# CMAQ Emissions Calculator Toolkit

## Documentation of Emissions Data for the Bicycle and Pedestrian Improvements Tool

This document supplements the User Guide for the Bicycle and Pedestrian 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 default-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

The Bicycle and Pedestrian Improvements Tool relies on running, start, evaporative, and crankcase exhaust emission rates as well as default-scale[2] activity rates from MOVES3. Vehicular emission rates were obtained with a set of default-scale model runs for years 2018-2040.[3]

## Default-Scale Runs

Three different sets of default-scale runs were conducted to obtain emission rates:

| 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 |
| | Primary Exhaust PM10 – Species | All Selected |
| | Primary PM10 – Brakewear Particulate | All Selected |

[2] Default-scale is MOVES' updated name for what was previously known as national-scale.
[3] EPA, https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves

| Category | Variable | Input |
|---|---|---|
| | 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 |

## Post-MOVES Run Data Processing

Results from the default-scale MOVES runs were utilized to obtain different categories of data for use in this tool:

1. **Activity rates –** MOVES national default activity data was used to produce estimates of vehicle miles traveled for passenger vehicles.
2. **Emission rates –** Per-mile and per-start emission rates over all vehicle operations were generated for passenger vehicles, a combination of passenger cars (sourceTypeID 21) and passenger trucks (sourceTypeID 31) by joining emission inventories from the movesoutput table and activity from the movesactivityoutput table.

Emission rates are based on evaluation year and pollutant. Those provided in the tool are disaggregated by running and start emissions processes, and aggregated over other processes and model parameters, such as model year, fuel type, and road type. Users interested in controlling those parameters can generate and import their own local emission rates, as described in the last section of this document.

Bicycle and pedestrian projects are projected to reduce overall VMT driven by light duty vehicles in the affected area. Because of this, off network idling activity is projected to change as well, in addition to emissions from evaporative processes while vehicles are operating on-network. Vehicles are also projected to reduce the amount of time spent refueling as a result of the reduction of VMT driven, thus reducing refueling evaporative emissions. The most recent version of this tool includes emissions per mile driven from off-network idling vehicle activity, as well as evaporative emissions from certain MOVES process types on certain road types. These evaporative processes include:

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

# USER-SUPPLIED EMISSION RATES

Some users may wish to incorporate local data into the tool's provided 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 Bicycle and Pedestrian Improvements Tool:

1. Re-specify the national run parameters listed in the MOVES Methodology to develop local emission rates. The CMAQ Emissions Calculator Toolkit does not prescribe which MOVES inputs are derived from local data. Users need 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.

2. Reformat the MOVES output so that it can be used in the tool, as described below:
    - Unhide the 'PVEmissionsData' tab in Excel and ensure that the new user-supplied, local emissions output has at least the same fields: yearID, pollutantid, and emissionRate. Codes for the pollutantid field are given below. Note that these fields must use the same column position as the defaults for the tool to function.

| Pollutantid | Pollutant Abbreviation | Pollutant Name |
|---|---|---|
| 2 | CO | Carbon Monoxide |
| 3 | NOx | Oxides of Nitrogen |
| 87 | VOCs | Volatile Organic Compounds |
| 90 | $CO_2$ | Carbon Dioxide |
| 91 | TEC | Total Energy Consumption |
| 98 | $CO_2e$ | Carbon Dioxide Equivalent |
| 110 | $PM_{2.5}$ | Particulate Matter (diameter <= 2.5 µm) |
| 100 | $PM_{10}$ | Particulate Matter (diameter <= 10 µm) |

    - Extract emissions by disaggregating the "movesoutput" table by the output parameters of yearID, pollutantID, and processID. Include only the vehicle source type (21 and 31 for PVEmissionsData) in the post-processed data and ensure that results consist of the running and start emissions, along with crankcase running and crankcase start where available.
    - Select all processIDs except 11, 12, 13 for roadtypeIDs 1, 3, 5. Select processIDs 11, 12, 13 for roadtypeIDs 3, 5.
    - Combine processIDs into "running" and "starts". Combine processID 1, 9, 10, and 15, (running exhaust, brakewear, tirewear, and crankcase running exhaust respectively) as "running", and processID 2, 16 (start exhaust and crankcase start exhaust respectively) as "starts".
    - Combine the particulates from brakewear and tirewear of 10-micron diameters or less (pollutantID 106, and 107, respectively) into the total PM10 (pollutantID 100). Similarly,

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

combine the PM2.5 brakewear and tirewear (pollutantID 116 and 117, respectively) into the total PM2.5 (pollutantID 110). Sum the emission quantities again to integrate the brakewear and tirewear into the total PM estimates.

- Merge the emission estimates from the movesoutput table and the VMT estimates from the movesactivityoutput table using yearID. As noted above, the emissions estimates for each individual pollutant will represent the total of all emissions processes for that pollutant, by year.
- Divide the appropriate emission estimates in kilograms by the VMT or by the number of starts to compute the emission rates per mile or per start in a new column and create three fields for massUnits (kg), distanceUnits (mi), and rateUnits (kg/mi).

The local MOVES data should now be structured and labelled exactly 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 two emissions data tabs and then copy and paste the local emission rates into the existing worksheet. Save the Bicycle and Pedestrian Improvements Tool under a different name and verify that the calculator yields new, expected results with the local data.