.

88. *See* Appendix Emission Reduction Strategy Analysis section 5.5.

89. Figure shows net jobs created (i.e., in addition to what would happen without the policies).

90. Note, MOVES2014 was released in July 2014, too late for use within this analysis. Adjustments to results from MOVES2010b to reflect new federal standards are discussed in Appendix Emission Reduction Strategy Analysis Section 2.4.

91. *See generally* Appendix Emission Inventory & Forecast section 2.

92. *See* Appendix Emission Inventory & Forecast section 2.2.

93. *See* Appendix Emission Inventory & Forecast section 2.4.

94. *See* Appendix Emission Reduction Strategy Analysis section 2.1.

95. VMT projections were obtained from state agencies for all but two states, though some states' VMT forecasts were more detailed than others. *See* Appendix Emission Inventory & Forecast section 2.5.

96. *See* Appendix Emission Inventory & Forecast section 2.6.

97. NEC Master Plan Working Group, Northeast Corridor Infrastructure Master Plan (May 2010), http://www.amtrak.com/ccurl/870/270/Northeast-Corridor-Infrastructure-Master-Plan.pdf.

98. *See* Appendix Emission Inventory & Forecast section 3.1.

99. *See* Appendix Emission Inventory & Forecast section 3.2-3.3.

100. U.S. Department of Transportation, Report to Congress, Transportation's Role in Reducing U.S. Greenhouse Gas Emissions (2010), http://climate.dot.gov/resources/presentations/html/2010_06_16.html.

101. *See* Appendix Emission Inventory & Forecast section 4.0.

102. *See* Appendix Emission Inventory & Forecast section 5.0.

103. U.S. Department of Transportation, Report to Congress, Transportation's Role in Reducing U.S. Greenhouse Gas Emissions (2010), http://climate.dot.gov/resources/presentations/html/2010_06_16.html; Cambridge Systematics, Inc., Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions (2009), http://www.camsys.com/pressreleases/pr_jul09_Moving_Cooler.htm.

104. Signatory states agreed to deploy 3.3 million zero emission vehicles by 2025. State Zero-Emission Vehicles Programs Memorandum of Understanding Among Eight States 2 (2013), http://www.nescaum.org/documents/zev-mou-8-governors-signed-20131024.pdf/.

105. *See* Appendix Emission Reduction Strategy Analysis section 3.2.

106. *See* Appendix Emission Reduction Strategy Analysis section 3.3.

107. The legislation set fixed payments ranging from $500 to $3,500 per unit depending upon the number of units built; $3,000 is the amount for a one-time density bonus payment. 760 MASS. CODE REGS. 59; Chapter 40 R, Massachusetts Executive Office of Housing and Economic Development website, http://www.mass.gov/hed/community/planning/chapter-40-r.html.

108. *See* Appendix Emission Reduction Strategy Analysis section 3.4.

109. *See* Appendix Emission Reduction Strategy Analysis section 3.5.

110. *See* Appendix Emission Reduction Strategy Analysis section 3.6.

111. *See* Appendix Emission Reduction Strategy Analysis section 3.7.

112. *See* Appendix Emission Reduction Strategy Analysis section 3.8.

113. *See* Appendix Emission Reduction Strategy Analysis section 3.9.

114. *See* Appendix Emission Reduction Strategy Analysis section 3.1.

115. *See* Appendix Emission Reduction Strategy Analysis section 2.4.

116. *See* Appendix Emission Reduction Strategy Analysis section 4.2.

117. *See* Appendix Emission Reduction Strategy Analysis section 6.1.

118. *See* Appendix Emission Reduction Strategy Analysis section 6.2.

119. *See* Appendix Emission Reduction Strategy Analysis section 6.3.

120. *See* Appendix Emission Reduction Strategy Analysis section 6.4.

121. *See* Appendix Emission Reduction Strategy Analysis section 6.5.

122. *See* Appendix Emission Reduction Strategy Analysis section 6.6.

The nonpartisan Georgetown Climate Center seeks to advance effective climate, energy, and transportation policies in the United States—policies that reduce greenhouse gas emissions, save energy, and help communities adapt to climate change.

For additional information, please visit **www.GeorgetownClimate.org**.

GEORGETOWN CLIMATE CENTER
A Leading Resource for State and Federal Policy

GEORGETOWN CLIMATE CENTER
A Leading Resource for State and Federal Policy

georgetownclimate.org