CMAQ Emissions Calculator Toolkit

Documentation of Emissions Data for the Telework Tool

This document supplements the User Guide for the Telework Tool in the Congestion Mitigation and Air Quality Improvement Program Emissions Calculator Toolkit (CMAQ Toolkit). It discusses the primary data sources and how the emissions datasets for the Telework Tool were derived. Emission estimates from the CMAQ Toolkit are not intended to meet specific requirements for State Implementation Plans (SIPs) or transportation conformity analyses.

The document details the emissions data obtained from the U.S. Environmental Protection Agency's (EPA) MOtor Vehicle Emissions Simulator (MOVES)[1] for passenger vehicles. The MOVES Methodology section describes the specific inputs, outputs, and post-processing that were used to generate the national-scale emission rates used within the tool.

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[1] US Environmental Protection Agency, Office of Transportation and Air Quality, https://www.epa.gov/moves.

U.S. Department of Transportation
Federal Highway Administration

EMISSION RATE SUMMARY

Telework programs reduce overall passenger vehicle miles traveled (VMT) by allowing employees to work from home instead of commuting to a place of work. The tool allows the user to input the commuting mode breakdown before and after a telework program is implemented. These inputs help to capture possible mode shift effects of the increased flexibility offered by teleworking. For more information on the effects of telework programs on mode shift, please see Appendix A of the User Guide.

SOV's and carpool vehicles both use the same MOVES default-scale run passenger vehicle data, while emissions from biking/walking and transit are assumed to be zero. Forms of mass transit such as subway or transit bus are assumed to operate at the same rate before and after the telework program is implemented, so no new emissions are generated by a shift in ridership to transit modes. If a telework program is expected to result in a sufficient increase in transit ridership to require expanded service or additional vehicle, please refer to the Transit Service Expansion module of the CMAQ Toolkit (see Table 1).

Emission reductions in this tool are calculated from the reduction in VMT and starts for single-occupancy passenger vehicles (SOV's). The share of employees that participate in a carpool (as entered by the user) are converted to the total number of SOV's diverted based on the average vehicle occupancy (AVO). The tool assumes that the average number of people in a carpool is two, including the driver.[2]

For a more detailed explanation of the emission reduction calculations in the Telework Tool, please refer to the User Guide. Note that the CMAQ Toolkit includes tools that allow users to complete a more detailed analysis of projects related to the commuting modes considered in the Telework Tool.[3] These related tools, as well as the emission rate sources for each mode in the Telework Tool, are summarized in Table 1 below.

Table 1. Emission rate source by mode

Mode	Emission Rate Source	Related CMAQ Tool[4]
Single-occupancy vehicle	MOVES3 Default-Scale Run (Passenger Vehicles)	NA
Carpool	MOVES3 Default-Scale Run (Passenger Vehicles)	Carpooling and Vanpooling
Transit	Assumed to be zero	Transit Bus Service and Fleet Expansion
Bike/Walk	Assumed to be zero	Bicycle and Pedestrian Improvements

[2] U.S. Census Bureau Private Vehicle Occupancy for Workers 16 years and over (2000)

[3] For example, to calculate emissions reductions from an increase in transit service, use the Transit Bus Service and Fleet Expansion Tool.

[4] All CMAQ Tools may be found at Toolkit - CMAQ - Air Quality - Environment - FHWA (dot.gov).

MOVES METHODOLOGY

The emissions reduction calculations for the Telework Tool rely on running, start, evaporative, and crankcase exhaust emission rates as well as default-scale[5] activity rates within MOVES. MOVES3.0.3 (version from January 2022)[6] was used to obtain the emission rates used in the tool. The MOVES emission rates for passenger vehicles are viewable in the tool by unhiding the 'PV_EmissionRates' tab. The emission rates worksheets can be viewed by right-clicking on one of the worksheet tabs, selecting *Unhide*, and then selecting the tab.

Default-Scale MOVES Parameters

A default-scale run was conducted in MOVES to generate national passenger-vehicle emissions, activity, and emission rates. Table 2 details the inputs to this default-scale run.

Table 2. Default-Scale Run Parameters

Categories	Variable	Input
Description	-----	<blank>
Scale (1/3)	Model	Onroad
Scale (2/3)	Domain/Scale	Default
Scale (3/3)	Calculation Type	Inventory
Time Spans (1/5)	Time Aggregation Level	Year
Time Spans (2/5)	Years	[2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040]
Time Spans (3/5)	Months	All Selected
Time Spans (4/5)	Days	All Selected
Time Spans (5/5)	Hours	All Selected
Geographic Bounds	-----	No Selection Needed
Onroad Vehicles	Fuels	All Selected
	Source Use Types	Passenger Car, Passenger Truck
Road Type	Road Types	All Selected
Pollutants and Processes (selected)	Total Gaseous Hydrocarbons	All Selected
	Non-methane Hydrocarbons	All Selected
	Volatile Organic Compounds	All Selected
	Methane (CH_4)	All Selected
	Carbon Monoxide (CO)	All Selected
	Oxides of Nitrogen (NOx)	All Selected
	Primary Exhaust PM2.5 – Total	All Selected
	[+] Primary Exhaust PM2.5 - Species	Running Exhaust, Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust

[5] MOVES3 uses the term "default-scale" to refer to what was previously called "national-scale". To maintain consistency, this document will use "default-scale" throughout.

[6] EPA, https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves

Categories	Variable	Input
	Primary PM2.5 – Brakewear Particulate	All Selected
	Primary PM2.5 – Tirewear Particulate	All Selected
	Primary Exhaust PM10 – Total	All Selected
	Primary PM10 – Brakewear Particulate	All Selected
	Primary PM10 – Tirewear Particulate	All Selected
	Total Energy Consumption	All Selected
	Atmospheric CO_2	All Selected
	CO_2 Equivalents	All Selected
General Output	Units	Mass: kilograms, Energy: Million BTU, Distance: miles
	Activity	All Selected
	Output Aggregation	Time: Year, Geographic: Nation
Output Emissions Detail	For All Vehicle/Equipment Categories	Model Year, Fuel Type, Emission Process
	Onroad	Road Type, Source Use Type, Regulatory Class
Create Input Database	Domain Input Database	<blank>
Advanced Features	Time Aggregation	Hour
	Region Aggregation	Nation

Post-MOVES Run Data Processing

Results from the default-scale MOVES run were utilized to obtain different categories of data for use in this tool. The following descriptions are of the MOVES activity and emissions inventory data used in the tool:

1. **Activity rates –** To obtain default-scale activity rates, vehicle population and miles traveled were extracted from the results for passenger vehicles. Populations were used to compute MOVES default estimates of miles traveled per vehicle.
2. **Emissions associated with Vehicle Miles Traveled –** Emission rates were generated on a per-mile basis. This involved joining emission inventories from the movesoutput table and activity from the movesactivityoutput table.

For this tool, emission rates for passenger vehicles are the aggregate of rates for gasoline and diesel passenger car and passenger trucks across all model years. Thus, passenger vehicle emission rates in a telework program are defined by evaluation year, pollutant, and emissions process. These composite passenger vehicle emission rates use default MOVES distributions for source type, fuel type, and model year. Users interested in controlling those parameters can generate and import their own local emission rates, as described in the last section of this document.

Telework projects are expected to reduce the overall VMT of passenger vehicles in the affected area. Off-network idling activity and emissions from evaporative processes from vehicles on-network are projected to decrease as a result of the reduced VMT. The tool includes emissions from off-network idling activity and evaporative emissions from certain MOVES process types on certain road types. The emission processes and associated road types included are displayed in Table 3 below.

Table 3. Emission processes and associated road types

MOVES processid's	MOVES roadtypeid's
• 11 (Evaporative Permeation) • 12 (Evaporative Fuel Vapor Venting) • 13 (Evaporative Fuel Leaks)	• 2 (Rural Restricted Access) • 3 (Rural Unrestricted Access) • 4 (Urban Restricted Access) • 5 (Urban Unrestricted Access)
• 1 (Running Exhaust) • 2 (Start Exhaust) • 9 (Brakewear) • 10 (Tirewear) • 15 (Crankcase Running Exhaust) • 16 (Crankcase Extended Idle Exhaust) • 18 (Refueling Displacement Vapor Loss) • 19 (Refueling Spillage Loss)	• All Road Types

USER-SUPPLIED EMISSION RATES

Some users may be interested in incorporating local data into the tool, which is based on default-scale MOVES runs. For those unfamiliar with developing local MOVES runs, please refer to EPA's mobile-source emissions modeling guidance and documentation for highway vehicles. This section provides basic instructions on how to import local emission rates into the Telework Tool.

Develop Local Emissions Inventories in MOVES

Using the default-scale run parameters listed in the table above, develop local emission rates. The CMAQ Toolkit is not prescriptive about which MOVES inputs are derived from local data. Users must only specify the same output parameters and details as the default-scale run. Complete any local MOVES runs for the selected calendar years and any other parameters listed above.

Import Local Emissions Rates

Users may take the following steps to replace passenger vehicle emission rates in the Telework Tool:

1. The MOVES output needs to be reformatted so that it can be used in the tool:
   - Unhide the 'PV_EmissionRates' tab in Excel and ensure that the new user-supplied, local emissions output has the same fields: yearID, pollutantID, and processID.
   - To post-process the new emission rates output from MOVES, join the movesoutput and movesactivityoutput tables using yearID, pollutantID, and processID and then should create

columns for vehicle miles traveled (VMT), population, miles per vehicle, starts, and starts per vehicle. Define units as appropriate. To include emissions from off-network idling activity and evaporative emissions, the following processes should be included in the movesoutput table:
    - processID 11, 12, and 13 on roadTypeID 2, 3, 4, and 5.
    - processID 1, 2, 9, 10, 15, 16, 18, and 19 on roadTypeID 1, 2, 3, 4, and 5.
- Include PM from brakewear and tirewear in the total particulate matter emissions. For PM10, change pollutantID 106 and 107 to 100. For PM2.5, change pollutantID 116 and 117 to 110. Also, the brakewear and tirewear processes should be labeled as a running exhaust process. Therefore, change processIDs 9 and 10 to 1.
- Similarly, set crankcase running exhaust processes to running exhaust and crankcase start exhaust processes to start exhaust. For crankcase running exhaust, processID 15 is changed to 1, and for crankcase start exhaust, processID 16 is changed to 2.
- Sum emissions inventory for light-duty passenger vehicles (sourceTypeID 21 and 31) where processID, pollutantID, and yearID are the same. This will create a set of composite rates for processIDs 1 and 2 for each pollutant in the table above, and for each calendar year selected during the MOVES runs. Include a column in the final output table for these inventories.
- Similarly, sum the distance traveled, the population of, and the number of starts for the entire fleet of light duty passenger vehicles in each year run in MOVES. This will create a value for total distance traveled, total population, and a total number of starts in each year by the fleet.
- Emission rates are calculated for the running exhaust (processID 1) by dividing the emissions inventory by the VMT for each combination of yearID, processID, and pollutantID. Emission rates are calculated for the start exhaust (processID 2) by dividing the emissions inventory by the number of starts made by the fleet of vehicles.
- Miles per vehicle are calculated by dividing vehicle miles traveled by the population. Starts per vehicle are calculated by dividing the number of starts in a year by the population in that year.

2. The local MOVES data should now be structured and labelled in exactly the same way as the national default data initially used in the tool. Export the local emission rates in .csv or .xlsx file format.
3. Delete any data in the 'PV_EmissionRates' tab and then copy and paste the local emission rates into the existing worksheet. Save the Telework Tool under a different name and verify that the tool yields new, expected results with the local data.