CMAQ Emissions Calculator Toolkit

Documentation of Emissions Data for the Alternative Fuel Vehicles and Infrastructure Tool

This document serves as a supplement to the documentation for the Alternative Fuel Vehicles and Infrastructure Tool in the Congestion Mitigation and Air Quality Improvement Program Emissions Calculator Toolkit (CMAQ Toolkit), specifically for the On-Road Alternative Fuel Vehicle Fleet Purchase & Restricted Access Alternative Fuel Infrastructure and Unrestricted Access Alternative Fuel Infrastructure modules. It discusses the primary sources and how the emissions datasets for these calculators were derived. Emission estimates from the CMAQ Toolkit are not intended to meet specific requirements for State Implementation Plans (SIPs) or transportation conformity analyses.

Contents

MOVES METHODOLOGY 1

National-Scale Run 2

AFLEET METHODOLOGY 4

USER-SUPPLIED EMISSION RATES 5

MOVES METHODOLOGY

The emission reductions calculators for the Alternative Fuels tool rely on running exhaust and start exhaust emissions rates as well as national-scale activity rates within MOVES. Extended idling and auxiliary power unit emissions are considered only for any alternative fuel vehicle replacements of long-haul combinations trucks. The most recent version of this tool includes emissions per mile driven from off-network idling vehicle activity, as well as evaporative emissions.

The rates were obtained with a set of MOVES runs in which all evaluation years were combined together into a single MOVES run, and were generated on the national scale. MOVES3[1] was used to obtain the emission rates used in the tool.

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

National-Scale Run

The National-Scale Run used to obtain emission rates was set up with the following parameters:

Table 1 National-scale run parameters

Category	Variable	Input
Description	-----	<blank>
Scale	Model	Onroad
	Domain/Scale	National
	Calculation Type	Inventory
Time Spans	Time Aggregation Level	Year
	Years	[2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2034, 2035, 2036, 2037, 2038, 2039, 2040]
	Months	All Selected
	Days	All Selected
	Hours	All Selected
Geographic Bounds	-----	Nation
Vehicles/Equipment	On-Road Vehicle Equipment	All Fuel/Type Combinations Selected
Road Type	Road Types	All Selected
Pollutants and Processes (selected)	Total Gaseous Hydrocarbons	Running Exhaust, Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust
	Non-methane Hydrocarbons	Running Exhaust, Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust
	Volatile Organic Compounds	Running Exhaust, Start Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust
	Carbon Monoxide (CO)	Running Exhaust, Start Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust
	Oxides of Nitrogen (NOx)	Running Exhaust, Start Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust
	Primary Exhaust PM2.5 – Total	Running Exhaust, Start Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust
	Primary PM2.5 – Brakewear Particulate	Brakewear

Category	Variable	Input
	Primary PM2.5 – Tirewear Particulate	Tirewear
	Primary Exhaust PM10 – Total	Running Exhaust, Start Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust
	Primary PM10 – Brakewear Particulate	Brakewear
	Primary PM10 – Tirewear Particulate	Tirewear
	Carbon Dioxide (CO_2) Equivalent, includes CO_2, Nitrous Oxide (N_2O), and Methane (CH_4)	Running Exhaust, Start Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust
	Total Energy Consumption	Running Exhaust, Start Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust
Manage Input Data Series	-----	<blank>
Strategies	Rate of Progress	<blank>
General Output	Units	Mass: kilograms, Energy: Million BTU, Distance: miles
	Activity	Distance Traveled, Population, Starts
Output Emissions Detail	Always	Year, Nation
	On Road/Off Road	Road Type, Source Use Type
	For All Vehicle/Equipment Combinations	Model Year, Fuel Type, Emission Process
Advanced Performance Features	-----	<blank>

Post-MOVES Run Data Processing:

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

1. **Activity rates –** To obtain national-scale activity rates, vehicle population and miles traveled were extracted from the results for all light-duty and heavy-duty 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 meant joining emission inventories from the movesoutput table and activity from the movesactivityoutput table. Since the AFLEET alternative fuel factors were developed over all vehicle operations (start, running, and idling and APU where applicable), the emission rates were not broken out by process. The aggregated emission results were then divided by the corresponding activity results to develop a table of emission rates in kilograms per mile.

For the Fleet Purchase and Restricted Access Infrastructure module, emission rates have primary keys of evaluation year, pollutant, model year, source type, and fuel type. For the Unrestricted Access Infrastructure module, emission rates were aggregated across all model years. Therefore, Unrestricted Access Infrastructure rates were keyed off evaluation year, pollutant, source type, and fuel type.

Emissions from the Restricted Access Infrastructure component include evaporative emissions from certain MOVES process types on certain road types since total emission reductions are based solely on the change in VMT driven as a result of the construction of the new facility. These evaporative processes include:

1) Processes 11, 12, and 13 on road types 2, 3, 4 and 5.
2) Processes 18 and 19 on all road types.

Emissions from the Fleet Purchase component and the Unrestricted module include evaporative emissions on all road types and for all processes.

AFLEET METHODOLOGY

The Alternative Fuel Emission Factor Multipliers from AFLEET 2020's Background Data tab were simply copied and pasted into this CMAQ tool. Where alternative fuel emission rates were not available in MOVES, alternative fuel factors from AFLEET 2020[2] were applied to default conventional fuel emission rates depending on vehicle source use type and pollutant. As included in the tool's other documentation, Table 2 below presents a matrix of alternative fuel types and vehicle source types and indicates whether the emissions data for each combination has come from MOVES directly or from AFLEET-adjusted conventional fuel emission rates. Combinations without emissions data are left blank. Note that all battery electric vehicles are included in a separate tool, the Electric Vehicle (EV) Fleet Purchase and EV Charging Infrastructure Tool.

Table 2 Vehicle source type-alternative fuel type combinations in tool

	Dual Fuel	B100	B20	CNG	E85	FCV	HEV	HHV	LNG	LPG
Passenger Car		A	A	A	M	A	A		A	A
Passenger Truck		A	A	A	M	A	A		A	A
Light Commercial Truck		A	A	A	M	A	A		A	A
School Bus		A	A	M	A	A	A	A	A	A
Refuse Truck	A	A	A	M		A	A	A	A	
Single Unit Short-haul Truck	A	A	A	M	A	A	A	A	A	A
Single Unit Long-haul Truck	A	A	A	M	A	A	A	A	A	A
Combination Short-haul Truck	A	A	A	M		A	A	A	A	
Combination Long-haul Truck	A	A	A	A		A	A	A	A	

[2] DOE, https://greet.es.anl.gov/afleet

M = MOVES emission rates, A = AFLEET factors combined with conventional fuel emission rates

It is also important to denote AFLEET's baseline conventional fuels to appropriately estimate alternative fuel vehicle emissions. Generally, AFLEET alternative fuel factors for light-duty vehicles were based on gasoline emission rates and factors for heavy-duty vehicles were based on diesel emission rates. As summarized in Table 3, sourceTypeID 21, 31, and 32 use baseline gasoline rates and sourceTypeID 43 and above use baseline diesel rates. As noted in the user guides, the alternative fuel vehicles with emission rates sourced from MOVES directly, as well as FCVs of all source types, will produce output for CO_2, CO_2e, and TEC, whereas all other alternative fuel vehicles will report "N/A" for greenhouse gases and energy. FCVs, like electric vehicles, have zero tailpipe emissions and only generate emissions for particulate matter from brakewear and tirewear.

Table 3 Vehicle source type and baseline conventional fuel for AFLEET factor

sourceTypeID	Vehicle Source Type	AFLEET Baseline Fuel
21	Passenger Car	Gasoline
31	Passenger Truck	Gasoline
32	Light Commercial Truck	Gasoline
43	School Bus	Diesel
51	Refuse Truck	Diesel
52	Single Unit Short-haul Truck	Diesel
53	Single Unit Long-haul Truck	Diesel
61	Combination Short-haul Truck	Diesel
62	Combination Long-haul Truck	Diesel

USER-SUPPLIED EMISSION RATES

Some users may be interested in incorporating local data into the tool's emission rates, which are originally based on national-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.[3] This section provides basic instructions on how to import local emission rates into the Alternative Fuels Tool.

Import Local Emissions Rates for Fleet Purchase and Restricted Access Infrastructure Module

Users may take the following steps to replace emission rates in the fleet purchase and restricted infrastructure alternative fuels projects module:

1. Using the national alternative fuel run parameters listed in Table 1, develop local emission rates. The CMAQ Toolkit is not prescriptive about which MOVES inputs are derived from local data, however users must specify the same output parameters and details as those listed in Table 1.

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

Complete local MOVES simulations for the calendar years shown in Table 1 individually, as local MOVES runs can only be performed for a single year input.

2. The MOVES output needs to be reformatted so that it can be used in the tool, as described below for the emissions rates associated with fleet purchase projects:

    - Unhide the 'purchaseEmissionsRates' tab in Excel and ensure that the new user-supplied local emissions output has the same fields: yearID, pollutantID, modelYearID, sourceTypeID, fuelTypeID.
    - To post-process the new emission rates output from MOVES, users should join the movesoutput, and movesactivityoutput tables using yearID, pollutantID, modelYearID, sourceTypeID, fuelTypeID and then create columns for vehicle miles traveled (VMT) and population. Define units as appropriate.
    - Include emissions for all source types except motorcycles, motor homes, and buses. However, do include school buses in the post-processed emission rates.
    - Include emissions from the following pollutants in the post-processed data: CO, NOx, VOC, CO_2, TEC, CO_2eq, and all particulate matter emissions.
    - 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.
    - Sum the emissions inventory for the included source vehicles where yearID, modelYearID, pollutantID, sourceTypeID, fuelTypeID, roadTypeID, processID are the same. This will create a set of composite rates for each unique combination of values in these fields.
    - Extract vehicle miles traveled (activityTypeID 1) for the relevant sources from the movesactivityoutput table and include these activity rates in the VMT column in the final post-processed data.
    - Extract vehicle populations (activityTypeID 6) for the relevant sources from the movesactivityoutput table and include these activity rates in the population column of the post-processed data table.
    - Include a column for miles traveled per vehicle in each entry. Miles per vehicle is calculated by dividing VMT by the population in each entry.
    - Include a column for emission rate in each entry. Emission rates are calculated by dividing the emissions inventory by the VMT in each entry.
    - Hydrogen fuel cell vehicles (FCV) do not produce any tailpipe emissions and therefore are not represented in MOVES output data. However, they will generate particulate matter from brakewear and tirewear. Select brakewear and tirewear PM rates from gasoline light-duty vehicles (sourceTypeID 21, 31, and 32) and diesel heavy-duty vehicles (sourceTypeID 42, 43, 51, 52, 53, 61, and 62), and add to the post-processed data table as the total PM rates for electric vehicles (fuelTypeID 9).

    The local MOVES data should now be structured and labelled in exactly the same way as the national default data initially provided in the tool. Export the local emission rates in .csv or .xlsx file format.

3. To generate emission rates associated with restricted infrastructure projects, the MOVES output needs to be post-processed separately from the file developed for the fleet purchase emissions so that it can be used in the tool, as described below:
    - Unhide the 'restrictedEmissionsRates' tab in Excel and ensure that the new user-supplied local emissions output has the same fields: yearID, pollutantID, modelYearID, sourceTypeID, fuelTypeID.
    - To post-process the new emission rates output from MOVES, users should join the movesoutput, and movesactivityoutput tables using yearID, pollutantID, modelYearID, sourceTypeID, fuelTypeID and then create columns for vehicle miles traveled (VMT) and population. Define units as appropriate.
    - Include emissions for all source types except motorcycles, motor homes, and buses. However, do include school buses in the post-processed emission rates.
    - Include emissions from the following pollutants in the post-processed data: CO, NOx, VOC, CO_2, TEC, CO_2eq, and all particulate matter emissions.
    - Include **only** processIDs 11, 12, and 13 on road types 2, 3, 4 and 5 and processIDs 18 and 19 on all road types.
    - 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.
    - Sum the emissions inventory for the included source vehicles where yearID, modelYearID, pollutantID, sourceTypeID, fuelTypeID, roadTypeID, processID are the same. This will create a set of composite rates for each unique combination of values in these fields.
    - Extract vehicle miles traveled (activityTypeID 1) for the relevant sources from the movesactivityoutput table and include these activity rates in the VMT column in the final post-processed data.
    - Extract vehicle populations (activityTypeID 6) for the relevant sources from the movesactivityoutput table and include these activity rates in the population column of the post-processed data table.
    - Include a column for miles traveled per vehicle in each entry. Miles per vehicle is calculated by dividing VMT by the population in each entry.
    - Include a column for emission rate in each entry. Emission rates are calculated by dividing the emissions inventory by the VMT in each entry.
    - Hydrogen fuel cell vehicles (FCV) do not produce any tailpipe emissions and therefore are not represented in MOVES output data. However, they will generate particulate matter from brakewear and tirewear. Select brakewear and tirewear PM rates from gasoline light-duty vehicles (sourceTypeID 21, 31, and 32) and diesel heavy-duty vehicles (sourceTypeID 42, 43, 51, 52, 53, 61, and 62), and add to the post-processed data table as the total PM rates for electric vehicles (fuelTypeID 9).

The local MOVES data should now be structured and labelled in exactly the same way as the national default data initially provided in the tool. Export the local emission rates in .csv or .xlsx file format.

4. Save this as a different copy of the CMAQ Alternative Fuels tool and ensure that the new data yields different results than the national default values.

Import Local Emissions Rates for Unrestricted Infrastructure Module

Similar to the fleet purchase and restricted infrastructure modules, users may take the following steps to replace emission rates in the unrestricted infrastructure module:

1. Using the national alternative fuel run parameters listed in Table 1, develop local emission rates. The CMAQ Toolkit is not prescriptive about which MOVES inputs are derived from local data, however users must specify the same output parameters and details as those listed in Table 1. Complete local MOVES runs for the calendar years shown in Table 1 individually, as local MOVES runs can only be performed for a single year input.

2. The MOVES output needs to be reformatted so that it can be used in the tool, as described below:

    - Unhide the 'unresrictedEmissionsRates' tab in Excel and ensure that the new user-supplies, local emissions output has the same fields: yearID, pollutantID, sourceTypeID, fuelTypeID.
    - To post-process the new emission rates output from MOVES, users should join the movesoutput, and movesactivityoutput tables using yearID, pollutantID, sourceTypeID, and fuelTypeID and then create columns for vehicle miles traveled (VMT) and population. Define units as appropriate
    - Include emissions for all source types except motorcycles, motor homes, and buses. However, do include school buses in the post-processed emission rates.
    - Include emissions from the following pollutants in the post-processed data: CO, NOx, VOC, and all particulate matter emissions.
    - 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.
    - Sum the emissions inventory for the included source vehicles where yearID, pollutantID, sourceTypeID, and fuelTypeID are the same. This will create a set of composite rates for each unique combination of values in these fields.
    - Extract vehicle miles traveled (activityTypeID 1) for the relevant sources from the movesactivityoutput table and include these activity rates in the VMT column in the final post-processed data.

- Extract vehicle populations (activityTypeID 6) for the relevant sources from the movesactivityoutput table and include these activity rates in the population column of the post-processed data table.
- Include a column for miles traveled per vehicle in each entry. Miles per vehicle is calculated by dividing VMT by the population in each entry.
- Include a column for emission rate in each entry. Emission rates are calculated by dividing the emissions inventory by the VMT in each entry.
- Hydrogen fuel cell vehicles (FCV) do not produce any tailpipe emissions and therefore are not represented in MOVES output data. However, they will generate particulate matter from brakewear and tirewear. Select brakewear and tirewear PM rates from gasoline light-duty vehicles (sourceTypeID 21, 31, and 32) and diesel heavy-duty vehicles (sourceTypeID 42, 43, 51, 52, 53, 61, and 62), and add to the post-processed data table as the total PM rates for electric vehicles (fuelTypeID 9).

The local MOVES data should now be structured and labelled in exactly the same way as the national default data initially utilized in the tool. Export the local emission rates in .csv or .xlsx file format.

3. Delete any data in the 'unrestrictedEmissionsRates' tab in the tool and copy and paste the processed local emissions data into the spreadsheet. Save this as a different copy of the CMAQ Alternative Fuels tool and ensure that the new data yields different results than the national default values.