TRANSPORTATION & CLIMATE INITIATIVE
Of the Northeast and Mid-Atlantic States

Modeling the Transportation and Climate Initiative

Overview and Modeling Approach

As the work on TCI proceeds, different models will be used to provide a fuller picture of the benefits and costs of different regional program design options. This may include some or all of the following types of modeling and analysis:

- Integrated energy system modeling, which can inform state decisions regarding how key regional program design elements would affect the broader energy system, including resulting changes in energy supply, demand, technologies, and prices.
- Investment strategy modeling, which can be used to estimate how investments of allowance proceeds in low-carbon transportation strategies (e.g., transit expansion, bicycle and pedestrian infrastructure) affect emissions and vehicle miles traveled.
- Incidence modeling, which can evaluate the benefits and costs for households of different policy designs and investment strategies.
- Economic modeling, which can generate state-level estimates of changes in jobs, income and GDP that would result from the proposed regional policy, including with a range of different policy designs, investment portfolios and other scenarios.
- Health effects modeling, which can assess how improved air quality and increased active transportation (e.g., biking and walking) associated with the TCI cap and invest program could provide benefits to the residents of TCI jurisdictions.

Decisions by TCI jurisdictions regarding the design of a regional cap and invest program are informed by many sources of information, including findings from technical analysis and outputs from modeling. Several types of models are being used to provide a fuller picture of the potential benefits and costs of different program design options. For example, models are being used to provide insights into the following types of questions:

1. How could regional and state emissions be affected by a program with different cap levels?
2. What could be the public health co-benefits from reductions in criteria air pollutants (e.g., PM2.5, NOx)?
3. How could different investment scenarios affect program outcomes?
4. What could be the range of potential allowance prices at different emissions cap levels?
5. How could program costs, fuel consumption patterns and emissions reductions be affected by the application of certain program design elements (e.g., timing and phasing of cap, emissions and cost containment, allowance banking)?
6. What could be the macroeconomic (GDP, Jobs, income) costs and benefits of different cap levels and other program design elements?
7. Who could bear the costs and benefits of the program?

To explore the potential implications of different TCI policy options, modeling and analysis will compare outcomes under *policy cases*—with declining emissions caps and associated investments in low-carbon transportation—against a TCI *reference case,* in which current policies currently in effect are assumed to remain in place, but there is no emissions cap or associated investments. This reference case reflects a variety of assumptions about how energy markets, technology costs, federal and state regulatory requirements, and other factors are likely to change under "business as usual." The *policy cases* represent options for the design of the emissions cap, including its initial level and the rate at which it declines over time. Policy cases will be modeled with "investment scenarios," which represent illustrative strategies that TCI jurisdictions may pursue with the revenues generated through the sale of emissions allowances. In addition, several additional analyses may be undertaken to explore the sensitivity of the model to various reference and policy case assumptions.

TCI jurisdictions are also exploring the potential benefits and costs of different program design options with models that estimate projected economic impacts, potential health benefits from improved air quality and greater use of active transportation, and changes in costs and benefits for households associated with the *policy cases* relative to the *reference case*.

Modeling Program Design, Costs, and Emissions Reductions

Integrated Energy System Modeling-NEMS (Consultant: OnLocation)

The TCI jurisdictions are using the National Energy Modeling System (NEMS), an integrated energy system model, to understand how key regional program design elements could affect the broader energy system, including changes in energy supply, demand, imports, prices, and technology, including vehicle electrification. In particular, NEMS will inform state decisions regarding program ambition, i.e., the appropriate level for a regional cap on carbon emissions from on-road fuels in the transportation sector.

An important benefit of using an integrated energy system model such as NEMS is that it provides results that shed light on how strategies to reduce emissions in the transportation sector can affect other energy sectors. For example, under a scenario in which electric vehicles (EVs) represent a rapidly growing share of light-duty, medium-duty, and heavy-duty vehicles, NEMS will provide information about increases in electricity demand and other changes in the electric sector.

OnLocation has enhanced the current model structure to improve its ability to represent the TCI region and to analyze potential regional caps covering emissions from on-road gasoline and diesel combustion.

Reference Case Assumptions: On August 8, TCI hosted a webinar during which the TCI jurisdictions shared updates and invited further input from the public to inform the design of the proposed regional cap-and-invest program. The webinar reviewed:

- Updates on the TCI reference case modeling run, the first step of the modeling process;
- Public input received following a May 23, 2019 TCI webinar on reference case assumptions; and
- Inputs and assumptions that were used to run the reference case.

The public was invited to join and learn more about this analysis, ask questions, and offer suggestions for TCI jurisdictions to consider during the subsequent stages of modeling, including modeling runs that will simulate regional CO_2 cap levels and other potential program design elements.

As discussed during the two webinars, the NEMS modeling for TCI is using the Energy Information Administration's 2018 Annual Energy Outlook (AEO) for a number of assumptions about fuel prices, technology costs, economic and population growth, and other factors. As with AEO 2018, the TCI reference case also assumes that current federal vehicle emissions standards will remain in place through 2025. To ensure that the modeling reflects current policies and the technology outlook of TCI jurisdictions, the TCI reference case includes several assumptions that *differ* from those of AEO 2018. These include different electric vehicle (EV) technology costs and EV model introduction years, projections of vehicle miles traveled (VMT) based on state estimates, electric power sector assumptions based on the most recent Regional Greenhouse Gas Initiative (RGGI) modeling, and other assumptions (see appendix to TCI Reference Case webinar presentation slide deck).

Policy Cases: The policy cases will start with the assumptions from the reference case discussed above and then add different potential cap levels and illustrative investment portfolios (discussed below). In the policy scenarios, the NEMS model treats the cap level as an emissions constraint, and calculates an emissions price that results in emission reductions to the level specified by the cap. NEMS also contains built-in assumptions about the costs of emissions reduction strategies (e.g. the incremental cost of electric vehicles), relevant technology constraints (e.g., need for EV charging infrastructure), consumer behavior (e.g., preferences among vehicle classes and responses to price changes), and other relevant variables. Allowance prices calculated by NEMS will reflect the combined effect of the emissions constraint and these specified assumptions.

Sensitivity Analyses Assumptions: TCI jurisdictions also may decide to pair policy cases with sensitivity analyses (of reference and/or policy cases) that reflect different assumptions regarding one or more factors. For example, jurisdictions may analyze different assumptions on technology costs, fuel prices, or future federal policies. These types of sensitivity analyses help to reflect different possible outcomes where there is uncertainty about key modeling assumptions.

Modeling Investment Scenarios—TCI Investment Tool (Contractor: Cambridge Systematics)

In previous work for the Georgetown Climate Center, Cambridge Systematics developed a spreadsheet tool known as the TCI Investment Tool. This tool takes inputs in the form of investments (expressed in dollar values) for clean transportation strategies, and provides outputs of CO_2 emission reductions; changes in VMT, delay in travel times, and petroleum use; economic changes (monetary flows) for businesses, consumers, and government; and other potential benefits including safety, physical activity, and air pollution.

The TCI jurisdictions are using this tool to understand the changes to VMT and other factors that could result from state investments of program proceeds into a wide range of low-carbon transportation strategies including:

a. transit expansion, such as bus rapid transit, light rail, and heavy rail;
b. promotion of urban infill and other compact land use;
c. pedestrian and bicycle infrastructure in urban areas;
d. travel demand management strategies;
e. system operations efficiency technologies; and
f. electric vehicles.

The TCI Investment Tool is necessary because integrated energy system models such as NEMS don't have the ability to directly simulate the types of VMT changes from policies or investment strategies such as expansion of mass transit and bike or pedestrian infrastructure in urban areas. As a result, it is necessary to estimate separately the VMT implications of such investments and then use this information as an input for integrated energy system modeling. In addition to estimating the emissions and other benefits of such investments, this approach will allow TCI jurisdictions to evaluate the potential broader energy system implications of low-carbon transportation investments and complementary policies. Where necessary, OnLocation can adjust VMT assumptions in NEMS to reflect specific policies (e.g., mass transit) modeled by Cambridge Systematics with the TCI Investment Tool.

To estimate the potential implications of different types of investments, TCI jurisdictions are developing illustrative regional investment portfolios that will be integrated with the NEMS policy cases. However, ultimately jurisdictions have differing priorities for the use of these revenues, and may use the proceeds for a range of purposes.

These scenarios will provide information regarding how different mixes of investments may affect emissions, VMT, carbon prices, and energy markets when integrated with the NEMS policy case runs. In addition, outputs from the policy case runs that incorporate investments will be used as inputs into the modeling for health, macro-economics, and cost incidence described below and will help jurisdictions estimate the potential range of costs and benefits for communities and businesses in the TCI region.

Modeling Economic and Health Impacts and Benefits

After policy cases with investment scenarios are run and evaluated by the jurisdictions, some cases will be chosen to evaluate more specific economic and health benefits. Following are three additional types of modeling that will help jurisdictions evaluate the potential costs and benefits of different regional program design options.

Economic Modeling—REMI (Cambridge Systematics)

Cambridge Systematics will run the Regional Economics Models, Inc. (REMI) model to estimate the economic implications of a regional cap-and-invest program. REMI will use capital expenditures, fuel expenditures and other types of outputs from NEMS and the Cambridge Systematics TCI Investment Tool as inputs to estimate macroeconomic impacts of different policy scenarios. REMI will provide estimates of changes in jobs, income, and GDP that could result from analyzed regional policy scenarios.

For example, if consumers are purchasing more electric vehicles, REMI will consider the implications of

- the higher vehicle purchase price (increased capital expenditure by households) on consumers' disposable income and on vehicle producers' revenues;
- the reduced gasoline spending on consumers' disposable income and gasoline suppliers' revenues; and
- the higher electricity spending on consumers' disposable income and utilities' revenues.

All of those direct implications will have spillover effects throughout related industry sectors (e.g., higher disposable income for consumers has implications for retail trades).

Incidence Modeling (Resources for the Future)

Modeling will also be used to help jurisdictions evaluate potential distributional costs and benefits of a regional cap and invest program for different populations or groups. Resources for the Future has developed an Incidence Model that can estimate changes in household expenditures resulting from a cap and invest program and the potential use of proceeds, with attention focused on household income. RFF will employ its Incidence Model to conduct a distributional analysis of the policy's economic implications for households resulting from a price on carbon emissions from transportation. Where it is possible for other models to identify quantitative or qualitative effects of these benefits, RFF will estimate those benefits at the household-level using the Incidence Model and through complementary research and analysis. Incidence Model results will be considered along with other information to provide a better understanding of the program's potential implications for residents of TCI jurisdictions. For example, changes in jobs estimated by REMI may have distributional impacts that are not fully reflected in the Incidence Modeling

Air Quality and Health Benefits Modeling—CMAQ/BenMap (Harvard T.H. Chan School of Public Health)

Reducing carbon emissions and investing in low-carbon transportation systems is also expected to result in public health benefits by improving air quality and providing greater access to public transportation, enhancing safe spaces for biking and walking, and encouraging alternatives to traveling in private motor vehicles. A multi-university team led by researchers at the Center for Climate, Health, and the Global Environment at the Harvard T.H. Chan School of Public Health (Harvard C-CHANGE), will use outputs from NEMS and the TCI Investment Tool to estimate changes in criteria pollutant emissions and increases in active transportation. With these emissions estimates as inputs, the research team will model pollution concentrations associated with different policy scenarios. The research team will then use a health impact assessment model to estimate changes in the number of cases of hospital admissions, non-fatal heart attacks, and premature deaths from air-pollution related illness. Researchers will also explore the potential health benefits from increased physical activity from investing in pedestrian and bike infrastructure. Finally, the team will estimate the monetized value of these health benefits to complement other components of the economic analysis.

Interrelationships Between Modeling Tools

The discussion above of different models used for TCI analysis references the interrelationships between different models. Some of those interrelationships are depicted in the simplified diagram below.

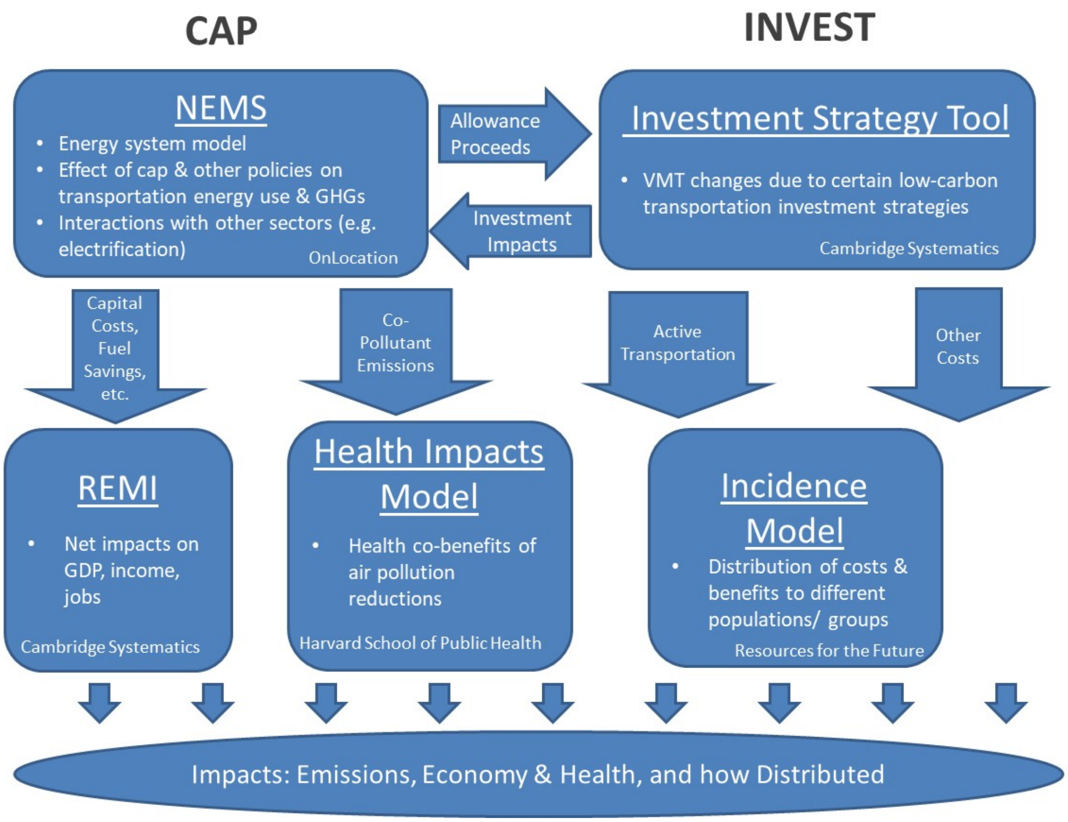

Figure: Diagram illustrating respective roles for each modeling tool and interrelationships.