THE EASTERN TRANSPORTATION COALITION
CONNECTING FOR SOLUTIONS

APPENDIX B

Revenue Visualization Tool User Guide

Revenue Visualization Tool Methodology

Introduction

This report describes the methodology used to develop a web-based tool for visualizing the implications of a range of alternative transportation revenue policy choices (the "Revenue Visualization Tool"). This tool can help agencies and policymakers understand how baseline revenues are forecast to change under different rates and to explore new revenue mechanisms and the magnitude of new revenue collection opportunities.

The tool allows users to configure transportation policy scenarios by defining which revenue mechanisms to deploy, at what rates, and over what time frames. The tool then provides a series of dashboard outputs addressing key questions on how the transportation policy performs across various criteria: financial, user fairness, and cost of administration.

This report summarizes the methodology to develop and deploy the transportation revenue visualization tool. It is organized as follows:

- Approach
- Perspective and Policy Questions
- Data Sources
- Forecasting Methods and Assumptions
- Inputs and Outputs

Approach

The overall approach followed to develop the revenue visualization tool is illustrated in **Figure 1**.

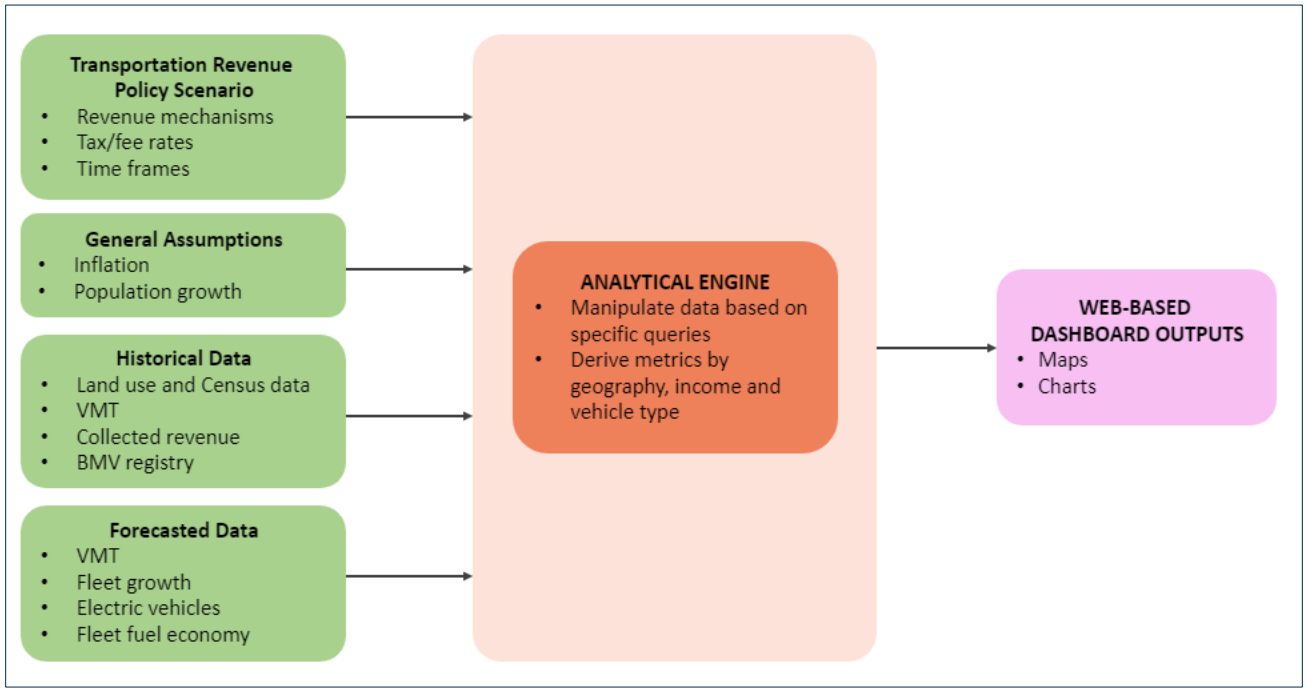
The left side of the figure (green blocks) represents the main inputs to the visualization tool. These include:

- **Transportation Revenue Policy Scenario**: The user defines a custom revenue policy scenario to be tested by specifying which revenue mechanism(s) would be implemented, at what rates, and over what time frames.
- **General Assumptions:** The tool includes general economic and demographic assumptions on inflation and population growth.
- **Historical Data:** Several datasets pertaining to a state's population, land use, vehicle fleet, vehicle usage, and transportation revenue are used to inform recent trends and provide a snapshot of existing conditions.
- **Forecasted Data:** The visualization tool relies on projection models for key factors pertaining to a state's vehicle fleet size and composition, and vehicle usage.

The central part of the tool is the **Analytical Engine** that incorporates all data processing techniques required to manipulate the data based on specific users' queries and to derive the desired metrics.

The right side of the framework includes the web-based **Dashboard Outputs** intended to communicate the analysis results through charts showing key outputs of interest, maps illustrating impact on specific geographies, population groups or vehicle types, and other revenue-related metrics.

Figure 1: Revenue Visualization Tool Framework



Perspective and Policy Questions

The focus of the revenue visualization tool is to better understand the attributes and tradeoffs between various transportation revenue mechanisms as measured over a specified time horizon. The tool was not designed or calibrated for near term financial decision-making, i.e., for biennial budgeting purposes. Rather, the tool compares the expected longer-term performance (over the next 25 years) of selected revenue mechanisms across multiple outputs of interest: gross revenue generated, impacts on drivers by geography, etc., with results displayed in a visual, easy-to-communicate format. The tool was developed to operate in the fiscal policy context in which ultimate decision-makers—legislators and executive branch officials—must operate. This section describes the questions that the tool is designed to help answer, as well as some other perspectives considered when the tool was designed.

Legislative Perspective and Likely Questions

Ultimately, policymakers will decide the key issues related to transportation funding:

- Whether to increase transportation funding levels and if so, by how much
- Which revenue mechanisms to implement
- Who will pay and how much
- When to implement changes to the revenue structure

Legislators must consider a wide range of public policy issues and potential impacts beyond just the state's transportation assets, such as:

- Potential impacts to different populations or areas of the state
- Impacts to certain industries in the state
- Impacts to other public institutions or programs that rely on the same tax base for their own funding needs

Perhaps the most prominent consideration is whether the general public would support (or at least tolerate) the proposed transportation revenue mechanism(s).

Core Questions

Based on this larger policy context in which decisions are made, a core list of questions can be expected from legislators. These core policy questions were then used to help guide development of the revenue visualization tool to ensure the tool is capable of analyzing data, providing answers to the core questions and visually displaying the results in an easy-to-understand format.

Government Fiscal Perspective

Fundamental characteristics and performance results of the revenue mechanism(s):

- How much revenue will the chosen scenario raise?
- How effective is the tax or fee at replacing a current revenue source(s)?
- How well does the tax or fee respond to inflation?
- Can the revenue be bonded?
- How do the expected administrative costs compare to similar public or private services?

Transportation Program Perspective

Impacts of the revenue mechanism(s) on the Department of Transportation's (DOT's) ability to effectively carry out its transportation mission and responsibilities:

- How well does the tax or fee track with transportation system usage?
- Which programs, projects, or activities will benefit?
- What other states impose a similar tax or fee?

Taxpayer Perspective

Costs, benefits and impacts of the revenue mechanism(s) on individuals and businesses:

How will the tax or fee financially impact various constituencies, including but not limited to:

- Who pays more/who pays less (income level, geography, industry)?
- Impacts by vehicle type (weight, fuel, engine, age, etc.)?
- Household impacts/contribution under each scenario?

This list of questions is not exhaustive but comprises the most common ones that decision-makers raise when considering new transportation funding mechanisms. Other common questions asked by decision-makers include how other states are addressing similar transportation funding challenges, how increased funding will be distributed and expended by the state, whether higher-cost projects could be delivered more economically through alternative project delivery methods, and other important fiscal policy questions. However, these types of questions are not well addressed using data analytics and thus are not included in the visualization tool.

Other Perspectives to Consider

Two other perspectives were taken into consideration in developing the revenue visualization tool. First, there was consideration for transportation agency executives that interface most with the legislature, governor's office, and key external stakeholders when pursuing transportation funding increases ("strategic mediators"). Second, the perspectives of state DOT fiscal analysts that have expertise in transportation budgeting, revenue collection, and/or tax policy and are often called upon to provide data, analysis, and other information to address questions raised by the legislature ("operators," since this group is expected to run the revenue visualization tool) were taken into account.

Strategic Mediators

Transportation agency executives must be able to provide information to both the Legislature and the Governor's Office. DOT executives must also serve as stewards or trustees of the statewide transportation system. Their role often requires balancing what is optimal or best from a system operations and preservation perspective with what is desired (or possible) in the policy-making arena of the legislature. Being able to provide useful and reliable information related to the impacts of various revenue mechanisms is imperative, as the success of a new revenue initiative can hinge on "strategic mediators" being able to serve as a trusted source of information for all decision-makers.

Being able to answer questions like how well the revenue mechanism responds to inflation, or how well the revenue mechanism scales based on system usage, not only provides important insight to decision-makers, but also helps portray the likely operational and asset lifecycle impacts that these decisions will have on the state's transportation system. For strategic mediators, being able to communicate and visually display these impacts can be very influential in the decision-making process.

Visualization Tool Operators

The revenue visualization tool was designed and developed so that the DOT's financial and policy experts can effectively use the tool to help answer the core questions asked by legislators. Consequently, principles of human-centered design were applied to improve the user experience (UX) for the operators of the tool.

Data Sources

Datasets

The following sources were assembled into datasets used by the revenue visualization tool.

Census Bureau

The Decennial Census, American Communities Survey, and other Census/Office of Management and Budget (OMB) data products (establishing whether a county was rural or urban based on Metropolitan Statistical Area (MSA) status) provided information about county-level demographics, including median income and population.

State Specific or Online Electric Vehicle (EV) Forecasts

If state-specific EV forecasts were available, these were used to develop a future fleet forecast. Where state-specific data was not available, other online resources were utilized to develop these forecasts.

Department of Transportation

DOT spatial data, including shapefiles for mapping.

State Motor Vehicle Registry Data and Private Sources

States maintain a database of all vehicle registrations in the state. This was used to summarize key vehicle characteristics at the county level, which are subsequently used by the tool to perform revenue calculations. This dataset was supplemented with vehicle annual mileage and retail values sourced from thousands of private and public sources.

National Highway Traffic Safety Administration

NHTSA's publicly available vehicle identification number (VIN) decoder and related resources were used to supplement vehicle information in the Department of Motor Vehicle (DMV) database. This included fields such as year, make, model, engine, and trim level.

Environmental Protection Agency (EPA)

The EPA publishes fuel economy ratings for nearly all passenger vehicles available to consumers. By combining these datasets with specific vehicle types, it was possible to determine the estimated fuel consumption for the statewide fleet.

Federal Highway Administration (FHWA)

FHWA publishes annual reports on roadway usage, vehicle registrations, and travel in its Highway Statistics Series. The tables were used to validate vehicle counts and travel in specific states, as well as information on commercial truck attributes.

State Travel Demand Model (TDM)

Statewide TDMs provided the project team with annual vehicle miles traveled, which were subsequently used to develop forecasts for travel in future years.

Replica

Replica is a synthetic travel demand model—using known data from a variety of sources, it creates a representative set of anonymous, artificial trips and travelers. For this project, two kinds of trips were of interest, those by transportation network companies (TNCs), like Uber and Lyft, as well as commercial deliveries.

Data Cleaning and Checking

The core dataset used for analysis was the list of vehicle registrations provided by a given state's DMV. This data required additional cleaning, primarily to remove duplicate vehicles and registration types outside the scope of the tool.

Next, any registration records without a 17-digit VIN were removed from the dataset since they are unable to be decoded for vehicle information. After this step, older records—any with a valid registration date prior to the base year (presumably vehicles no longer resident in the state)—were removed, and the table was filtered to eliminate duplicate VINs. If there were duplicate VINs in multiple records, only the record with the most recent registration issue date was kept.

Using the same list of VINs, encoded vehicle year, make, and model information were matched to fuel economy datasets maintained by the EPA. This was combined with the main DMV database and other private and public data sources, using VIN as the matching key. For the purposes of the tool, passenger cars and noncommercial trucks were grouped together as "passenger vehicles," as they are used for personal travel and pay flat registration fees, while commercial trucks differ significantly in usage and fee schedules.

Since the DMV dataset contains the location of each registration, it was possible to determine how the vehicle fleet was distributed across the state. For each county in the state, the number of vehicles by registration type (passenger and commercial truck) was calculated. For passenger vehicles (including noncommercial trucks), it was possible to calculate county-level estimates for the following characteristics:

- **Powertrain Type:** Based on fields in the DMV database, vehicles could be categorized as gasoline, diesel, hybrid, plug-in hybrid electric, or electric.
- **Vehicle Age:** Using model year data encoded in each VIN, vehicles were divided into age bins.
- **Vehicle Fuel Economy:** Vehicles were divided into miles per gallon (MPG) bins. For each bin, average fuel economy of vehicles contained within it were also calculated.
- **Vehicle Fuel Economy by Powertrain:** The number of each powertrain type that uses fuel (excluding EVs) were also counted for each MPG bin. These counts were accompanied by corresponding MPG averages.
- **Annual Vehicle Miles Traveled (VMT):** The average distance driven by passenger vehicles in each county.

- **Vehicle Value:** The average estimated retail value of vehicles for each county within a state was joined to the dataset.
- **Vehicle Weight:** The average weight of vehicles for each county was joined to the data set. Vehicles were divided into weight bins.

In contrast with passenger vehicles, fewer resources are available for granular data on truck usage and specific vehicle characteristics. While commercial truck totals by powertrain were calculated for diesel and gasoline (no other powertrain types were present in significant numbers), MPG and VMT estimates were initially sourced from FHWA. These were then adjusted to meet known totals of fuel sales and statewide VMT.

The remainder of the data processing consisted of assembling the outputs into a table for the base year. The county-level vehicle and travel data described above were supplemented with total tax collections on the sale of motor vehicles, as well as estimated trip counts by TNCs (e.g., Uber and Lyft) and deliveries. Finally, demographic data was appended to each county. This present-day dataset was then used in the forecasting process to create data tables starting in the base year, and then in specified increments through the horizon year.

Forecasting Methods and Assumptions

This section describes forecasting methods and assumptions, with a focus on fleet growth projections and trends for future share of EVs and VMT growth projections.

Fleet Growth Projections and EV Share

The fleet growth projections are based on:

- **Base Year Registry Data**: The DMV's vehicle registry dataset provided a snapshot of the state's vehicle fleet for the base year. VIN decoding was performed on this dataset to extract the specific data relevant for revenue analysis: vehicle age, value, fuel efficiency, engine type and weight. The vehicle fleet distribution across categories such as Diesel, Gasoline, Hybrid, Plug-in Hybrid Electric Vehicle (PHEV), and EV provided a foundation upon which future projections were built.
- **Scrappage Rate**: A fixed scrappage rate based on industry research was applied to each vehicle category to simulate natural fleet reduction due to vehicle age, accidents, and other attrition factors. The scrappage rate is the ratio of scrapped vehicles in a year as a percentage of vehicles on the road.
- **New Vehicle Purchases**: The inflow of new light-duty vehicles added to the state vehicle fleet was estimated for each vehicle type based on state population forecasts and using state-specific EV forecasts (if available) or forecasts developed using online resources.

Inputs and Outputs

This section summarizes the inputs selected by the user (the revenue mechanisms available to add) and the outputs that are shown to the user. Additionally, this section discusses how outputs are adjusted for the cost of collection of each revenue mechanism.

Inputs Summary: Revenue Mechanisms

The inputs screen provides users with the ability to design a customized revenue policy. A list of revenue mechanisms is shown to a user, and they select and customize the policies to their preference—at a minimum, the rate can be adjusted for each policy. These mechanisms include revenues collected on behalf of the state and do not include local, county, or federal revenue mechanisms. Below is a brief description of each revenue mechanism:

- **Gasoline Tax Step Increase/Inflation Indexing**: Increases to the existing gasoline tax
- **Diesel Tax Step Increase/Inflation Indexing**: Increases to the existing diesel tax
- **Public Charging Kilowatt-Hour (KWH) Tax:** Entered as a per kilowatt-hour electricity tax in dollars
- **Base Light Vehicle Registration Fee**: The base fee is the default; proposed increases are entered in dollars
- **Hybrid/PHEV/EV Registration Fee**: Engine type-based surcharges, entered in dollars
- **Base Heavy Vehicle Registration Fee**: The average base fee is the default; proposed increases are entered as a percent
- **Value Tax/Age-Based/MPG-Based/Weight-Based Fees on All Light Vehicles**: Registration fees in addition to the Base Light Vehicle Registration Fee, entered in dollars
- **Miscellaneous Registration Revenue:** Includes motorcycle/moped/motor scooter, trailer, and mobile home registration revenues, as well as hauling permits, temporary operating permits, and penalty and interest; revenues are entered in dollars
- **Mileage-based User Fee (MBUF) for Light Vehicles**: Fee can be applied to vehicles by either combined miles per gallon (mpg) rating or vehicle age; when this policy is added, the tool ensures that taxpayers pay only MBUF and do not pay fuel taxes or Hybrid/PHEV/EV registration fees (gasoline taxes and fees are waived on light vehicles subject to MBUF)
- **MBUF for Heavy Vehicles**: Applied to all heavy vehicle miles traveled in the state; when this policy is added, the tool ensures that taxpayers pay only MBUF and do not pay fuel taxes (diesel taxes are waived on heavy vehicles subject to MBUF)
- **Delivery Fee**: Entered as a per-transaction charge in dollars on all online purchases
- **For Hire Transportation Fee**: Entered as a per-trip charge in dollars
- **General Fund**: Annual lump sum general fund transfer from the Legislature
- **Auto Sales Tax**: Taxed percentage of the value of total vehicle sales, entered in dollars
- **Auto Lease Tax:** Taxed percentage of the value of total vehicle leases, entered in dollars

Outputs Summary

The outputs screen displays the results of the policy scenario. Multiple modules and buttons have been designed to provide the user access to the findings, as described below:

- **Statewide Projected Revenue (Nominal and Real Dollars):** Displays the planning totals for each specified multi-year interval in either nominal or real dollars (assumes 2.5% inflation); includes the net and gross revenues along with anticipated baseline revenue assuming existing revenue mechanisms.
- **Statewide Per Vehicle-Mile Driven Projected Revenue:** Displays the planning totals for each specified multi-year interval; includes the anticipated baseline revenue per VMT assuming existing revenue mechanisms.
- **County Average Cost Per Vehicle:** Clickable map that shows variation across the state in cost over time; clicking on a county reveals the change over time and information about the fleet mix by engine type.
- **Geographic Vulnerability Index:** Clickable map shows the areas most exposed to transportation costs over time; clicking on a county reveals the change over time and information about the baseline costs.
- **Tracks with System Usage:** Insight into each revenue mechanism's relationship to system usage; some mechanisms are flat rates independent of usage, while others are directly related to road wear.
- **Mechanism Maps:** Each revenue mechanism includes a map showing its use nationwide by state for reference; these maps encourage further research by policymakers to explore how different states fund transportation costs.
- **Export Data:** Users can download the input revenue mechanism assumptions along with the gross revenue by mechanism (revenue before the cost of collections is removed).
- **Help:** Provides access to a user guidance document.

Cost of Collection

Cost of collection was calculated and removed from each revenue mechanism added in a policy package. Cost of collection was given its own category in the output charts, so that total net revenue could be easily discerned from total gross revenue. The cost of collection for each revenue mechanism was determined using existing rates available from the DOT for existing revenue mechanisms and determined using national best practices for new revenue mechanisms.