Smarter MODES Tool
User Guide & Methodology

V1.2

Rocky Mountain Institute

Contents

Overview of the Tool

Decision-makers in the United States are increasingly considering mode shift strategies to reduce climate pollution from transportation sector. According to USEPA, surface transportation constitutes the majority of transportation pollution, primarily due to tailpipe emissions from light duty vehicles.

The Smarter Mobility Options for Decarbonization, Equity, and Safety (Smarter MODES) tool explores how various combinations of 1) vehicle electrification and 2) vehicle miles traveled (VMT) reduction can impact mode shift emissions reductions from the transportation sector and additional co-benefits from improved health, safety, cost, and power generation outcomes as compared to vehicle electrification-alone strategies in all 50 US states.

Given 1) a state, 2) an electrification scenario, and 3) a VMT reduction scenario, the tool outputs the following outcomes and associated costs:

- Avoided tailpipe and charging emissions
- Avoided fuel and charging costs
- Avoided crash fatalities and injuries
- Avoided inactivity fatalities
- Avoided air pollution fatalities
- Avoided congestion time and costs

This tool contains state specific-data and its outputs may be useful for long term program planning, especially to develop "size-of-the-prize" estimates for achieving climate pollution reductions and expanding transportation options in a given state. However, the tool:

- Is not a travel demand or land use model
- Is not an individual project level planning tool
- Should be used in concert with other reputable analysis tools & models

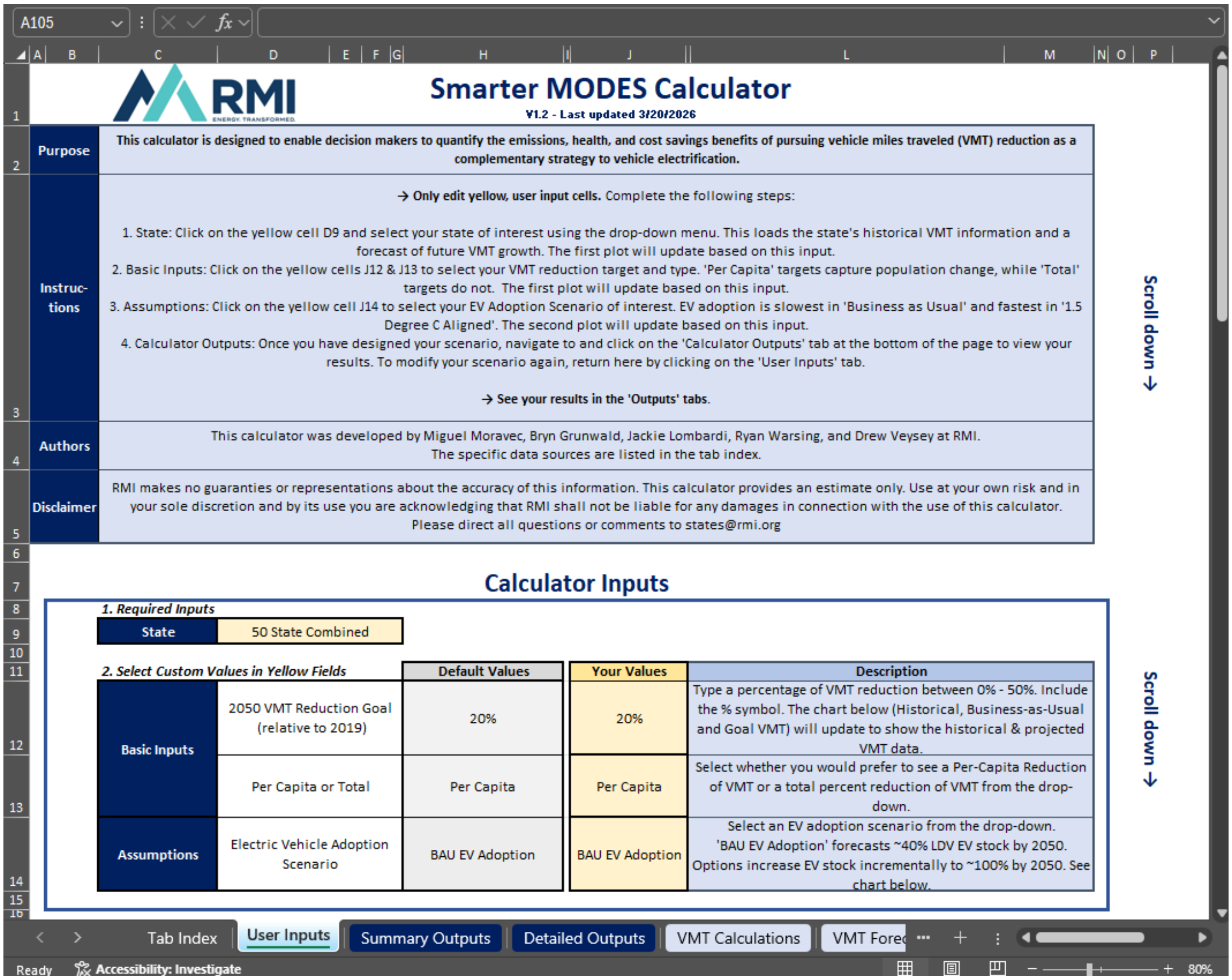
User Guide

The tool is a spreadsheet-based analysis tool contained in a single file, "RMI_Smarter_MODES_Calculator_V1.2.xlsx". Once the tool is open in Microsoft Excel, the user can dynamically select inputs to create a desired scenario and then view the outputs of said scenario.

In most cases, the user should only need to interface with the 'User Inputs' and 'Calculator Outputs' tabs. Advanced users can refer to the 'Tab Index' tab and the 'Methodology' section of this document to learn about the supporting data and calculation tabs.

Inputs

After opening the Excel sheet associated with the Tool, the user arrives at the 'User Inputs' tab, which resembles the image below:



The yellow cells are user drop down menus. The user should complete the following steps to create the desired scenario for analysis:

1. State:
    a. Click on the yellow cell D9 and select your state of interest using the drop-down menu. This loads the state's historical VMT information and a forecast of future VMT growth. The first plot on the left will update based on this input.
2. Basic Inputs:
    a. Click on the yellow cells J12 & J13 to select your VMT reduction target and type. 'Per Capita' targets capture population change, while 'Total' targets do not. The first plot on the left will update based on this input.

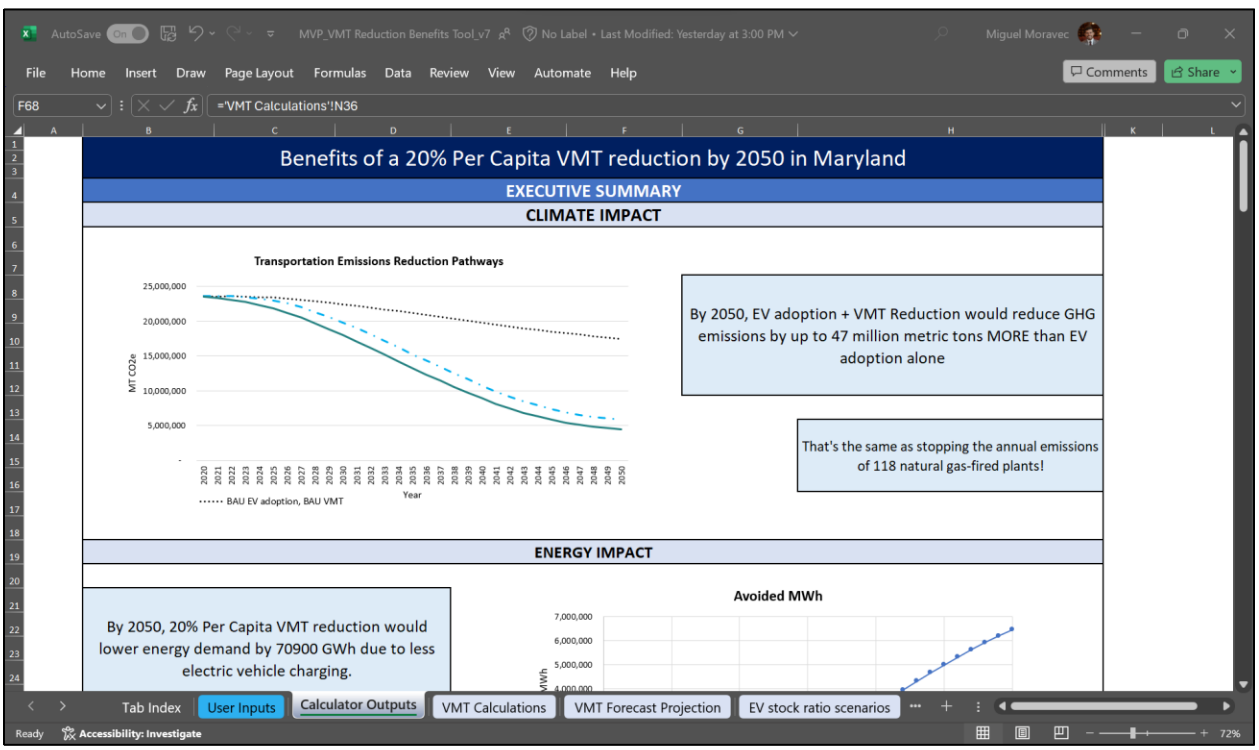
3. Assumptions:
    a. Click on the yellow cell J14 to select your EV Adoption Scenario of interest. EV adoption is slowest in 'Business as Usual' and fastest in '1.5 Degree C Aligned'. The second plot (on the right) will update based on this input.

These instructions are also included in the tool for user convenience. Note: Default values are provided in the gray cells H12:H17. Users should not edit the 'Default Values' column.

After each input is selected, the spreadsheet instantaneously completes a new analysis. The results are then available on the 'Calculator Outputs' tab.

Outputs

Once the user has designed their scenario using the desired inputs, the user should navigate to and click on the 'Calculator Outputs' tab at the bottom of the page to view the tool results. The 'Calculator Outputs' tab should resemble the following image below:



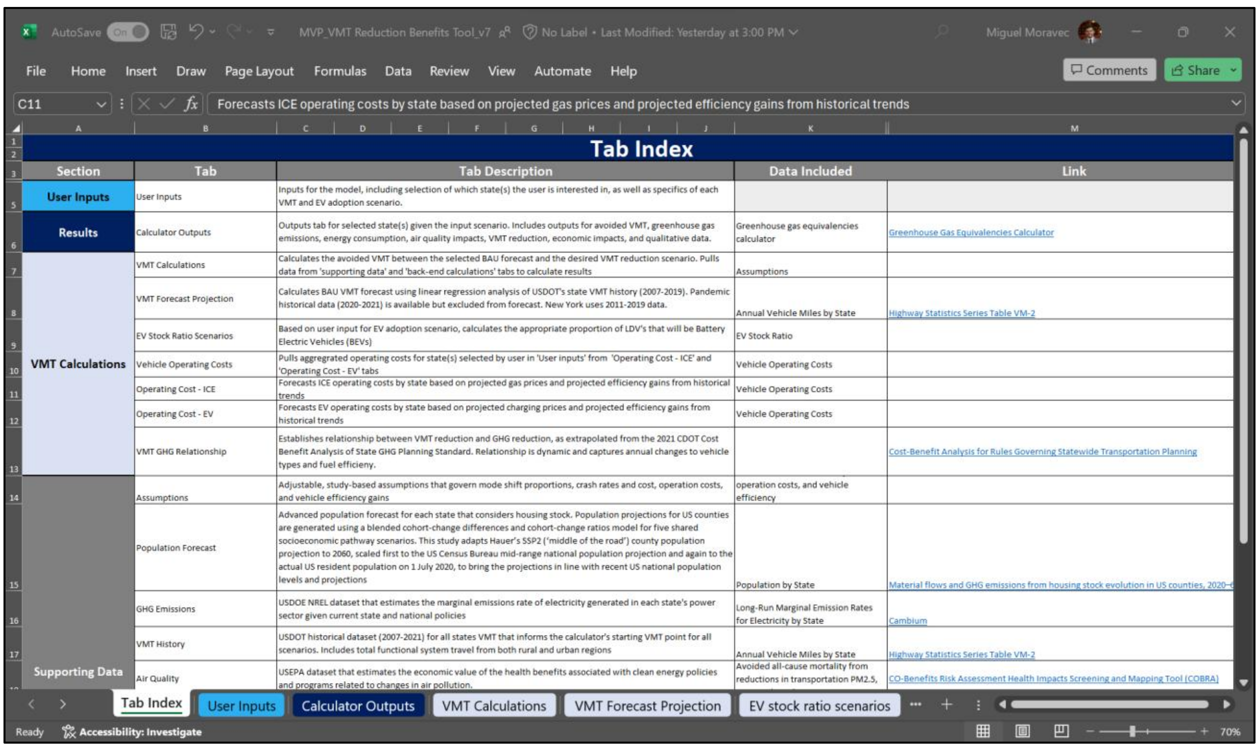
The outputs tab is separated into two sections: 1) an executive summary of high-level outputs, and 2) a detailed results table with additional estimated outputs. **The user must scroll down to view the complete outputs from both sections.**

The 'executive summary' contains high-level outputs of the tool's climate, energy, safety, and household savings impacts. The executive summary automatically contextualizes these findings with US EPA greenhouse gas equivalencies where possible.

The ‘detailed results’ section presents these same outputs and additional, more detailed values in a broader table. Generally, results are presented in both annual averages and cumulative scenario results form. Where possible, this section also automatically contextualizes the findings with [US EPA greenhouse gas equivalencies](#).

Tab Index

The ‘Tab Index’ tab serves as a handy reference for advanced users to identify the location, description, and data behind the full set of tabs contained in the spreadsheet. In addition to the previously discussed ‘User Inputs’ and ‘Calculator Outputs’ tabs, the user is also able to read information about the ‘VMT Calculations’ and ‘Supporting Data’ set of tabs.



Tab Index

Section	Tab	Tab Description	Data Included	Link
User Inputs	User Inputs	Inputs for the model, including selection of which state(s) the user is interested in, as well as specifics of each VMT and EV adoption scenario.		
Results	Calculator Outputs	Outputs tab for selected state(s) given the input scenario. Includes outputs for avoided VMT, greenhouse gas emissions, energy consumption, air quality impacts, VMT reduction, economic impacts, and qualitative data.	Greenhouse gas equivalencies calculator	Greenhouse Gas Equivalencies Calculator
VMT Calculations	VMT Calculations	Calculates the avoided VMT between the selected BAU forecast and the desired VMT reduction scenario. Pulls data from 'supporting data' and 'back-end calculations' tabs to calculate results	Assumptions	
	VMT Forecast Projection	Calculates BAU VMT forecast using linear regression analysis of USDOT's state VMT history (2007-2019). Pandemic historical data (2020-2021) is available but excluded from forecast. New York uses 2011-2019 data.	Annual Vehicle Miles by State	Highway Statistics Series Table VM-2
	EV Stock Ratio Scenarios	Based on user input for EV adoption scenario, calculates the appropriate proportion of LDV's that will be Battery Electric Vehicles (BEVs)	EV Stock Ratio	
	Vehicle Operating Costs	Pulls aggregrated operating costs for state(s) selected by user in 'User inputs' from 'Operating Cost - ICE' and 'Operating Cost - EV' tabs	Vehicle Operating Costs	
	Operating Cost - ICE	Forecasts ICE operating costs by state based on projected gas prices and projected efficiency gains from historical trends	Vehicle Operating Costs	
	Operating Cost - EV	Forecasts EV operating costs by state based on projected charging prices and projected efficiency gains from historical trends	Vehicle Operating Costs	
	VMT GHG Relationship	Establishes relationship between VMT reduction and GHG reduction, as extrapolated from the 2021 CDOT Cost Benefit Analysis of State GHG Planning Standard. Relationship is dynamic and captures annual changes to vehicle types and fuel efficieny.		Cost-Benefit Analysis for Rules Governing Statewide Transportation Planning
Supporting Data	Assumptions	Adjustable, study-based assumptions that govern mode shift proportions, crash rates and cost, operation costs, and vehicle efficiency gains	operation costs, and vehicle efficiency	
	Population Forecast	Advanced population forecast for each state that considers housing stock. Population projections for US counties are generated using a blended cohort-change differences and cohort-change ratios model for five shared socioeconomic pathway scenarios. This study adapts Hauer's SSP2 ('middle of the road') county population projection to 2060, scaled first to the US Census Bureau mid-range national population projection and again to the actual US resident population on 1 July 2020, to bring the projections in line with recent US national population levels and projections	Population by State	Material flows and GHG emissions from housing stock evolution in US counties, 2020–
	GHG Emissions	USDOE NREL dataset that estimates the marginal emissions rate of electricity generated in each state's power sector given current state and national policies	Long-Run Marginal Emission Rates for Electricity by State	Cambium
	VMT History	USDOT historical dataset (2007-2021) for all states VMT that informs the calculator's starting VMT point for all scenarios. Includes total functional system travel from both rural and urban regions	Annual Vehicle Miles by State	Highway Statistics Series Table VM-2
	Air Quality	USEPA dataset that estimates the economic value of the health benefits associated with clean energy policies and programs related to changes in air pollution.	Avoided all-cause mortality from reductions in transportation PM2.5,	CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)

The ‘Supporting Data’ set of tabs contain state and country specific data from open-source repositories, as described in the ‘Tab Index’.

The ‘VMT Calculations’ set of tabs pull information from the ‘Supporting Data’ tabs and reformats and/or models it as described in the methodology and in the ‘Tab Index’. The results of this modeling are available in the ‘Calculator outputs’ tab as discussed in the previous section.

For the tool to work as designed, users should not modify the ‘Supporting Data’ or ‘VMT Calculations’ set of tabs.

Saving and Exporting Results

The tool does not automatically save or export the outputs generated by user inputs. Thus, a user who wants to preserve the results of a given scenario can either:

1) Save the spreadsheet as a new file using the “save as” function in Excel, or
2) Manually transcribe the results to a new, separate Excel sheet, Word document, or other file.

In both cases, the user should consider naming the new file to represent the unique user inputs that generated the scenario.

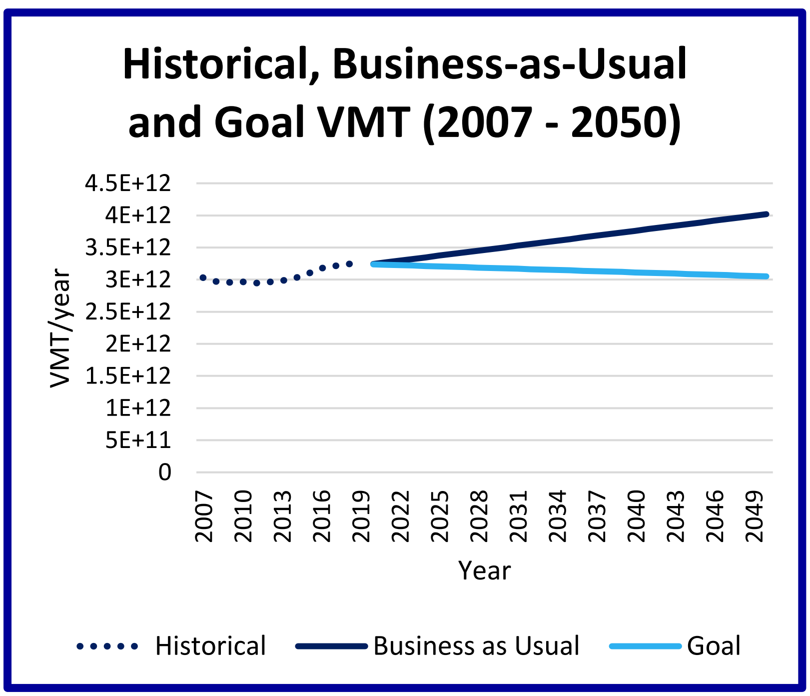
Methodology

The tool works by modeling the impacts of avoided automobile VMT between two scenarios that occur between the years 2024 and 2050:

1) a business-as-usual (BAU) VMT and LDV electrification case, and;

2) a user defined VMT and LDV electrification case.

The two scenarios are represented by the diverging, solid lines in the plot below. The BAU case shows more VMT growth, while the user defined case shows equal or less VMT growth.



The tool considers FHWA historical state VMT data (represented by dotted line) and RMI Energy Policy Simulator (EPS) vehicle stock data to forecast the VMT and Electrification cases for both scenarios. The tool also uses state and national data to model the impacts of the avoided VMT.

The tool largely does not determine *how* automobile VMT is avoided, but rather captures the impacts of *if* the automobile VMT is avoided. The tool makes light assumptions about avoided VMT being shifted to walking and biking, but otherwise does not make additional assumptions about if avoided automobile VMT is shifted to other modes or avoided entirely through shorter or fewer trips.

VMT model

Business as Usual (BAU) Forecast

Historical VMT data is collected for all 50 states from a period that spans 2007 to 2019 from the USDOT Highway Statistics Series Table VM-2. Historical VMT data is truncated to exclude the pandemic years of 2020-2021, which are considered outliers due to the global pandemic. This historical data is analyzed using linear regression, and the resulting trend line is the basis of the BAU forecast of VMT growth for each state through 2050.

In the national context, our regression model forecasts a 0.63% year over year increase in VMT for all motor vehicles in the '50 State Combined Scenario.' This is consistent with the latest official USDOT forecast, which states, "FHWA's Spring 2023 long-term forecast of National Vehicle Miles of Traveled has total VMT increasing at an average annual rate of 0.6% between 2019 and 2049." USDOT does not forecast individual state VMT.

Alternative approaches were considered but not implemented due to the complexity of these methods compared to the simple regression approach that could be applied to all 50 states with open-source data.

Similar cost benefit analysis use state-specific Travel Demand Models (TDM's) to forecast VMT growth. However, such tools must be licensed and not available uniformly across all 50 states.

Others use DOE National Energy Modeling System (NEMS) national VMT forecasts and downscale the forecasts to states based on state population projections. The advantage of the regression analysis compared to this NEMS approach is that it is less contrived, as recent state population trends are somewhat captured in recent historical VMT trends. The disadvantage of the regression approach compared to downscaling NEMS data is that our regression approach assumes VMT from all vehicle types change at the same rate, while NEMS outputs specific forecasts for each vehicle type.

However, historical data from USDOT Table VM-1 suggests that LDV VMT has remained stable at approximately ~89% percent of total motor vehicle VMT for the most recent 14 years VMT data is available. Thus, for the purposes of this analysis, we assume LDV VMT will remain ~89% of the total motor vehicle VMT, even as VMT reductions are accomplished.

Year	LDV VMT	All Motor Vehicle VMT	LDV Share of Total VMT
2021	2,768,999	3,132,411	88.40%
2020	2,572,988	2,903,622	88.61%
2019	2,924,053	3,261,772	89.65%
2018	2,897,083	3,240,327	89.41%
2017	2,877,378	3,212,347	89.57%

2016	2,849,718	3,174,408	89.77%
2015	2,779,693	3,095,373	89.80%
2014	2,710,556	3,025,656	89.59%
2013	2,677,730	2,988,280	89.61%
2012	2,664,060	2,969,433	89.72%
2011	2,650,458	2,950,402	89.83%
2010	2,648,456	2,967,266	89.26%
2009	2,633,248	2,956,764	89.06%
2008	2,630,213	2,976,528	88.37%
2007	2,691,034	3,031,124	88.78%

USDOT Table VM-1

As a final "gut-check," the outputs of the linear regression model were compared to State DOT VMT BAU forecasts where available. Many State DOTs do not publicly release State DOT forecasts, however our linear regression results were comparable to the forecasts of 6 of the 7 State DOT's that we identified as having recently published such forecasts.

The exception to this result was related to the case of New York. In its 2021 Clean Transportation Roadmap Report, NYSDOT projects VMT to grow between 0.77% to 1.29% per year across all motor vehicles between 2020 and 2050. However, linear regression of historical VMT data from New York from 2007 to 2019 suggests a negative trendline and therefore a decrease in VMT year over year through 2050. This discrepancy is in part due to a 2011 change in how NYSDOT calculates VMT, which abruptly modified historical VMT trends in New York. Thus, in the case of New York only, we truncate the training data for the linear regression model to only include VMT from 2011-2019.

Future iterations of this tool may include a 'User Input' option to use the State DOT's forecast, rather than the regression model, as the BAU VMT scenario, should users desire to defer to official state projections when available.

Reduction

The VMT Reduction forecast is calculated from a 2019 baseline through 2050.

In the case that a user selects the "Total" reduction option on the 'User Inputs' tab, the Tool calculates the 2050 goal VMT based on the user's selected reduction target of the 2019 value, then determines a linear year over year reduction rate that produces the appropriate outcome.

In the case that a user selects the "Per Capita" reduction option on the 'User Inputs' tab, the Tool incorporates state population data into its calculation. This Tool uses an advanced population forecast that is based on US Census mid-range projections and available housing stock in each state's counties. Using this population data, 2019 VMT per capita is calculated. Then, the Tool calculates the 2050 goal VMT per capita and resultant total VMT based on the state's projected 2050 population. Finally, the tool determines a linear year over year reduction rate to achieve the appropriate 2050 goal VMT.

In both cases, the user can confirm the final year over year reduction rate used by the Tool for a given scenario in the 'VMT Calculations' tab under the 'VMT YoY Changes' section. This section resembles the image below, with the value of interest in the final row.

VMT YoY Changes	
If per capita reduction, use this math:	
2019 VMT per capita	9,900
2050 Goal reduced VMT per ca	7,920
2050 Goal VMT (if per capita)	3,050,935,299,583
Effective VMT Reduction 2019, 2	6.46%
YoY VMT Change, Starting 2024	10,012,291,978.37
YoY VMT % Change, Starting 202	0.30%
If true reduction, use this math:	
2019 VMT	3,261,771,662,841
2050 Goal VMT (if total)	2,609,417,330,273.05
YoY VMT Change, starting 2024	26,364,809,360.20
YoY VMT % Change, starting 202	0.79%
Final YoY value	
This Scenario: YoY VMT%	0.30%
This Scenario: YoY Change	10012291978.37

Avoided VMT

The annual 'avoided VMT' values are calculated by taking the annual difference between the BAU and Reduction VMT scenario forecasts. These values are the basis for many of the subsequent health, safety, cost, and energy consumption outcomes.

Light Duty Vehicle model

LDV fuel type forecasts were retrieved from RMI's Energy Policy Simulator (EPS) for 2020-2050. The EPS is an open-source model for estimating the environmental, economic, and human health impacts of hundreds of climate and energy policies, including EV-sales related policies and their effects on transportation vehicle stock by fuel type. EPS models are available for 48 states and the US as a whole. For the two states that do not have a specific EPS model (Alaska and Hawaii), national vehicle stock trends are used.

Each state and national EPS model offers a 'BAU' scenario and an 'NDC Aligned' scenario of EV adoption and stock. The 'NDC aligned' scenario represents ambitious decarbonization efforts that would achieve the 'Nationally Determined Contribution' of emissions reductions apportioned to the United States from the Paris Agreement, such as adopting the 'Advanced Clean Cars II' policy. The 'BAU' scenario assumes significantly less EV adoption as a result of a policy environment that features less EV related incentives, mandates, and subsidies. In addition to EV adoption and stock, each EPS scenario also projects the associated stock of Internal Combustion Engine (ICE) vehicles.

For each state, an annual ratio of EV to ICE LDV's is calculated given the EV adoption scenario the user selects in the 'User Inputs' tab. To represent that states may achieve EV adoption between BAU and NDC-alignment, additional mid-range scenarios are generated using the percentile feature of Excel, representing EV adoption that is 25%, 50%, and 75% of the NDC scenario compared to the BAU scenario.

While EPS also projects alternative and hybrid fuel LDV stock, for the purposes of this Tool these fuel types are not considered in the EV/ICE ratio. According to DOE, the vast majority (86%) of hybrid LDV stock on the road today is non-plug-in hybrid, meaning that the onboard battery is charged primarily by the ICE engine. While this improves the fuel efficiency of the vehicle, the vehicle still produces tailpipe greenhouse gas emissions and incurs fuel charges at the pump rather than at home or at charging stations. The effect of hybrid vehicles on state ICE fuel efficiency is thus largely captured in state average fueling costs.

Future iterations of the tool may incorporate the fuel efficiency of alternative LDV fuels, including diesel. According to DOE, diesel LDV vehicles represent less than 1% of current LDV stock. Unlike EV's, the proportion of diesel LDV stock is not projected to change drastically according to EIA.

Operating cost model

A model is created to forecast annual average fuel and charging costs per mile by state. The model considers state data on 1) historical fuel costs and 2) historical electricity rates to project future costs for these services. Then, the model uses state data on contemporary LDV vehicle sizes (pickup truck, SUV, sedan, hatchback) and their respective fuel efficiencies to determine an average fuel and charging cost per mile in each state. The model also assumes that vehicle fuel efficiency improves based on projected efficiency gains for ICE and EV LDV's from the Bloomberg New Energy Finance terminal. The results of this modeling are available in the 'Vehicle Operating Costs' tab.

Maintenance costs per mile for both EV and ICE vehicles are retrieved from Kelly Blue Book. Unlike fuel and electricity rates, which in this Tool increase based on historically derived fuel and electricity trends, maintenance costs are assumed to increase with inflation from present day value. See the 'Key Assumptions' section for more on assumed inflation.

The depreciation rate per mile is estimated using the online Kelley Blue Book Car Worth Calculator. As suggested by an expert reviewer, we investigated how popular vehicle trade-in values differ across several realistic odometer mileage scenarios in 2024, holding all other vehicle features, including age, constant. For example, results showed that lowering mileage by 1,000 miles increased the trade-in and private-party values of a popular sedan by $105 (about 10.5 cents per mile) and of a popular pick-up truck by $109 (about 10.9 cents per mile). Thus we use 10.7 cents per mile as our depreciation rate in 2024 and adjust for expected inflation in subsequent years. This result is more conservative than the

2024 IRS business vehicle depreciation rate of 30 cents per mile, but this IRS rate reflects how aging also depreciates a vehicle during a tax year, a phenomenon which we sought to isolate and exclude.

Parking costs are assigned using estimates from Litman (2025), which suggest average parking costs of approximately 11 cents per vehicle-mile paid directly by users, within a broader total parking cost of roughly 45 cents per mile when including indirect and subsidized costs. Consistent with the approach used for depreciation, this 11 cents per mile value is applied as a uniform per-mile cost in 2024 and adjusted for inflation in subsequent years. This approach reflects a conservative estimate that captures out-of-pocket parking expenses while excluding the larger share of indirect and externalized parking costs embedded in rents, taxes, and goods prices.

The output annual fuel, charging, maintenance, parking and depreciation costs per mile from this model are applied to the 'avoided VMT' values to produce total estimated cost savings. US Census data on households is retrieved to determine cost savings per household per state.

This approach may underestimate cost savings due to its assumption that avoided VMT represents only reduced LDV fuel or charging costs. Medium Duty Vehicle (MDV) and Heavy Duty Vehicle (HDV) trips are generally considered to incur larger fuel/charging costs per mile than LDV's. USDOT projects that national truck (MDV and HDV) VMT will increase at 2 to 4 times the rate of LDV VMT across all economic scenarios over the next 20-30 years. However, this iteration of the model does not contain MDV and HDV fuel cost information.

Emissions model

Method 1: Fuel and Charging

Using the fuel efficiencies from the 'Operating cost model,' annual averages for 1) avoided gallons of gasoline consumed per mile and 2) electricity consumption per mile are calculated for each given state.

While the emissions associated with the consumption of a gallon of gasoline is held constant, the emissions from electricity consumption are dynamic and based on a state's changing energy generation portfolio.

To address the unique emissions associated with the dynamic nature of state energy generation, data is retrieved from the US DOE Cambium dataset. This dataset estimates the marginal emissions rate of electricity generated in each state's power sector given state and national policies as of 2022. For this model, we use the Cambium Emission intensity's (kg/MWh) of the Mid Case Long-Run Marginal Emissions Rate scenario.

Since AK and HI were not included in Cambium's dataset, AK and HI emission intensity was determined using AKGD and HIOA eGRID 2019 data. From this data, it's estimated that Alaska's marginal emission rate would decrease by 60% by 2050 given the Cambium state average. For Hawaii, a 95% marginal emission rate reduction by 2050 is assumed given the state's current Renewable Portfolio Standard (RPS). Since DC was not included in Cambium's dataset, its marginal emissions rate is estimated by averaging the MD and VA Cambium data for each year.

The values for the marginal emissions rate of electricity generated in each state's power sector are available in the 'GHG Emissions' tab.

The output gasoline and electricity consumption values per mile from this model are applied to the 'avoided VMT' values to produce total estimated avoided emissions in each state.

This approach may underestimate emissions savings due to its assumption that avoided VMT represents only reduced LDV energy consumption and associated emissions. Medium Duty Vehicle (MDV) and Heavy Duty Vehicle (HDV) trips are generally considered to consume more energy per mile than LDV's. USDOT projects that national truck (MDV and HDV) VMT will increase at 2 to 4 times the rate of LDV VMT across all economic scenarios over the next 20-30 years. However, this iteration of the model does not contain MDV and HDV energy consumption information.

Method 2: VMT/GHG relationship from CDOT Analysis

To ground-truth and improve upon results from the Method 1 emissions model, a second methodology was developed based on data from a 2021 Cost-Benefit Analysis commissioned by the Colorado Department of Transportation.

This CDOT analysis estimated the net outcomes on GHG and VMT in Colorado if the state pursued a suite of expanded travel choice, transit, and land use strategies with the explicit goal of meeting a new GHG standard. These strategies were considered additional to Colorado's goal to adopt EV's in line with the Advanced Clean Cars II standard. The analysis of the impact of these policies was made possible in part due to the state's unique, activity-based travel demand model, which is inclusive of multimodal forms of transportation.

Tables A.11 and A.15, below, represent the net results of these strategies on state GHG emissions and VMT:

Table A.11
VMT by Year, Light-Duty Vehicles

	Vehicle-Miles of Travel (millions)		
Scenario	**2030**	**2040**	**2050**
Baseline VMT Estimate	63,551	71,069	78,587
Change from Baseline			
Proposed Rule Implementation: Travel Choices + Transit + Land Use	(6,943)	(8,378)	(9,814)
Alternative 1: Travel Choices	(5,876)	(6,197)	(6,146)
Alternative 2: Travel Choices + Transit	(6,633)	(7,593)	(8,138)

Table A.15
GHG Emissions Change from Baseline Forecast by Year

	GHG Emissions Change in Year (million metric tons)		
Scenario	**2030**	**2040**	**2050**
Proposed Rule Implementation: Travel Choices + Transit + Land Use	(1.70)	(1.20)	(0.70)
Alternative 1: Travel Choices	(1.43)	(0.88)	(0.44)
Alternative 2: Travel Choices + Transit	(1.62)	(1.09)	(0.59)

The method 2 model assumes that a state pursues the same travel choice, transit, and land use strategies that Colorado did, and that there is a dynamic relationship between VMT reduction and GHG reductions as a result of these strategies.

For the years provided in the analysis (2030, 2040, and 2050), the model calculates the relationship between each million miles of VMT decreased and each million metric tons of GHG decreased, as compared to the baseline scenario. The values for this relationship in intermittent years are calculated using extrapolation.

The output 'GHG per VMT' reduction values are applied to the 'avoided VMT' values to estimate net total avoided emissions in each state. As expected, this 'net' measure generates lower emissions outcomes than the alternative model from Method 1, which calculates only avoided fuel and energy consumption from LDV's and does not consider new energy consumption from other modes (transit, rail, etc).

This method may understate the benefits of VMT reduction for states with less EV adoption than Colorado (note that the GHG benefit of VMT reduction decreases with time in Colorado due to aggressive electrification). In addition, the results from this method depend on states deploying a similar suite of strategies as Colorado to reduce emissions, which may or may not be available.

Co-benefits

Air Quality

The air quality averted fatalities were calculated using data retrieved from the EPA's Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) for the Energy Policy Simulator (EPS).

Avoided all-cause mortality from NO_x, and SO_2 in each state's transportation sector were normalized and assumed to be reduced in proportion to the share of 'avoided VMT' that comes from ICE vehicles, using the LDV model EV/ICE ratio.

Avoided all-cause mortality from $PM_{2.5}$ in each state's transportation sector was normalized and assumed to be reduced in proportion to the share of 'avoided VMT' that comes from *both* ICE and EV vehicles. This assumption was made due to new research that suggests EVs emit approximately the same $PM_{2.5}$ as ICE vehicles as a result of non-exhaust pollution from tires.

The latest 2021 U.S. DOT guidance for the statistical value of life is used to calculate savings from averted deaths.

Future iterations of the Tool may more directly model air quality benefits by calculating the avoided pollutants generated per avoided mile, rather than assuming air quality fatality outcomes improve in proportion to system VMT reductions. This would allow non-fatal health outcomes and damages, such as the occurrence of asthma, to be addressed.

Congestion

Roadway congestion leads to longer travel times for official business trips and freight movements, as well as longer personal arrands and commuter trips, adversely affecting economic outcomes. National studies from the Texas Transportation Institute suggest that transit expansion and other mitigation measures that reduce VMT are associated with congestion relief and therefore time savings.

Based on this research, the tool retrieves the following relationship from the 2021 CDOT Cost Benefit Analysis, which values time savings at 0.015 hours per mile of vehicle-travel reduced. This value represents a weighted average across Colorado metro area sizes and is conservative compared to national averages, which may value time savings as high as 0.020 hours of delay reduced per VMT reduced.

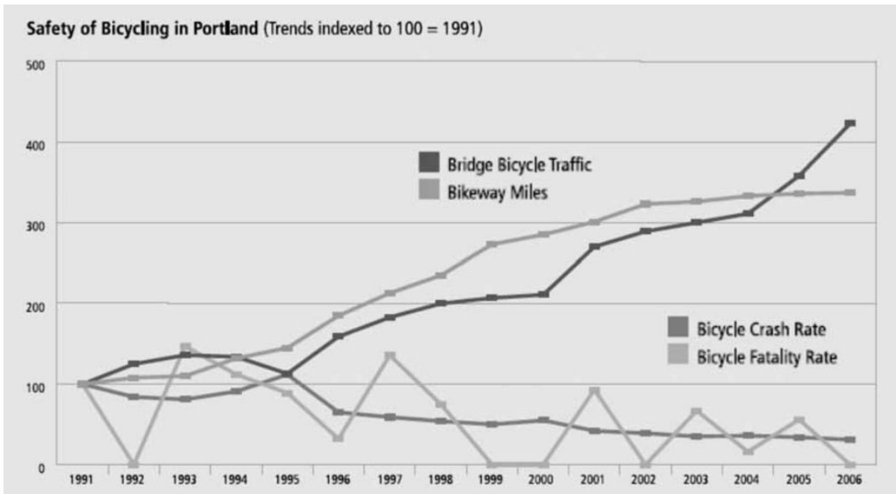
This value is applied to the 'avoided VMT' model output to estimate total congestion relief outcomes. Delay savings are valued at $16.50 per hour based on U.S. DOT 2021 Benefit-Cost Analysis Guidance.

Fuel and charging costs from avoided congestion relief are not calculated, as they are considered captured by the achievement of larger VMT reduction outcomes.

Safety

To estimate the cost savings from avoided automobile crash fatalities and injuries, crashes are assumed to be reduced in proportion to VMT reduction. Average million vehicle-mile crash rates are used from Fatality Analysis Reporting System (FARS) fatality data from 2000-2009 and injury rates reported by the Bureau of Transportation Statistics (BTS) in National Transportation Statistics (Table 2-17: "Motor Vehicle Safety Data"). The latest 2021 U.S. DOT guidance for the statistical value of life is used to monetize the cost of traffic fatalities, while injuries are valued using data from 2021 official Federal Transit Administration reporting templates.

Presumably, reduced light duty vehicle (LDV) VMT represents shorter trips, avoided trips, or trips shifted to other modes. For the purposes of this tool, fatalities associated with increased trips on other modes are considered marginal and are not examined. According to the National Safety Council, the US fatality rates on busses and trains are ten and seventeen times smaller, respectively, than the LDV fatality rate per *passenger* mile. The literature also describes a “safety in numbers” effect in which increases in biking and walking are associated with no change or decreases in the fatality rate per person mile traveled (PMT). For example, according to a study, the city of Portland saw a three-fold increase in biking PMT between 1991 and 2006. In the same time period, the number of bike-related fatalities and crashes decreased in total.



We therefore assume that states would see neither an increase or decrease in pedestrian and bicyclist fatality events, although we acknowledge that this outcome would be most likely when mode shift is paired with increased investments in safety infrastructure.

Physical Inactivity

Active transportation health benefits are calculated based on two key assumptions. First, the Tool assumes that for every 10 miles of reduced LDV VMT, 1 mile shifts to new biking PMT (person mile traveled) and 1 mile shifts to new walking PMT compared to BAU. Second, the Tool uses the medium rate of avoided fatalities per PMT from biking and walking active transportation health benefits as measured in a 2020 Harvard study evaluating the impacts of mode shift in 12 U.S. states.

These rates are applied to the ‘Avoided VMT’ model output, generating total annual avoided pre-mature fatalities. These averted fatalities are considered indirect and are *not* included in the direct monetized cost savings, since the magnitude of averted fatalities could be quite large but the impact is indirect and thus more uncertain than the other direct health benefits which are monetized.

Key Assumptions

Monetary Assumptions

Annual inflation is assumed to occur at a rate of 3.20% per year. The inflation rate is applied to all values except refueling and charging costs, which are forecast to increase based on historical trends rather than inflation. A discount rate of 2.22% is applied to all cost savings.

Future iterations of the model may apply unique inflation and discount rates to avoided fatalities to better align with federal guidance on the value of avoided fatalities.

Investments Assumption

The tool assumes that 'net-neutral' state investments into the transportation system can produce the desired reduced VMT reduction outcome. In other words, the Tool assumes that the revenue needed to develop and maintain VMT reducing infrastructure would be reprioritized from other planned projects that increase VMT and/or emissions in a manner that is incompatible with desired outcomes. This assumption was also used in the 2021 CDOT cost benefit analysis of its GHG standard, which found that the state would be able to meet its GHG target by gradually shifting up to 28% of its investment into transportation options that reduced VMT. A table of this investment shift is available below.

Table 1
Net Neutral Investment Levels and Dollars Shifted to Multimodal Transportation and other Environmentally Beneficial Transportation Investments
(net present value, millions of 2021 dollars)

Years	Total RTPs + 10-Year Plan	Total Shift to Mitigation	Percent Shift
2022-2025	$3,842.07	$417.90	11%
2026-2030	$4,802.59	$974.90	21%
2031-2040	$9,605.17	$2,655.80	28%

[1]

States that would similarly desire to achieve the reduction target with a net-neutral investment approach may need to evaluate the flexibility of their transportation revenue streams to fund different kinds of projects. Many federal program dollars can be flexed across programs and modes.

Disclaimer

RMI makes no guaranties or representations about the accuracy of this information. This calculator provides an estimate only. Use at your own risk and in your sole discretion and by its use you are acknowledging that RMI shall not be liable for any damages in connection with the use of this calculator. Please direct all questions or comments to states@rmi.org.

Version 1.1 Technical Update

Version 1.1, released in fall of 2025, updates several values and bugs from Version 1.0 of the Smarter MODES Calculator:

- Averages Calculation:
  - The issue: the formula to calculate several "average annual" benefits pulled data from years 2020-2050, rather than the evaluated scenario of 2024-2050.
  - The effect: the value of several averages was understated.
  - The update: The formula was corrected to only consider the proper years for average calculations.
- Depreciation Method:
  - The issue: the previous mileage depreciation rate, adopted from Kelly Blue Book reports and official IRS guidance, conflates both time *and* mileage in establishing the rate of depreciation. However, VMT reduction does not necessarily combat depreciation caused by vehicle aging.
  - The effect: the value of the depreciation savings was overstated.
  - The update: a new, reviewer-recommended method was adopted that controls for the aging element of depreciation and more specifically evaluates the trade-in value impact of various odometer mileage scenarios. This method is described in the Operating Cost Model section.
- VMT Reduction Annual Quantity:
  - The issue: the annual VMT reduction quantity used for calculations was slightly different than the true annual reduction required to meet the 2050 VMT reduction goal selected by the user due to a formula error.
  - The effect: the benefits of VMT reduction were slightly overstated (~3% in the default 50 states scenario) because more reductions were occurring than selected on the "user input" tab.
  - The update: the formula has been corrected to properly allocate VMT reductions annually for calculation.
- Colorado State BAU VMT Forecast
  - The issue: Colorado's business as usual VMT forecast was erroneously based on national average 'business as usual' VMT growth, rather than state specific data as intended.
  - The effect: the benefits of VMT reduction were significantly understated in Colorado, because reductions were calculated relative to a lower 'business as usual' VMT baseline than is likely.
  - The update: Colorado's 'business as usual' forecast has been updated to use the Colorado historical trend line analysis as intended.

Version 1.2 Feature and Assumptions Update

Version 1.2, released in spring of 2026, adds a new Parking Cost feature and updates default EV assumptions since Version 1.1 of the Smarter MODES Calculator:

- Default EV Forecast:
  - The issue: Due to federal policy changes, EV adoption forecasts have been updated.
  - The effect: The benefits of VMT reduction are understated when using the recommended default values.
  - The update: The tool was updated to recommend using the 'BAU EV Forecast' by default, rather than a more ambitious EV adoption scenario.
- New Feature Added – Parking Cost
  - The operating cost model was updated to quantify the benefit of reduced parking expenses per mile of vehicle travel. The method for this feature is explained in the updated 'Operating Cost Model' section of this document.