CMAQ Emissions Calculator Toolkit

Documentation of Emissions Data for the Traffic Flow Improvements Tool

This document supplements the User Guide for the Traffic Flow Improvements Tool in the Congestion Mitigation and Air Quality Improvement Program Emissions Calculator Toolkit (CMAQ Toolkit). It discusses this tool's primary data sources and the derivation of its emissions datasets.

The document highlights the emissions data obtained from the US Environmental Protection Agency's (EPA) Motor Vehicle Emissions Simulator (MOVES).[1] The MOVES Methodology section describes the specific inputs, outputs, and post-processing used to generate the tool's national-scale emission rates.

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

MOVES METHODOLOGY

MOVES3 project-level runs were used to determine running and idling emission rates at different speeds across varying road types for this tool. MOVES runs for the Traffic Flow Improvements Tool include speeds of 0 to 75 miles per hour (mph) in one-mph intervals. Project-level links were created to correspond to the road type and speed. Note that each MOVES 3-digit linkID was formed by concatenating roadTypeID (first digit) and speed in mph (subsequent two digits) – for example, 335 indicates roadType 3 (urban unrestricted) and 35 mph.

In order to run MOVES at the project level, some national-scale runs, as described in Table 1, were completed first so that default data could be used as inputs for the project-scale runs, laid out in Table 2a, in order to differentiate emission rates by average speed. The national defaults used as inputs for the Project Data Manager, are documented in Table 2b.

Table 1: National-Scale Run Specifications

Category	Variable	Input
Description	-----	<blank>
Scale	Model	ONROAD
	Domain/Scale	Default
	Calculation Type	Inventory
Time Spans	Years	[2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040]
	Months	All Selected
	Days	All Selected
	Hours	All Selected
Geographic Bounds	-----	No Selection Needed
Vehicles/Equipment	On-Road Vehicle Equipment	All Selected
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
	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
	Primary PM2.5 – Brakewear Particulate	All Selected
	Primary PM2.5 – Tirewear Particulate	All Selected
	Primary Exhaust PM10 – Total	All Selected

Category	Variable	Input
	Primary Exhaust PM10 – Species	All Selected
	Primary PM10 – Brakewear Particulate	All Selected
	Primary PM10 – Tirewear Particulate	All Selected
	Carbon Dioxide Equivalent (CO_2e)	All Selected
	Total Energy Consumption (TEC)	All Selected
	Atmospheric CO_2	All Selected
	Select Prerequisites	All Selected
General Output	Units	Mass: Kilograms, Energy: Million BTU, Distance: Miles
	Activity	All Selected
Output Emissions Detail	Output Aggregation	Year, Nation
	On Road	Road Type, Source Use Type
	For All Vehicle/Equipment Combinations	Model Year, Fuel Type, Emission Processes
Advanced Features	Time Aggregation	Hour
	Region Aggregation	Nation

Users that are importing their own emission rates do not need to complete national-scale runs if they have all the local data necessary for project-level analysis. The generic parameters used in project-scale runs can be found in Table 2a. Further guidance on developing local rates is available in the User-Supplied Emission Rates section contained in this document.

Table 2a: Project-Scale Run Specifications

Category	Variable	Input
Description	-----	<blank>
Scale	Model	Onroad
	Domain/Scale	Project
	Calculation Type	Inventory
Time Spans	Time Aggregation Level	Year
	Years[2]	2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040
	Months	January
	Days	Weekday

[2] To avoid an excessively large output database, each evaluation year was run individually and results were placed in separate output databases.

Category	Variable	Input
	Hours	00:00 – 00:59
Geographic Bounds	Selections:	Middlesex County, MA (25017)
Vehicles/Equipment	On-Road Vehicle Equipment	All Vehicle Source Types
Fuel Type	-----	All Combinations
Road Type	Road Types	All Road Types
Pollutants and Processes (selected)	Total Gaseous Hydrocarbons	Running Exhaust, Crankcase Running Exhaust, Start Exhaust, Crankcase Start Exhaust, Evap Permeation, Evap Fuel Leaks, Refueling Displacement Vapor Loss, Refueling Spillage Loss
	Non-methane Hydrocarbons	Running Exhaust, Crankcase Running Exhaust, Start Exhaust, Crankcase Start Exhaust, Evap Permeation, Evap Fuel Leaks, Refueling Displacement Vapor Loss, Refueling Spillage Loss
	Volatile Organic Compounds	Running Exhaust, Crankcase Running Exhaust, Start Exhaust, Crankcase Start Exhaust, Evap Permeation, Evap Fuel Leaks, Refueling Displacement Vapor Loss, Refueling Spillage Loss
	Methane (CH4)	Running Exhaust, Crankcase Running Exhaust, Start Exhaust, Crankcase Start Exhaust
	Carbon Monoxide (CO)	Running Exhaust, Crankcase Running Exhaust, Start Exhaust, Crankcase Start Exhaust
	Oxides of Nitrogen (NOx)	Running Exhaust, Crankcase Running Exhaust, Start Exhaust, Crankcase Start Exhaust
	Nitrous Oxide (N2O)	Running Exhaust, Crankcase Running Exhaust, Start Exhaust, Crankcase Start Exhaust
	Primary Exhaust PM2.5 – Total	Running Exhaust, Crankcase Running Exhaust, Start Exhaust, Crankcase Start Exhaust
	Primary Exhaust PM2.5 – Species	Running Exhaust, Crankcase Running Exhaust, Start Exhaust, Crankcase Start Exhaust
	Primary PM2.5 – Brakewear Particulate	Brakewear
	Primary PM2.5 – Tirewear Particulate	Tirewear

Category	Variable	Input
	Primary Exhaust PM10 – Total	Running Exhaust, Crankcase Running Exhaust, Start Exhaust, Crankcase Start Exhaust
	Primary PM10 – Brakewear Particulate	Brakewear
	Primary PM10 – Tirewear Particulate	Tirewear
	Total Energy Consumption	Running Exhaust, Start Exhaust
	Atmospheric CO2	Running Exhaust, Start Exhaust
	CO2 Equivalent	Running Exhaust, Start Exhaust
General Output	Units	Mass: kilograms, Energy: million BTU, Distance: miles
	Activity	All Selected
Output Emissions Detail	Output Aggregation	<blank>
	For All Vehicle/Equipment Categories	Model Year, Fuel Type, Emission Process
	Onroad	Road Type, Source Use Type, Regulatory Class
	Nonroad	<blank>
Advanced Performance Features	-----	<blank>

Considering that the MOVES project-scale runs utilized a series of inputs from the national-scale runs outlined above and from the MOVES default database, the data entered into each Project Data Manager tab has been recorded in Table 2b.

Table 2b. Project Data Manager – Inputs by Tab

Data	Source
Age Distribution	Adopted MOVES3 age distributions for all evaluation years from 2018 through 2040 (taken from sourcetypeagedistribution table in movesdb20210726 database)
AVFT	Used default tables for each run
Fuel Formulation	Used default tables for each run
Fuel Supply	Used default tables for each run
Fuel Usage Fraction	Used default tables for each run
Generic	---
Hotelling	---
I/M Programs[3]	Used imcoverage table from movesexecution database in default-scale inventory run for all evaluation years (2018 through 2040)
Links	Customized input with the following data: • linkID: roadTypeID concatenated with linkAvgSpeed (i.e., 200, 201, 202… 275)

[3] Inspection and Maintenance Programs. Note that default-scale MOVES runs were used to populate the I/M Program table, as it is not populated in the MOVES default database. If needed, please follow the parameters in Table 1 for the default-scale runs.

	• countyID: 25017 • zoneID: 1 • roadTypeID: 2, 3, 4, 5 • linkLength: equal to linkAvgSpeed (except when 0 mph, then equal to 1 mile) • linkVolume: 1000 • linkAvgSpeed: 0 through 75 mph (repeated for all four road types) • linkDescription: --- • linkAvgGrade: 0
Link Source Type	Customized input with the following data: • linkID: 200-275, 300-375, 400-475, 500-575 • sourceTypeID: all 13 types • sourceTypeHourFraction: normalized values from movesactivityoutput table in default-scale inventory run for all years 2018-2040 of vehicle miles traveled by source type over the total vehicle miles traveled on a given road type (source type fractions sum to 1 by road type)
Meteorological Data	Used default tables for each run
Off-Network	For all source types: • Vehicle Population: 4 • Start Fraction: 0.5 • Extended Idle Fraction: 0 • Parked Vehicle Fraction: 0.5
Operating Mode Distribution	Data from default-scale inventory run described previously
Retrofit Data	---
Tools	---

Users supplying their own emission rates do not need to follow the default inputs used in the Project Data Manager above and can develop the necessary project-level inputs from an analysis of local data. Guidance for developing local rates follows.

Post-MOVES Run Data Processing

Results from the project-level MOVES runs described above were used to obtain different categories of data for use in the Traffic Flow Improvements Tool. The following section describes how MOVES activity and emissions inventory data were used to develop the tool's emissions rates.

Light- and heavy-duty vehicle emission rates were calculated separately using otherwise identical procedures: light-duty rate aggregate output for passenger vehicles and light commercial trucks (sourceTypeID 21, 31, and 32); heavy-duty rate aggregate output for the various types of buses, single unit trucks, and combination trucks (all sourceTypeIDs greater than 40). Brake and tire wear were aggregated into the particulate matter (PM) results for both sets of rates.

1. **Activity rates –** To obtain project-level activity rates, the distance travelled (activityTypeID 1) was extracted from the results for all vehicles.

2. **Hourly emissions –** Emission rates were generated on a per-mile basis. This involved joining emission inventories from the movesoutput table and activity from the movesactivityoutput. To determine emission rates, emissions (aggregated across all processes) were divided by distance travelled.

Emission rates are based on project evaluation year, speed, pollutant, and road type.

Once the MOVES project-level run completed for a given project year, the 'movesactivityoutput' table was retrieved to obtain the source hours operating activity. The emissions quantity found in the 'movesoutput' table of the output database is divided by the value of source hours operating for a given vehicle, pollutant, on a given road type, to determine idling emission rates in kg/hr. These idling emission rates serve as the emission rates used in the Intersection Improvements and Roundabouts modules of the Traffic Flow Improvements tool.

USER-SUPPLIED EMISSION RATES

Some users may wish to incorporate local data into the tool's emission rates. For those unfamiliar with developing local MOVES runs, please refer to EPA's mobile-source emissions modeling guidance and documentation for highway vehicles.[4] Take the following steps to replace default emission rates in the Traffic Flow Improvements Tool:

1. The MOVES output data needs to be reformatted so that it can be used in the tool. The details on post processing this output are described below:
    - Unhide the 'emissionsRates' tab in Excel and ensure that the MOVES output has the following parameters: *yearID, pollutantID, linkID, speed, and roadTypeID*. As noted earlier, the linkID is concatenated from the roadTypeID (one digit) and speed (2 digits) ranging between 0 and 75 miles per hour. For light-duty emission rates, post-processed data should include only passenger cars (sourceTypeID 21), passenger trucks (sourceTypeID 31), and light commercial trucks (sourceTypeID 32). For heavy-duty emission rates, post-processed data should include all buses (sourceTypeID, 41, 42, and 43), single unit trucks (sourceTypeID 51, 52, 53, and 54), and combination trucks (sourceTypeID 61 and 62).

      Note that light-duty and heavy-duty rates are separated by 'classID', where classID 1 denotes light-duty and classID 2 denotes heavy-duty. These values are assigned during the post-processing of emissions rates. Assign heavy and light duty rates to the appropriate classifications.
    - From a local MOVES run, aggregate the emission quantities in the movesoutput table by year, pollutant, speed, and road type.
    - Incorporate brakewear and tirewear PM emissions in total PM emissions. For PM10 emissions, change pollutantIDs 106 and 107 to 100. For PM2.5, change pollutantIDs 116 and 117 to 110.
    - After these pollutantIDs have been changed, sum the emission quantities again to ensure a unique combination of fields exist in the post-processed data.

[4] EPA, https://www.epa.gov/moves/tools-develop-or-convert-moves-inputs

- Extract vehicle miles traveled (VMT) from the movesactivityoutput table (activityTypeID 1) by year, speed, and road type.
- Separately merge the emission inventories from the movesoutput table and the VMT estimates from the movesactivityoutput table using year and link for light-duty and heavy-duty vehicles by the source type filters indicated in the table.
- Include a column in the post-processed data for each emission rate. Emission rates are calculated by dividing emission quantity by VMT or by source hours operating for each unique combination of year, pollutant, and link.
- Be sure to define unit columns where appropriate, namely massUnits (kg), time units (hr), distanceUnits (mi), and rateUnits (kg/mi, kg/hr).

The local MOVES output data should now be structured and labeled in exactly the same way as the national default output data initially used in the tool. Export the post-processed local emission rates in .csv or .xlsx file format, one for light-duty vehicles and another for heavy-duty vehicles.

2. Delete any data (keep the title of the columns the same) in the tool's existing rates tab and then copy and paste the appropriate exported local emission rates into the existing worksheet with the same table format. Save the Traffic Flow Improvements Tool under a different name and verify that it produces expected results with local emission rates.