CMAQ EMISSIONS CALCULATOR TOOLKIT

The purpose of the Congestion Mitigation and Air Quality Improvement Program Emissions Calculator Toolkit (CMAQ Toolkit) is to help a user with limited modeling experience estimate emission reductions associated with implementation of a CMAQ-funded project. The CMAQ Toolkit uses emission rates and activity data based on default-scale (also known as national-scale) runs of the U.S. Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator (MOVES). This document explains the use and methodology of the Bicycle and Pedestrian Improvements Tool.

Emission estimates from the CMAQ Toolkit are not intended to meet specific requirements for State Implementation Plans (SIPs) or transportation conformity analyses. For further information regarding the specific setup of MOVES used to generate the emission rates provided in this tool, please refer to the Emissions Data Documentation associated with this emissions calculator.

Bicycle and Pedestrian Improvements Tool

The Bicycle and Pedestrian Improvements Tool estimates emissions reductions accomplished by diverting trips from passenger vehicles to bicycle or pedestrian trips through improvements to bicycle or pedestrian infrastructure. It is recommended that users calculate related mode shifts through a travel demand model in advance of using this emissions calculator.[1]

Successful bicycle and pedestrian infrastructure projects improve the quantity and quality of non-motorized trips, increasing the facilities' ease of use and encouraging mode shift. Diverting trips ordinarily taken by motorized modes to non-motorized trips improves air quality and reduces congestion by removing motorized vehicles, and their accompanying emissions, from the roadway. Projects covered by this tool include but are not limited to horizontally separated non-motorized paths e.g., sidewalks, dedicated bicycle infrastructure, improved wayfinding, mid-block crossing installations, bike share systems, and bike parking improvements.[2] Note that the tool does not consider trip chaining that may result from a project to improve bicycle and pedestrian trip quality, and it assumes that transit service miles will remain unchanged, though transit utilization may change.

This document is divided into three sections – User Guide, Tool Methodology, and Examples. The User Guide defines user inputs and tool outputs, assumptions made by the tool, and error messages. The Tool Methodology section outlines the steps taken by the tool to calculate emission reductions and equations used within the tool. The Examples section provides instructive examples of how to use the tool for different types of analysis.

[1] The most current version of the tool is dated May 2022. To verify the version, check the date on the Introduction page of the tool. Release notes are included in the Change Log tab, which can be viewed by right-clicking on any tab in the tool, selecting "Unhide", and revealing the tab.

[2] CMAQ projects must benefit air quality through demonstrated emission reductions. See the CMAQ guidance at www.fhwa.dot.gov/environment/air_quality/cmaq/ for a full list of projects that may be eligible for CMAQ funds. CMAQ funds may be used for shared use paths, but may not be used for trails primarily for recreational use.

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USER GUIDE

This section describes each user input and tool output, error messages, and other tool assumptions.

User Inputs

The Bicycle and Pedestrian Improvements Tool's interface contains a series of questions to guide the user through properly inputting information for emission reductions calculations in a step-by-step process. The user-defined inputs for this tool are described in Table 1.

Table 1. User Inputs

Item	User Input	Units	Description
(1)	Project evaluation year	-----	Year the project is fully implemented. For example: if construction begins in 2023 and concludes in 2025, the evaluation year is 2025. Use the drop-down menu to choose a year between 2018-2040.
(2)	Daily individual motorized trips by mode	One-way trips	Enter the number of trips taken by passenger vehicle before and after the project. The difference represents the number of diverted trips as a result of the project.
(3a)	One-way trip distance source	-----	Use the drop-down menus to select either "Average" or "Distribution" as the one-way trip distance type used to derive subsequent VMT estimates. This selection activates the appropriate inputs for Question 3b. Distances of passenger vehicle trips diverted to non-motorized modes are used to calculate emissions. If you wish to use default values for Question 3b, press the appropriate "Fill National Values" button once you have selected the trip distance source.
(3b)	Typical trip distance	Miles one way	If you selected "Average" in (3a), enter the trip distance representing the typical traveler's trip distance for passenger vehicles.
(3b)	Distribution of trip distances	-----	If you selected "Distribution" in (3a), enter the fraction of travelers whose trip distances fit into the distance bins shown. These must sum to 100%. Please note that the distribution excludes trips greater than five miles.

Note: This tool uses the number of one-way trips and one-way trip distance of diverted trip distances to calculate daily emissions. If your inputs are round trips, multiply the number of trips (Question 2) by two and divide round-trip distances (Question 3b) by two to adjust. An example calculation is provided in the Tool Methodology section (see Round Trip Adjustments

As discussed earlier, the tool analyzes one-way trip characteristics as inputs. Therefore, users with round trip data will need to adjust their inputs to correspond to those used by the tool.

To adjust round trips into one-way trips, multiply by two:

$$Trips_{one\ way} = Trips_{round} * 2 \quad (6)$$

To adjust round trip distances to one-way distances, divide the known distance by two:

$$Distance_{one\ way} = \frac{Distance_{round}}{2} \quad (7)$$

).

Note: If users wish to evaluate a project's impacts to pedestrian and bicycle trips separately, simply run the tool's analysis separately for each component.

Vehicle Type: The tool uses a combined Passenger Car (sourcetypeid 21) and Passenger Truck (sourcetypeid 31) as the vehicle for "Passenger Vehicle".

Default Typical Trip Distances

In the event that users cannot provide a passenger vehicle typical trip distance, the Bicycle and Pedestrian Tool includes default values derived from the most recent National Household Transportation Survey (NHTS 2017). Since non-motorized trips are assumed to have zero emissions, the tool is concerned with the length of the diverted motorized trips in order to calculate the change in emissions due to the project. An analysis of the NHTS dataset revealed that most bicycle and pedestrian trips are five miles or less; therefore, trip distributions by mode should be truncated at five miles. The default trip distance distribution provided in the tool corresponds to the proportion of passenger vehicle trips in that truncated distribution from the NHTS 2017 data. For illustration, please see Appendix A for graphs of these distributions across a number of modes.

If your trip distribution used in analyzing this project includes trips greater than five miles, simply calculate the weighted average and enter this using the "Average" selection for Input Question 3a (please see the Methodology section for a more thorough explanation).

Travel Demand Modeling

As previously described, the Bicycle and Pedestrian Improvements Tool derives emissions benefits from motorized passenger vehicle trips diverted to non-motorized modes. In addition to direct modal substitutions, some CMAQ-eligible projects will enable multimodal trip chaining, such as beginning or completing a transit journey by walking or bicycling. However, the Bicycle and Pedestrian Improvements Tool does not account for changes to any transit service activity, adhering to the assumption that primarily passenger vehicle trips are diverted to non-motorized modes. Moreover, the tool assumes that, regardless of travel behavior shifts toward or away from transit, transit service itself does not change in conjunction with a bicycle or pedestrian project, and therefore transit-based emissions do not

change. Users should separately model emissions impacts from new or modified transit service, such as through other tools in the CMAQ Toolkit.[3]

Successful use of this CMAQ calculator relies on credible travel demand modeling (TDM) to provide mode shifts as activity inputs. TDM can be a complex computational process. However, there are a number of simplified methodologies that enable agencies to conduct robust TDM analyses with fewer resources. Several of these methodologies are provided in Appendix B, including links to primers on travel behavior and travel modeling, as well as some simplified tools.

Tool Outputs

Emission reductions are calculated for five pollutants – carbon monoxide (CO), particulate matter with diameters of 2.5 microns or less ($PM_{2.5}$), particulate matter with diameters of 10 microns or less (PM_{10}), nitrogen oxides (NOx), volatile organic compounds (VOC), as well as greenhouse gases in terms of carbon dioxide (CO_2) and carbon dioxide equivalent (CO_2e) – in kilograms per day, and total energy consumed (TEC) in million BTU. Note that positive numbers indicate reduction amounts; negative numbers indicate an a disbenefit.

Error Messages

Table 2 lists error messages the user may encounter, the reason for the error message, and the solution. Once you correct any errors, please press 'Calculate Output' to recalculate the results.

Table 2. Error Messages

Error Message	Reason for Error	Solution
Missing Project Evaluation Year: Please enter an appropriate project evaluation year between 2018-2040 before proceeding.	Invalid input for project evaluation year.	Input a year between 2018 and 2040 by using the drop-down menu.
"Change In Trips" Error: Entry for change in the number of trips is invalid. Please revise your before and after values before proceeding.	Blank or non-numeric information provided for the change in daily trips.	Ensure valid inputs for both before and after the project, for all modes.
"Trip Distance Source" Error: Your trip distance source for passenger vehicles is invalid. Please review and revise your selection before proceeding.	Invalid selection for trip distance source.	Select either "Average" or "Distribution" from the drop-down menu.

[3] https://www.fhwa.dot.gov/environment/air_quality/cmaq/toolkit/

Error Message	Reason for Error	Solution
(If "Distribution" is selected) "Distribution" Error: Your distribution for passenger vehicles does not sum to 100%. Please review and revise your distribution before proceeding.	Trip distances are not properly allocated.	Prepare a distance distribution where all mileage allocations sum to 100% with a tolerance of at least three significant digits (0.999 ≤ sum ≤ 1.001). Alternatively, select the "Fill National Values" button in Question (3a).
(If "Average" is selected) Missing Input Error: You have not provided a typical trip distance for passenger vehicles. Please review and provide a distance value before proceeding.	Typical trip distance is invalid.	Input a typical one-way trip distance in miles.

TOOL METHODOLOGY

Emissions Equations

The equations below summarize how the tool calculates emissions changes, i.e., the difference between the emissions from baseline travel behavior and the emissions after the implementation of the project. Emission reductions, reported in kilograms per day, are calculated for a given pollutant as follows:

$$E_{i,p} = \left[\left(VMT_{before_i} - VMT_{after_i}\right) * e_{i,p,c}\right] + \left[\left(Starts_{before_i} - Starts_{after_i}\right) * e_{i,p,c}\right] = \Delta VMT_i * e_{i,p,c} + \Delta Starts_i * e_{i,p,c} \quad (1)$$

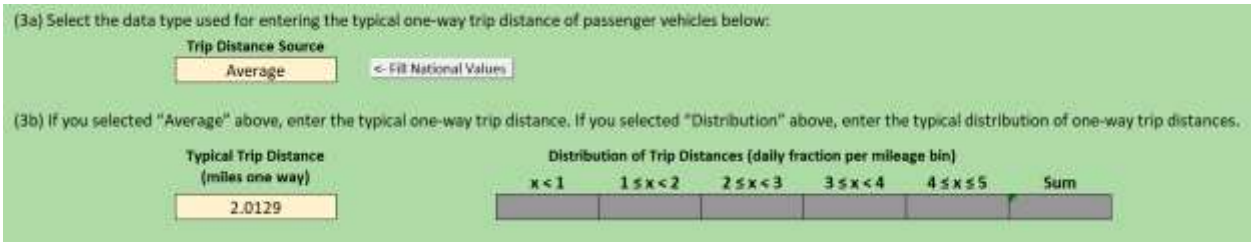
$$total\ emissions\ reduced_p = \sum_{i \in I} E_{i,p} = \sum_{i \in I} \left(\Delta VMT_i * e_{i,p,c}\right) + \left(\Delta Starts_i * e_{i,p,c}\right) \quad (2)$$

For all i and p where:

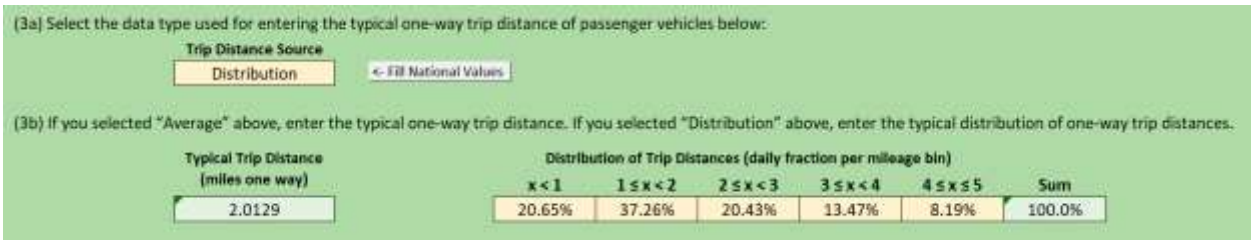
$E_{i,p}$	emissions by mode *i*, and pollutant *p*;
$i \in I$	mode *i* across all modes *I*, currently includes passenger vehicles only;
p	pollutant, including the five criteria pollutant above (CO, $PM_{2.5}$, PM_{10}, NOx, VOC) as well as CO2e and total energy consumption;
$e_{i,p,c}$	emission rate by mode *i*, pollutant *p*, and process *c;*
VMT_{before_i}	vehicle miles traveled (VMT) before project completion for mode *i*; and
VMT_{after_i}	vehicle miles traveled (VMT) before project completion for mode *i*.

As the emissions estimation methodology relies on distance, estimating vehicle-miles traveled (VMT) is made relatively flexible (2). Users are required to provide the number of trips before and after the project's implementation. Subsequently they are able to determine the specificity of their analysis by

providing either a single trip distance or proportions of trips taken, less than five miles,[4] which is calculated as the weighted average of trips among the one-mile distance bins (3). Note that the national average typical trip distance is derived from, and therefore equivalent to, the national default for the "Distribution" selection, as shown below:



Trip distance source – Passenger vehicles: Average
Typical trip distance – Passenger vehicles: 2.0129 mi (default national value)



Trip distance source – Passenger vehicles: Distribution
Typical trip distance – Passenger vehicles: 2.0129 mi (default national value, derived from distribution)
$x < 1 = 20.65\%$
$1 \leq x < 2 = 37.26\%$
$2 \leq x < 3 = 20.43\%$
$3 \leq x < 4 = 13.47\%$
$4 \leq x \leq 5 = 8.19\%$

If the trip distribution used includes trips greater than five miles, and therefore differs from the default distance categories provided in the tool interface, calculate an alternative weighted average using (3) and enter this as using the "Average" selection for Input Question 3a. The weighted average trip distance is assumed constant before and after project completion.

$$VMT_{before_i} = N_{before_i} * D_i \quad (3)$$

$$VMT_{after_i} = N_{after_i} * D_i \quad (4)$$

[4] The five-mile threshold was selected based on an analysis of the NHTS 2009, used for the national defaults, which states that the vast majority of bicycle and pedestrian trips in the United States are five miles or less. Please truncate user-supplied distributions as necessary to fit the bins, or calculate a weighted average.

$$D_i = \sum_{j \in J} \left(d_{midpoint_j} * k_{i,j} \right) = \sum_{j \in J} \left(\left(\frac{d_{max_j} + d_{min_j}}{2} \right) * k_{i,j} \right) \quad (5)$$

For all i and j where:

N_{before_i}	number of trips before project completion for mode *i*,
N_{after_i}	number of trips after project completion for mode *i*,
D_i	weighted average commute distance for mode *i*,
$j \in J$	bin *j* in the group of all bins of the trip distance distribution *J*, bins in one-mile intervals,
$d_{midpoint_j}$	midpoint distance of each bin *j* in the trip distance distribution, i.e. 0.5, 1.5, 2.5, 3.5, 4.5
d_{max_j}	maximum value of distance bin *j* in the distance distribution, i.e., 1, 2, 3, 4, 5
d_{max_j}	maximum value of distance bin *j* in the distance distribution, i.e., 0, 1, 2, 3, 4, and
$k_{i,j}$	proportion of trips that fall in distance bin *j* for all trip distances of given mode *i.* trip distance distributions must sum to one for each mode.

As an example of calculating this weighted average, let us assume the following distance distributions:

Distribution of Trip Distances (daily fraction per mileage bin)

x < 1	1 ≤ x < 2	2 ≤ x < 5	5 ≤ x < 8	8 ≤ x ≤ 9
.1990	.2040	.2130	.1720	.2120

In order to calculate the weighted average one-way trip distance, we would use Equation (5) above, computing the midpoint of each mileage bin, multiplying by the proportion of trips in each bin, and summing across the bins. The calculation for the fourth bin (5 ≤ x < 8mi) would occur thus:

$$D_4 = \sum_{j \in J} \left(\left(\frac{d_{max_j} + d_{min_j}}{2} \right) * k_{i,j} \right)$$

$$D_{4_{(5 \le x < 8)}} = \left(\frac{8 + 5}{2} \right) * 0.1720$$

$$D_{4_{(5 \le x < 8)}} = 1.118$$

Users would calculate the average trip distances for each bin in a similar fashion, and sum the results into a single typical trip distance for the distribution. Users would then enter this as the Typical Trip Distance using the “Average” selection for Input Question 3a.

$$D_i = \sum_{j \in J} (0.5 * 0.1990), (1.5 - 0.2040), (3.5 * 0.2130), (6.5 * 0.1720), (8.5 * 0.2120)$$

$$D_i = 4.071\ mi$$

Round Trip Adjustments

As discussed earlier, the tool analyzes one-way trip characteristics as inputs. Therefore, users with round trip data will need to adjust their inputs to correspond to those used by the tool.

To adjust round trips into one-way trips, multiply by two:

$$Trips_{one\ way} = Trips_{round} * 2 \quad (6)$$

To adjust round trip distances to one-way distances, divide the known distance by two:

$$Distance_{one\ way} = \frac{Distance_{round}}{2} \quad (7)$$

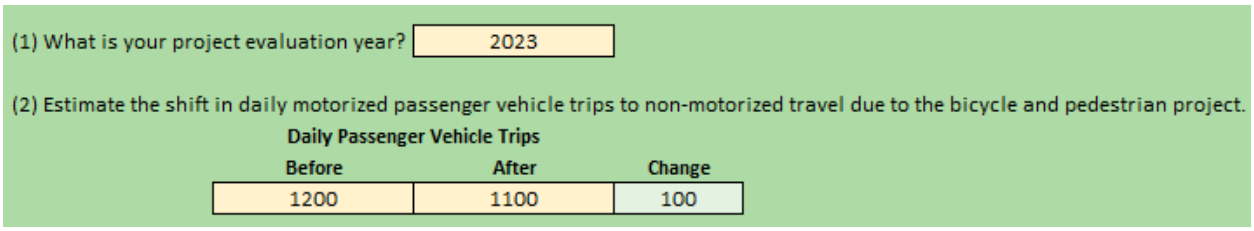
EXAMPLES

Example 1: Mid-block Crossing with a Pedestrian Hybrid Beacon (PHB)

After examining a long divided arterial road with residential and commercial land uses on both sides, a city department of transportation determines that the long blocks and the median effectively increase the distance and time of walking trips, diverting them instead to motorized travel.

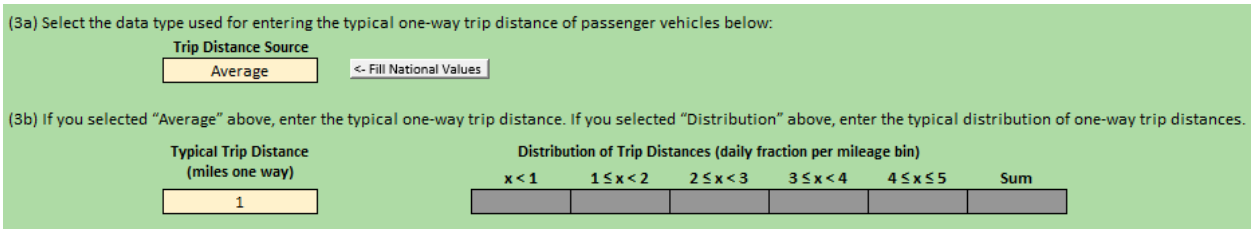
The study concludes that, out of the 1200 daily passenger vehicle trips destined for this area, 100 daily trips taken from nearby residences would instead be taken on foot if the effective travel distances were shortened with mid-block crossings signalized using PHBs (also known as HAWK lights).

Using this information, the user would enter the following inputs into the tool to analyze the scenario, as shown below:



Project evaluation year: 2023
Before passenger vehicle trips: 1200
After passenger vehicle trips: 1100

The city determined a one mile average typical trip distance would be appropriate for their analysis. After selecting "Average" from the drop-down menu, enter the typical trip distance into the appropriate box, as shown below:



Trip distance source – Passenger vehicles: Average
Typical trip distance – Passenger vehicles: 1 mi

Pressing the "Calculate Output" button produces the following results:

Pollutant	Total
Carbon Monoxide (CO)	0.408
Particulate Matter <2.5 µm ($PM_{2.5}$)	0.001
Particulate Matter <10 µm (PM_{10})	0.005
Nitrogen Oxide (NOx)	0.025
Volatile Organic Compounds (VOC)	0.018
Carbon Dioxide (CO_2)	38.822
Carbon Dioxide Equivalent (CO_2e)	39.144
Total Energy Consumption (MMBTU/day)	0.525

The emission reductions in kg/day and TEC reductions in millions of British Thermal Units (MMBTU) are:

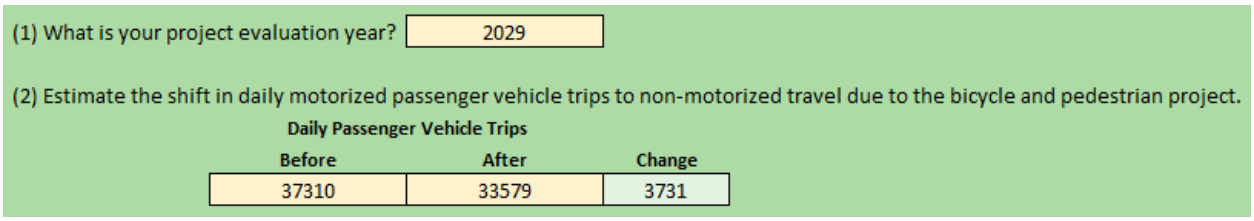
Carbon Monoxide (CO): 0.408
Particulate Matter (PM2.5): 0.001
Particulate Matter (PM10): 0.005
Nitrogen Oxide (NOx): 0.025
Volatile Organic Compounds (VOC): 0.018

Carbon Dioxide (CO_2): 38.822
Carbon Dioxide Equivalent (CO_2e): 39.144
Total Energy Consumption (TEC): 0.525

Example 2: Protected Infrastructure Installation

A municipality conducts a travel survey and finds that its transportation system handles 41,000 daily work trips, 91% of which are taken by personal automobiles. However, they notice that 45% of auto commuting trips take less than 15 minutes, suggesting that many of these short trips could be taken by non-motorized modes instead.

The municipality is considering a project involving the installation of several miles of protected bicycle infrastructure that would divert drivers and make walking on the sidewalk more pleasant by reducing bicycle congestion there. Subsequent travel behavior analysis estimates the total trip diversion could be as high as 10%. Based on this information, the user would enter the following inputs into the tool, as shown below:

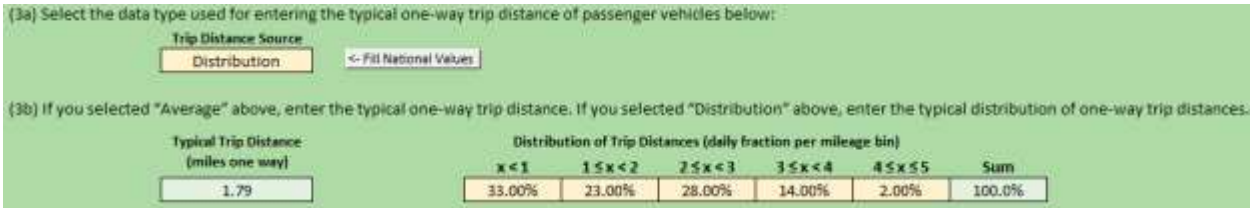

(1) What is your project evaluation year? 2029

(2) Estimate the shift in daily motorized passenger vehicle trips to non-motorized travel due to the bicycle and pedestrian project.

Daily Passenger Vehicle Trips		
Before	After	Change
37310	33579	3731

Project evaluation year: 2029
Before passenger vehicle trips: 37,310
After passenger vehicle trips: 33,579

The city used their travel survey to input a distribution of trip distances for their VMT calculations for passenger vehicles, which they entered as shown below:


(3a) Select the data type used for entering the typical one-way trip distance of passenger vehicles below:

Trip Distance Source: Distribution <- Fill National Values

(3b) If you selected "Average" above, enter the typical one-way trip distance. If you selected "Distribution" above, enter the typical distribution of one-way trip distances.

Typical Trip Distance (miles one way)	Distribution of Trip Distances (daily fraction per mileage bin)					
	x<1	1≤x<2	2≤x<3	3≤x<4	4≤x≤5	Sum
1.79	33.00%	23.00%	28.00%	14.00%	2.00%	100.0%

Trip distance source – Passenger vehicles: Distribution
Typical trip distance – Passenger vehicles: 1.79 mi (derived from distribution)

$x < 1 = 33\%$
$1 \le x < 2 = 23\%$
$2 \le x < 3 = 28\%$
$3 \le x < 4 = 14\%$
$4 \le x \le 5 = 2\%$

Pressing the "Calculate Output" button produces the following results:

Pollutant	Total
Carbon Monoxide (CO)	16.712
Particulate Matter <2.5 µm ($PM_{2.5}$)	0.062
Particulate Matter <10 µm (PM_{10})	0.298
Nitrogen Oxide (NOx)	0.595
Volatile Organic Compounds (VOC)	0.577
Carbon Dioxide (CO_2)	2233.488
Carbon Dioxide Equivalent (CO_2e)	2244.464
Total Energy Consumption (MMBTU/day)	30.177

The emission reductions in kg/day and TEC reductions in MMBTU are:

Carbon Monoxide (CO): 16.712
Particulate Matter (PM2.5): 0.062
Particulate Matter (PM10): 0.298
Nitrogen Oxide (NOx): 0.595
Volatile Organic Compounds (VOC): 0.577

Carbon Dioxide (CO_2): 2233.488
Carbon Dioxide Equivalent (CO_2e): 2244.464
Total Energy Consumption (TEC): 30.177

Appendix A: Tool Updates

Table 3. Tool Updates Log

Date	Update
12/2018	Initial release
6/2019	Updated rates to MOVES2014b Updated years to range 2019-2030
8/2019	Updated calculations methodology to include starts independently of running
6/2022	Updated rates to MOVES3 Updated trip distribution data to NHTS 2017 Incorporated evaporative and ONI emissions

Appendix B: NHTS 2017 Modal Trip Distribution Analysis

The following figures indicate the distribution of trip distances by mode for walking, bicycling, passenger vehicles, and transit buses; the latter is provided for illustrative purposes only and is not included in the tool at this time. Note that the percentages shown represent the proportion of trips five miles or less. The percentages for passenger vehicles correspond to those provided in the tool as the national default trip distance distribution for trips less than 5 miles, from which the national default weighted average is derived.

For purposes of the NHTS analysis:

- Passenger vehicles includes NHTS vehicle types car, van, SUV, and light-duty truck.
- Transit bus includes NHTS vehicle types local public bus, and commuter bus.

Figure 1: NHTS 2017 One-Way Commute Distance – Walking

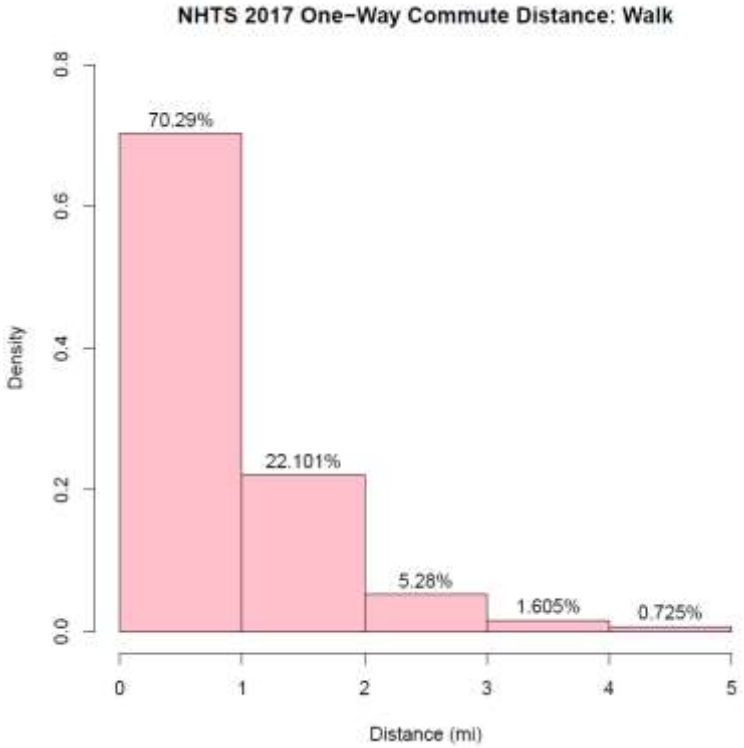


Figure 2: NHTS 2017 One-Way Commute Distance – Cycling

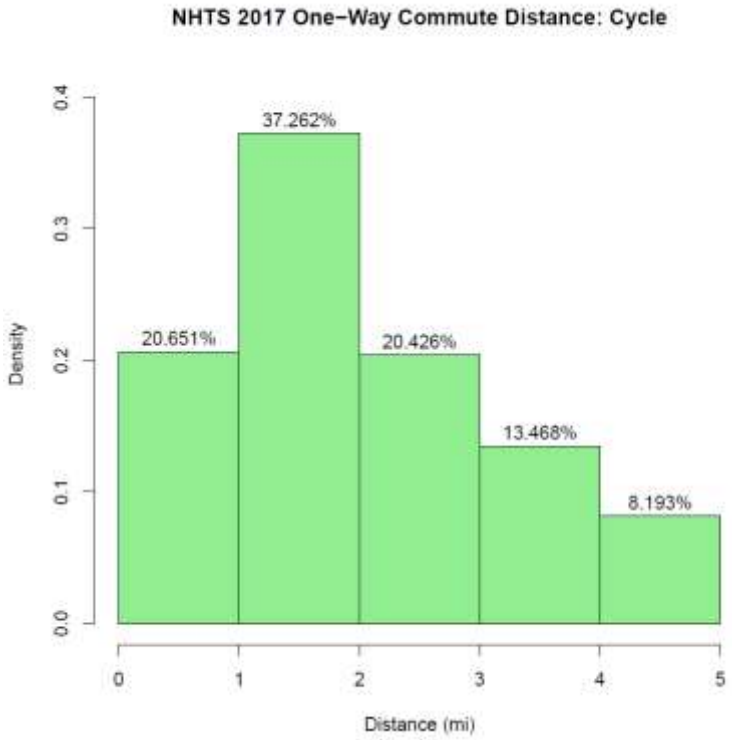


Figure 3: NHTS 2017 One-Way Commute Distance – Passenger Vehicle

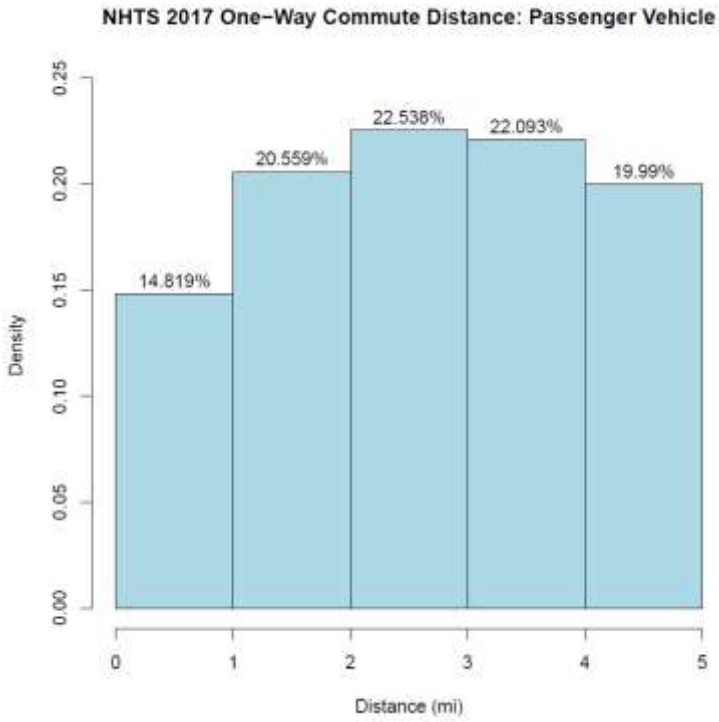
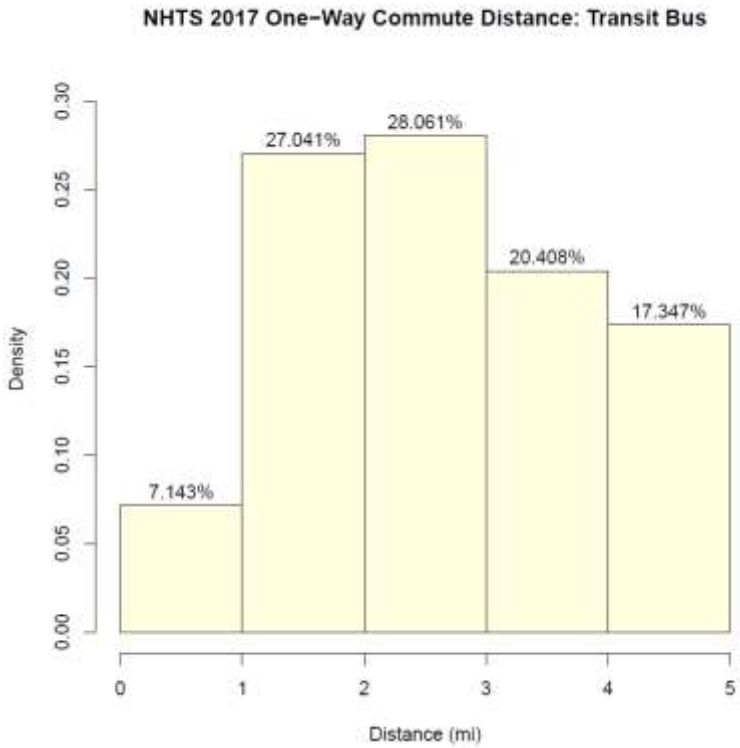


Figure 4: NHTS 2017 One-Way Commute Distance – Transit Bus



Appendix C: Travel Demand Modeling Resources

Successful use of this CMAQ calculator relies on credible travel demand modeling (TDM) to provide mode shifts as activity inputs. TDM can be a complex computational process involving a great deal of effort. However, there are a number of simplified methodologies that enable agencies to conduct robust TDM analyses with fewer resources. Several of these methodologies are described below, and include primers on travel behavior and travel modeling, as well as links to some simplified tools.[5] Questions about individual resources should be directed to their respective authors.

TDM Concepts

The following provide an overview of travel demand analysis core concepts, both theoretical and practical.

Integrating Demand Management into the Transportation Planning Process: A Desk Reference (FHWA 2012) was prepared to assist transportation officials' incorporation of TDM into policy and implementation. It characterizes a number of ways TDM relates to policies regularly considered by state and local governments, including air quality and environment. It also includes a chapter on TDM strategies and tools available to the transportation community.

Transportation Research Board Special Report 288 (TRB 2007) is the product of several years' dedicated research to evaluate the state of TDM practice among American MPOs and State DOTs. The report includes the history and statutory origins of travel modeling in the United States, and gives a plain language overview of the economic principles informing its applications to planning a transportation system. It also discusses the technical and resource considerations for various modeling scales i.e., Federal, state, and local.[6]

Understanding Transport Demands and Elasticities (Litman 2017) describes the relationship between travel behavior and the demographic, geographic, and economic factors that lead to mode choice. The paper gives an assessment of theoretical bases for travel behavior, and emphasizes the role of total cost pricing when modeling transportation scenarios. In addition, the author describes a computationally light modeling strategy involving demand elasticities, which are provided in tables summarizing other economic research.[7]

Example Simplified Tools

The three tools listed below provide simplified methodologies for estimating shifts in travel demand for a number of modes as a result of level of service, land use, pricing, and infrastructure changes; each account for non-motorized as well as motorized changes.

Trip Reduction Impacts of Mobility Management Strategies (TRIMMS) is a spreadsheet tool developed by the Center for Urban Transportation Research (CUTR) at the University of South Florida that evaluates transportation and land-use impacts of policy scenarios. TRIMMS[8] has a built-in TDM

[5] Note that the CMAQ program does not endorse the use of any particular tool, and provides this list as a starting point for agencies without their own preferred modeling approach. Each of the simplified tools described here can be used to produce the necessary inputs for CMAQ tools relatively quickly.
[6] Transportation Research Board (TRB), http://onlinepubs.trb.org/onlinepubs/sr/sr288.pdf.
[7] Victoria Transportation Policy Institute, www.vtpi.org/elasticities.pdf.
[8] TRIMMS is available at www.trimms.com/download/

calculator, which uses a demand elasticity methodology to calculate shifts in trips by mode resulting from changes in the time/money costs of each mode.[9] Note that users must convert these outputs into distance-based units using known typical trip distances.[10] TRIMMS comes pre-loaded with default values that the user may modify at their discretion. Depending on input data availability, a simple run of the tool might take less than one day.

Rapid Policy Analysis Tool (RPAT) is a graphical user interface (GUI)-based transportation scenario planning software package developed by the American Association of State Highway and Transportation Officials (AASHTO) in partnership with FHWA and the second Strategic Highway Research Program (SHRP2).[11] RPAT's six internal models use inputs on local household dynamics, economics, urban form, and transportation characteristics to evaluate regional land use + transportation policy scenarios; this includes a TDM whose outputs are in vehicle-miles traveled. RPAT provides modifiable default input data, and its user guide provides step-by-step instructions for obtaining data and constructing scenarios. RPAT is expressly designed to be accessible for users with no prior modeling experience. However, due to its comprehensiveness and ability to consider multiple scenarios at once, using RPAT with local data may require 1-2 days if the needed inputs are not readily available.

Simplified Trips-on-Project Software (STOPS) is a standalone software package developed by the Federal Transit Administration.[12] STOPS applies a set of travel models to predict detailed transit travel patterns using a modified approach to the conventional "four-step" method. STOPS uses the Census Transportation Planning Package (CTPP) to describe the local travel market, and replaces the traditional coded transit network with transit services in the General Transit Feed Specification (GTFS) framework. STOPS outputs include a prediction of changes in the automobile mode person-miles of travel (automobile mode trips plus auto access to transit trips) that can be converted into a VMT change. Note that using the software requires a meaningful background with applying travel models to project-specific forecasts, as well as familiarity with GIS and the other data required for the analysis, including GTFS and zonal transportation characteristics. Depending on the availability of data and skilled personnel, successful use of STOPS for project analysis may take several weeks.

TDM Best Practices and Practitioner Forums

Resources on TDM abound, and many are internet-accessible including some useful items here:

The Transportation Modeling Improvement Portal is the long-term home for the Travel and Freight Modeling Improvement Programs (TMIP/FMIP) that came out of SHRP2. Supported by TRB and FHWA, their website includes a library of hundreds of documents, datasets, and an archive of

[9] Florida Department of Transportation hosts the TRIMMS user manual at www.fdot.gov/research/Completed_Proj/Summary_PTO/FDOT_BDK85_977-27_UserManual.pdf

[10] For an example of a simplified methodology extracting typical commute distances, see www.brookings.edu/wp-content/uploads/2016/07/Srvy_JobsProximity.pdf

[11] RPAT is available at www.planningtools.transportation.org/551/rapid-policy-analysis-tool.html

[12] For the latest information about STOPS, and to obtain the latest software and documentation, please visit www.transit.dot.gov/funding/grant-programs/capital-investments/stops

webinar presentations by private and public transportation professionals over the course of the programs (2007-2016).[13]

Travel Forecasting Resource (TFR) is the long-term home of the community that produced the aforementioned TRB Special Report 288. TFR's website includes a curated resource library with documents and webinar recordings, an active user forum, and information on their annual Innovations in Travel Modeling Conference.[14]

The Victoria Transport Policy Institute (VTPI) is an independent think tank in Victoria, British Columbia. VTPI regularly publishes white papers, topical policy analyses, and evaluation references for free. Their website houses the Online TDM Encyclopedia, a comprehensive resource for travel modeling information.[15]

Advanced TDM Resources

For those interested in expanding their modeling capacity beyond trip-based and simplified methods, the following documents provide guidance and instruction in activity-based modeling.

Activity-Based Travel Models: A Primer (FHWA 2015) is a report prepared by FHWA and AASHTO to serve as a practical guide for understanding activity-based travel modeling, and considerations applying this kind of modeling to transportation system planning.[16]

A Self Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models (Koppelman and Bhat 2006) is a manual written for the Federal Transit Administration. It instructs the reader in the fundamentals of discrete choice probabilistic modeling, as well as model construction using recommended software.[17]

[13] Transportation Modeling Improvement Portal, https://tmip.org
[14] Travel Forecasting Resource (TFR), https://tfresource.org
[15] VTPI, Online TDM Encyclopedia, www.vtpi.org.
[16] FHWA, https://planningtools.transportation.org/files/108.pdf
[17] Koppelman and Bhat, www.caee.utexas.edu/prof/bhat/COURSES/LM_Draft_060131Final-060630.pdf