Estimating the Regional Environmental, Health, and Economic Benefits and Costs of the Transportation and Climate Initiative Program

The Transportation and Climate Initiative (TCI) has been using economic, transportation investment, and health benefits modeling to better understand the potential benefits and costs of the Transportation and Climate Initiative Program (TCI-P), a multi-jurisdiction cap-and-invest program for transportation carbon dioxide (CO_2) pollution.

KEY FINDINGS

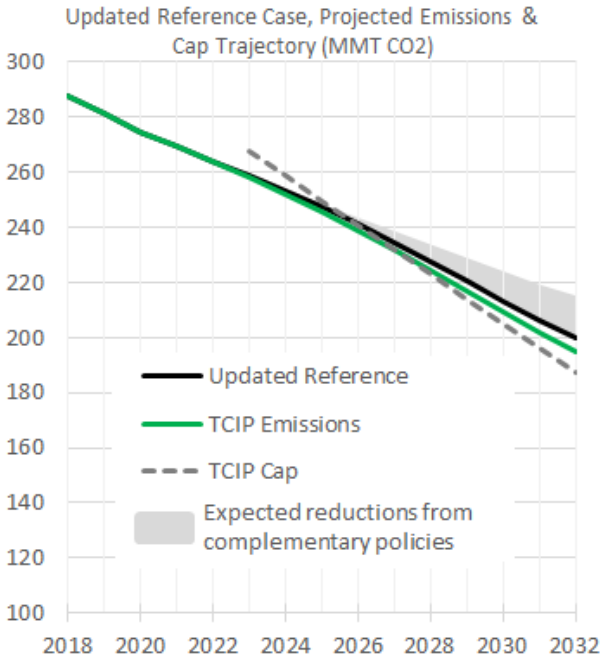
- The TCI-P cap on CO_2 pollution from transportation will decline by 30 percent from 2023 to 2032, reducing emissions by at least 26 percent in participating jurisdictions from 2022 to 2032.
- The TCI-P has the potential to spur billions of dollars of economic growth, thousands of new jobs, and improved public health due to cleaner air and safer transportation options. If all jurisdictions participate, by 2032 annual benefits could be up to:
  - $3 billion in health and safety improvements;
  - Hundreds fewer childhood asthma cases and exacerbations; and
  - 300 avoided deaths.
- In addition to up to $2 billion in annual clean transportation investments, state and federal complementary policies will play important roles in helping participating jurisdictions achieve their emission reduction goals cost effectively.[1]

Projected Emissions Reductions under the TCI-P

The TCI-P will set a cap on CO_2 pollution from on-road transportation that declines by 30 percent from 2023 to 2032. In combination with low-carbon transportation investments, this is projected to reduce on-road emissions by at least 26 percent from participating jurisdictions from 2022 to 2032.[2]

The TCI-P cap is different from the policy scenarios that TCI shared on webinars in December 2019 and September 2020 in three ways:

1) Following one year of emissions reporting in 2022, the TCI-P cap starts in 2023, one year later than earlier modeling.



[1] The modeling results summarized in this document reflect potential benefits and costs of the TCI-P if all thirteen jurisdictions in the TCI region choose to participate.

[2] TCI modeling results can be found at: https://www.transportationandclimate.org/modeling-methods-and-results

2) In 2023, the cap starts at 267.6 MMT[3], which is below estimates of recent historical emissions[4] but higher than Reference Case emissions in that year.
3) To account for this higher starting cap level, after 2023 the TCI-P cap declines by 30 percent through 2032, a more ambitious decline than in the 2019 cap scenarios.

Economic and Public Health Benefits

If all jurisdictions participate in the TCI-P, the cap on emissions and up to $2 billion in annual investments in low-carbon transportation is projected to modestly increase gross domestic product (GDP), disposable personal income (DPI), and jobs for all participating jurisdictions. Results from Regional Economics Models, Inc. (REMI) modeling of region-wide macroeconomic benefits are summarized in the table below.

Economic Indicators	Year 2032	Year 2040	Average annual 2023 - 2040
Gross Domestic Product (GDP)			
Increase in GDP (Billions of 2017$)	0.57	1.22	0.59
% Increase from Reference Case	0.01	0.02	0.01
GDP at Projected Reference Case Level (Billions of 2017$)	6,163	7,004	6,138
Disposable Personal Income (DPI)			
Increase in DPI (Billions of 2017$)	0.42	1.11	0.46
% Increase from Reference Case	0.01	0.01	0.01
DPI at projected Reference Case Level (Billions of 2017$)	6,913	9,699	7,165
Employment			
Increase in Employment (job-years)	2,520	6,053	2,660
% Increase from Reference Case	0.01	0.01	0.01
Employment at projected Reference Case Level	48,391,000	49,410,000	48,441,000

Additionally, a preliminary region-wide analysis conducted by the Transportation, Equity, Climate and Health (TRECH) Project projected that cleaner air and more physical activity would result in billions of dollars in monetized public health benefits for residents of the region.[5] Separately, Cambridge

[3] This starting cap level is based on modeled emissions under the COVID Low 1 Scenario, which is described in Appendix 2.
[4] Historical emissions from on-road diesel and motor gasoline was based on a three-year average of the years 2016-2018.
[5] The TRECH Project analyzed a variety of 2019 TCI modeling scenarios. Among those, the scenario that most closely resembles the policy agreed to in the TCI-P MOU – in terms of the incremental, cumulative emission reductions achieved and the level of investments – is the 20 percent Cap Reduction scenario. The modeling assumes that all 13 jurisdictions participate in the program and that just over 90% of the proceeds are invested in a

Systematics used the TCI Investment Strategy Tool to estimate potential safety benefits that could result from low-carbon transportation investments. The table below summarizes some of the projected health and safety benefits.

Region-Wide Health and Safety Benefits	Year 2032
Avoided deaths from increased physical activity (TRECH)	200 (130 – 260)
Avoided deaths from improved air quality (TRECH)	80 (54 – 110)
Avoided deaths from improved safety	37
Avoided Injuries from improved safety	559
Total monetized health and safety benefits (2017$)	$3 billion

**Estimated health benefits from the TRECH Project are preliminary and subject to change.*

One important policy not reflected in this analysis is the commitment by MOU Signatory Jurisdictions to dedicate at least 35 percent of the auction proceeds—up to $700 million annually if all jurisdictions participate—to projects and programs that directly benefit overburdened and underserved communities. As noted in the TCI-P MOU, each Signatory Jurisdiction will work with communities and with their Equity Advisory Bodies to assess the equity impacts of the program on an ongoing basis, including by monitoring air quality in communities overburdened by air pollution to ensure the effectiveness of policies and investments. Participating jurisdictions will also annually review and report the impacts of each jurisdiction's individual program, including with respect to equity.

Managing Uncertainty and Potential Costs of the TCI-P

The TCI-P is projected to have CO_2 allowance prices beginning at nearly $6.60 per metric ton in 2023, and rising to nearly $12.50 per metric ton in 2032 (including inflation). The "cap" in cap-and-invest programs inherently leverage market dynamics to achieve guaranteed emissions reductions at relatively low cost for consumers and businesses. When auction proceeds are invested in low-carbon transportation programs, it makes it easier to meet the emissions cap in any given year. Still, to ensure that program costs remain within an acceptable range, the TCI-P will include cost containment and emissions containment reserves. In 2023, if allowance prices fall below $6.50 per metric ton, the emissions containment reserve (ECR) would tighten the cap by up to 10 percent to take advantage of the opportunity to reduce emissions at lower than expected cost. If allowance prices rise above $12 per metric ton the cost containment reserve (CCR) will release additional allowances equal to up to 10 percent of the cap to mitigate higher than expected prices.

Estimating Future Transportation Emissions under "Business as Usual" (Updated Reference Case)

Since 2019, the TCI jurisdictions have evaluated a range of scenarios as part of this modeling effort. They fall into two categories:

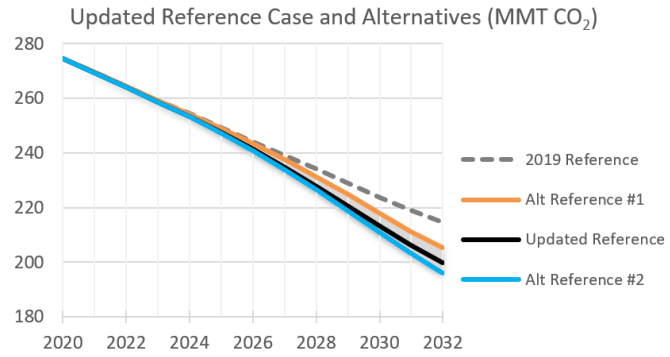
- **Reference Case** scenarios examine how different external factors, including economic and behavioral impacts of COVID-19, oil prices, federal policies, and technology costs, could lead to lower or higher emissions, in the absence of the TCI-P.

broad range of low-carbon transportation strategies (i.e., investment portfolio B). Potential implications of power-sector related emissions are discussed in Appendix 4 of this paper.

- **Policy Scenarios** illustrate a range of different outcomes based on variations in CO_2 emission cap levels and the portfolios of transportation investments participating jurisdictions might choose to make with proceeds from allowance auctions.

The updated business-as-usual analysis, or updated Reference Case, projects that CO_2 emissions from on-road transportation fuels are expected to decrease by 24 percent by 2032 compared to emissions in 2022. The projected decline in future emissions reflects improving vehicle efficiency and greenhouse gas (GHG) emission standards and a shift away from internal combustion engines and toward zero emission vehicles (ZEVs). The shift to ZEVs is expected to be achieved through implementation of existing and new federal and state regulations, vehicle purchase incentives, and lower vehicle costs due to continued manufacturing improvements and innovation. Accounting for the near-term implications of the COVID-19 pandemic is discussed in the next section.

In modeling the 2019 Reference Case that was presented with the release of the draft MOU in December 2019, the TCI jurisdictions used a set of assumptions based on the best-available projections of technology and commodity prices at that time, as well as a continuation of existing vehicle efficiency and GHG regulation. As discussed on the September 16, 2020 TCI webinar, if key variables, such as oil prices, technology costs, and federal policies, were to change, reductions anticipated in the Reference Case could be significantly lower or higher.



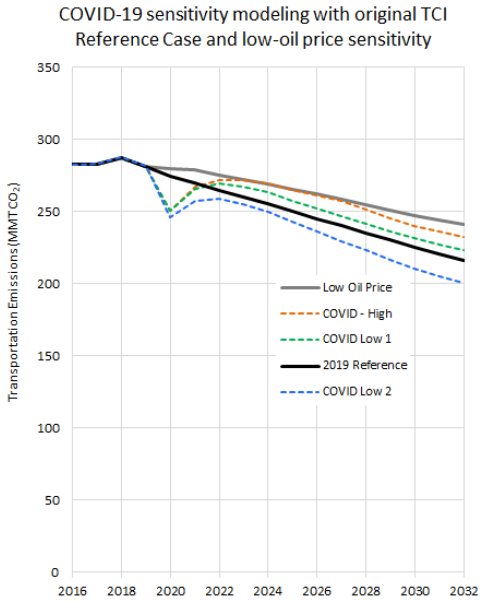
Reference Case Options, with with Policy Assumptions	**% Reductions 2022 to 2032**
2019 Reference	18.8%
Alternative Reference #1 CAFE Ext, MHD ZEV MOU	22.4%
Updated Reference Low EV costs, CAFEext	24.3%
Alternative Reference #2 Low EV costs, CAFE ext, MHD ZEV MOU	25.7%

The above graphic illustrates how the TCI Reference Case has been updated for the TCI-P MOU based on changes since December 2019. The updated Reference Case reflects the fact that more ambitious federal policies are likely given the stated priorities of the incoming Biden Administration, and TCI jurisdictions will also continue to develop and adopt complementary policies designed to achieve emission reductions from all vehicle classes.

When updating the reference case, TCI leaders considered a range of complementary, additional emission reduction policies that could be implemented in the coming months and years, including 1) continuous improvements in federal vehicle emissions standards through 2025 and beyond, 2) electric vehicle purchase incentives, and 3) jurisdictions achieving the sales targets outlined in the recently signed Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding. The updated assumptions in the Reference Case result in lower projected emissions compared to the previously released TCI modeling.

Estimating the Potential Implications of COVID-19 for TCI-P Starting Cap Levels

The TCI jurisdictions conducted modeling to better understand how the COVID-19 pandemic could affect emissions over the next few years, particularly in 2023, when the TCI-P cap will go into effect. TCI developed three no-policy "sensitivity case" scenarios—evaluating potential economic, behavioral, and market effects of the pandemic (see Appendix 2 for more details). Results from the modeling suggest that if low oil prices persist over the next few years and residents continue to favor private over public modes of transportation, emissions could increase to higher levels than initially projected by the 2019 Reference Case during the first year of the program, particularly as the economy recovers. This insight about near-term emissions in the wake of the pandemic informed starting cap levels for the program in 2023. In the longer term, once the TCI-P is in place, a variety of other factors (e.g., oil prices) are expected to have a relatively greater influence on emissions, as explained in Appendix 2.



Estimating Changes in Fuel Prices

Because gasoline and diesel prices vary widely over time due to a variety of global factors, it is not possible to predict price levels after the TCI-P is implemented. If the regulated entities in the petroleum industry choose to pass the full cost of allowances on to consumers, gas prices in 2023 are projected to be $0.05 per gallon higher than they would otherwise be. If demand for CO_2 allowances is higher than expected, the CCR would help ensure that any impact on gas prices would not exceed $0.09 per gallon in 2023. These changes would be well within the range of historical gas price variability, as illustrated by the below figure. The goal of a cap-and-invest program is to use auction proceeds to further reduce emissions by investing in clean transportation options, which will also provide more transportation choices and reduce the exposure of residents and businesses to oil market price fluctuations. Complementary policies that further reduce emissions are also expected to moderate TCI-P costs.

Background Information on the Modeling Approach

Economic, transportation, and public health models provide information to help policy makers and the public understand what trends—such as changes in vehicle-miles traveled[6] (VMT) and emissions—we can expect in transportation and in other sectors of the economy. The modeling results presented here are derived from several different models, and they reflect potential benefits of the TCI-P if all thirteen jurisdictions in the TCI region choose to participate.[7] The National Energy Modeling System (NEMS), developed and maintained by the U.S. Energy Information Administration, was modified for use in the TCI region to create a modeling tool called TCI-NEMS. TCI-NEMS was used as the primary modeling tool to better understand trends in both the transportation and electricity sectors with and without a new TCI cap-and-invest program. An investment strategy modeling tool was used to estimate the effect of investing auction proceeds in a wide variety of low-carbon transportation technologies and programs, and those effects were fed back into the TCI-NEMS model. The Regional Economics Models, Inc. (REMI) model[8] was used to project macroeconomic impacts, including changes in economic growth, income, and employment. Using outputs from the TCI modeling conducted in 2019, the Transportation, Equity, Climate and Health (TRECH) Project conducted independent analysis to estimate potential changes in health outcomes from active mobility (e.g., biking and walking) and air quality using published, peer-reviewed models commonly employed in regulatory analysis. On October 6, 2020, the TRECH Project published a research update with preliminary results from their analysis.

Modeling Participation in the Program

Results from the modeling have helped to inform decision-making on the program design features included in the TCI-P MOU, but they do not guarantee any specific future outcomes. In particular, the modeling results summarized in this document reflect potential benefits of the TCI-P across the entire thirteen-jurisdiction TCI region. Appendix 1 includes results scaled to reflect the participation of the initial Signatory Jurisdictions: Connecticut, the District of Columbia, Massachusetts, and Rhode Island. Benefits will increase as additional jurisdictions join the program in the future. Another important consideration is that participating jurisdictions may choose to invest their program proceeds differently than the illustrative investment portfolios modeled.

[6] Vehicle miles traveled (VMT) measures the total distance traveled by all vehicles in a geographic region over a given period of time, typically 12 months.

[7] More information regarding modeling tools and methods is detailed in "TCI Investment Strategy Tool Documentation." https://www.transportationandclimate.org/sites/default/files/TCI%20Invest-Tool-Documentation_09212020_final.pdf.

[8] The REMI model is a dynamic forecasting and policy analysis tool commonly used to evaluate the macroeconomic effects of energy and environmental policies.

Appendix 1: Estimated Benefits Scaled to Signatory Jurisdictions in the TCI-P

The economic, public health and safety benefits summarized in this appendix were scaled to estimate potential benefits for the initial Signatory Jurisdictions: Connecticut, the District of Columbia, Massachusetts, and Rhode Island. The first table includes estimated macroeconomic benefits, based on scaled REMI modeling that was conducted for the TCI region (above).

Scaled Economic Benefits for CT, DC, MA & RI	Year 2032	Year 2040	Average annual 2023 - 2040
Gross Domestic Product (GDP)			
Increase in GDP (Billions of 2017$)	0.092	0.200	0.097
% Increase from Reference Case	0.01	0.02	0.01
GDP at Projected Reference Case Level (Billions of 2017$)	1,005	1,142	1,001
Disposable Personal Income (DPI)			
Increase in DPI (Billions of 2017$)	0.069	0.190	0.075
% Increase from Reference Case	0.01	0.01	0.01
DPI at projected Reference Case Level (Billions of 2017$)	1,127	1,582	1,168
Employment			
Increase in Employment (job-years)	411	987	434
% Increase from Reference Case	0.01	0.01	0.01
Reference Case Level	7,892,572	8,058,771	7,900,727

As noted earlier, preliminary research published by TRECH study estimated potential health benefits from a series of policy scenarios in which all thirteen jurisdictions were assumed to participate in the TCI-P. The TRECH project published preliminary estimates of state-level health benefits, including physical activity benefits for Signatory Jurisdictions that are included in the table below. However, TRECH did not consider scenarios with partial TCI-P participation, or where some jurisdictions may implement the program at different times, though this would be needed to isolate the potential air quality-related benefits of the TCI-P for Signatory Jurisdictions, given cross-boundary transport of air pollution. Recognizing this source of uncertainty, the following table uses state-level air quality-related benefits from the low end of the TRECH Project's estimated ranges, or confidence intervals. This is intended to serve as a rough proxy for a partial, or phased, participation scenario in which Signatory Jurisdictions don't fully benefit from air quality-related improvements in 2032 that could have resulted from more emission reductions by neighboring jurisdictions.

Scaled Health and Safety Benefits for CT, DC, MA & RI[9]	Year 2032
Avoided deaths from increased physical activity (TRECH)	15.7 (10.8 - 20.7)
Avoided deaths from improved air quality (TRECH)	8
Avoided deaths from improved safety (Investment Strategy Tool)	6
Avoided Injuries from improved safety (Investment Strategy Tool)	85
Total monetized health and safety benefits (2017$)	$264 million

**Estimated health benefits from the TRECH Project are preliminary and subject to change.*

[9] This table includes numbers from the low end of the confidence intervals in the TRECH study's Technical Appendix for air pollution-related "Deaths avoided (Air Pollution)" and the "Value of Air Pollution Health Benefits."

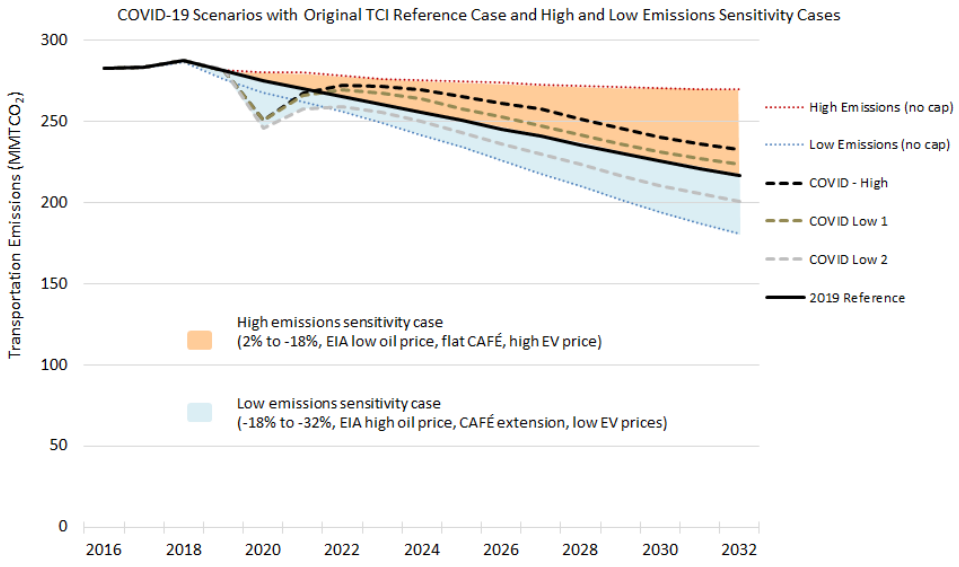
Appendix 2: Modeling Uncertainties Including Economic Impacts, Travel Behavior, and Low Oil Prices

To better understand how regional transportation emissions could be affected by COVID-19, three different no-policy "sensitivity case" scenarios were developed, starting with TCI Reference Case assumptions. Macroeconomic implications of the pandemic were accounted for using IHS Markit projections from May 2020 as inputs. Potential behavioral effects were accounted for by adjusting projected VMT for personal light-duty vehicles (LDV) to reflect continued higher-than-normal levels of telecommuting and working from home, as well as reductions in the use of public transit and associated increases in driving. The oil market implications of COVID-19 were accounted for by assuming low oil prices in two of the three scenarios modeled. Assumptions used for the three scenarios are summarized in the table below.

	COVID High	COVID Low 1	COVID Low 2
Macroeconomic	Recession	Recession	Recession
Oil Prices	AEO 2018 Low oil price	AEO 2018 Low oil price	TCI Reference oil price
Personal LDV VMT	High	Low	Low

The figure below shows results in the context of the 2019 TCI Reference Case and the high and low ranges of emissions sensitivity cases. This shows that projected emissions under the three COVID scenarios are within the range of uncertainty that TCI had projected in sensitivity cases discussed with the release of previous modeling (e.g., assuming a range of oil prices, electric vehicle costs, and federal policies). Note also:

- The macroeconomic effect of the recession puts persistent downward pressure on emissions;
- Personal VMT assumptions increase or decrease projected emissions, depending on the scenario; and
- Low oil prices through 2032 put upward pressure on projected emissions, resulting in higher emissions than the TCI Reference Case for both scenarios with that assumption (COVID High and COVID Low 1).



Implications for TCI-P Design

With a regional cap on emissions set to take effect in 2023, the COVID sensitivity analysis is useful to evaluate potential effects of COVID-19 on emissions in that year, and to inform starting cap levels. If oil prices remain low through 2023, the modeling shows that emissions could be slightly higher than initially projected by the Reference Case during the first year of the program.

In the longer term, once a regional program is in place, a variety of other factors (e.g., oil prices in particular) are expected to have a relatively greater influence on VMT and emissions, as explained in detail on the September 16 TCI webinar. These uncertainties and potential implications for the TCI-P will be tracked on an ongoing basis and evaluated during future program reviews.

Appendix 3: Final Model Revisions to TCI-NEMS

As noted on the September 16 TCI webinar, the final round of TCI modeling runs with TCI-NEMS includes updates from the original set of cases, which were first presented with the release of the draft MOU and published in September on the TCI website. These updates include revisions to the freight truck VMT calibration, as well as incorporation of non-transportation gasoline and diesel adjustments within the fuel and emissions accounting for the policy cases. The growth in freight truck (heavy- and medium-duty trucks) VMT was adjusted upwards slightly in all the regions in order to better match the VMT projected by the jurisdictions. The original calibration had not included trucks of all fuel types in the model's reported total VMT, which led to an underestimation of VMT in the calibration process. The second modification was to account for emissions associated with all gasoline consumption, regardless of end user, as well as an improved estimate of highway diesel consumption. In the first round of modeling, these had been treated outside the cap and published as adjustments to projected emissions.

Appendix 4: Assessing the Emissions Implications of Electric Vehicle Deployment

TCI modeling presented on the September 16 TCI webinar found that while greater deployment of electric vehicles yields a slight increase in electricity demand across the region, the transportation CO_2 pollution reductions achieved through the TCI-P is projected to outweigh the estimated increase in power sector emissions by 4 to 1. This is consistent with results from a 2019 study published by the Nicholas Institute at Duke University, which found meaningful net reductions in emissions of carbon dioxide and nitrogen oxides for all the scenarios and market conditions that they modeled.[10] Additionally, complementary policies to reduce power-sector emissions can significantly reduce any additional emissions from electricity generation.

The TRECH Project also included an initial assessment of potential adverse health impacts from an increase in power sector emissions associated with projected increases in electric vehicle deployment spurred by TCI-P investments. Preliminary analysis by the TRECH project estimates that the health benefits of the TCI-P could be several times greater than the adverse health impact of increased electric power generation and associated emissions from across the eastern U.S. The TRECH team is conducting additional modeling to integrate power sector emissions into future health benefit analysis.

[10] Martin T. Ross, 2019. Emissions Benefits of Electric Vehicles: Influencing Electricity Generation Choices. Nicholas Institute for Environmental Policy Solutions, Duke University, Working paper. https://nicholasinstitute.duke.edu/publications/emissions-benefits-electric-vehicles-influencing-electricity-generation-choices