

Congestion Mitigation and Air Quality (CMAQ) Improvement Program:

CMAQ Toolkit Overview and Demo

International Emissions Inventory Conference

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CMAQ Background

- FHWA's CMAQ Program was established in 1991 and most recently reauthorized under the FAST Act of 2015 to fund state and local projects that will improve air quality and reduce congestion
 - Granted more than \$2 billion annually over past three years
- CMAQ Toolkit: Suite of simplified, Excel-based tools for estimating emissions benefits

The screenshot shows the FHWA website's navigation and content for the CMAQ Emissions Calculator Toolkit. The top navigation bar includes the FHWA logo, "About Programs Resources Briefing Room Contact Search FHWA", and social media icons. Below this is the "Office of Planning, Environment, & Realty (HEP)" section with tabs for "Planning", "Environment", and "Real Estate". A secondary navigation bar contains "HEP", "Events", "Guidance", "Publications", "Glossary", "Awards", and "Contacts". The main content area is titled "Air Quality" with a sub-header "Congestion Mitigation and Air Quality Improvement (CMAQ) Program". A breadcrumb trail reads "FHWA → Environment → Air Quality → CMAQ". The page features a sidebar with a table of contents including "Laws and Regulations", "Policy and Guidance", "Reference Materials", "Performance Measures", "Emissions Calculator Toolkit", "Research", "Training", "Reporting", and "Other Links". The "Emissions Calculator Toolkit" item is highlighted. The main content area is titled "CMAQ Emissions Calculator Toolkit" and contains introductory text and a table of tools and documentation.

U.S. Department of Transportation
Federal Highway Administration

About Programs Resources Briefing Room Contact Search FHWA

Office of Planning, Environment, & Realty (HEP)

Planning Environment Real Estate

HEP Events Guidance Publications Glossary Awards Contacts

Air Quality

Congestion Mitigation and Air Quality Improvement (CMAQ) Program

Air Toxics CMAQ Conformity It All Adds Up

Laws and Regulations
Policy and Guidance
Reference Materials
Performance Measures
Emissions Calculator Toolkit
Research
Training
Reporting
Other Links

Air Quality Contacts

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FHWA → Environment → Air Quality → CMAQ

CMAQ Emissions Calculator Toolkit

The Federal Highway Administration (FHWA) Office of Natural Environment developed a series of tools to provide technical support and resources for the implementation of the Congestion Mitigation and Air Quality Improvement (CMAQ) Program.

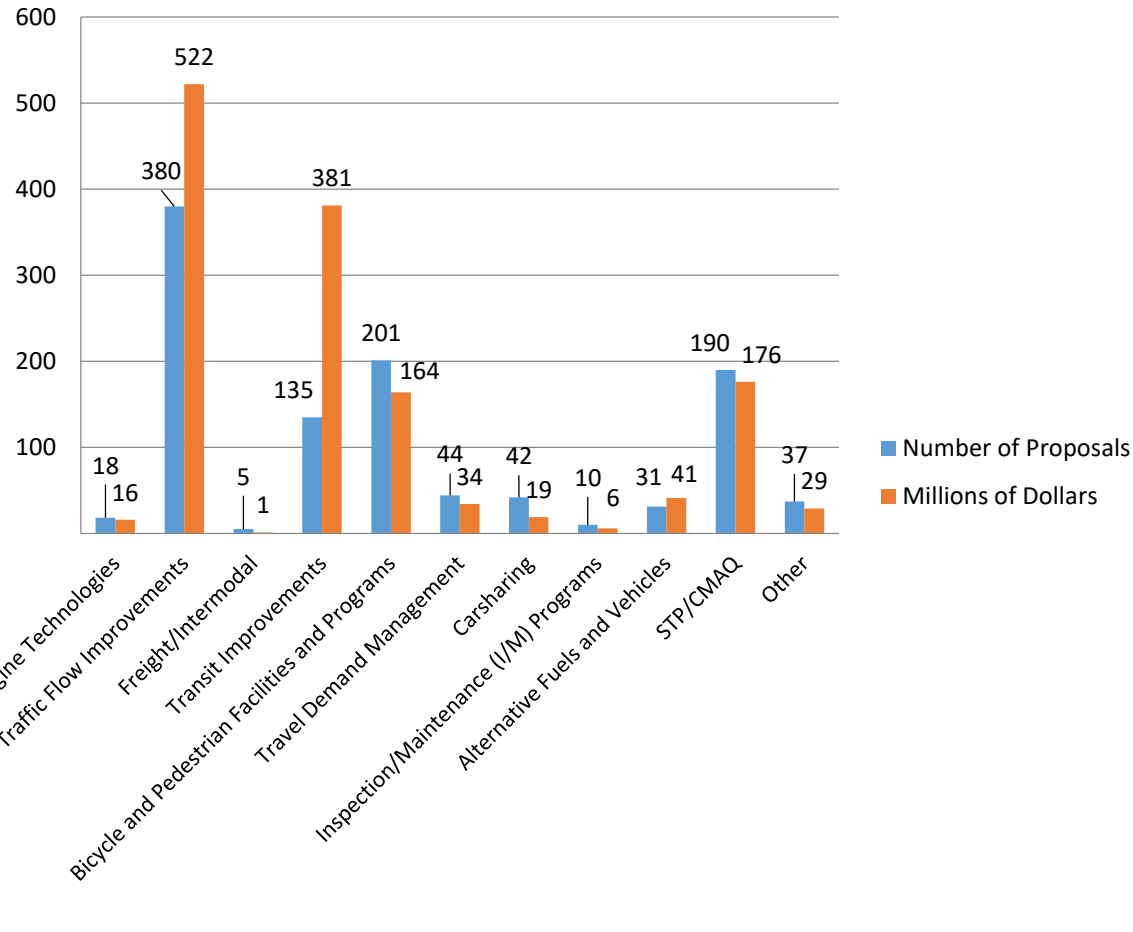
CMAQ project justification as well as annual reporting require the development of reliable air quality benefit estimates. Realizing that every potential project sponsor may not have the capacity for developing independent air quality benefit estimates, the FHWA has undertaken the initiative of developing a series of spreadsheet based tools to facilitate the calculation of representative air quality benefit data.

This CMAQ Emissions Calculator Toolkit (in Microsoft Excel format) is only offered as an additional resource to assist DOTs, MPOs and project sponsors in the project justification process. Agencies and individuals using a preferred methodology to generate air quality benefit information are welcome to continue their current practice. The tool kit will be released in modules by project type.

Tool	Documentation
Bicycle and Pedestrian Improvements	<ul style="list-style-type: none">• Bicycle and Pedestrian Improvements• MOVES Documentation
Diesel Idle Reduction Technologies	<ul style="list-style-type: none">• Diesel Idle Reduction Technologies• MOVES Documentation
Transit Bus Service and Fleet Expansion	<ul style="list-style-type: none">• Transit Bus Service and Fleet Expansion• MOVES Documentation

Project Distribution

Type of Proposals Funded by Category in 2018



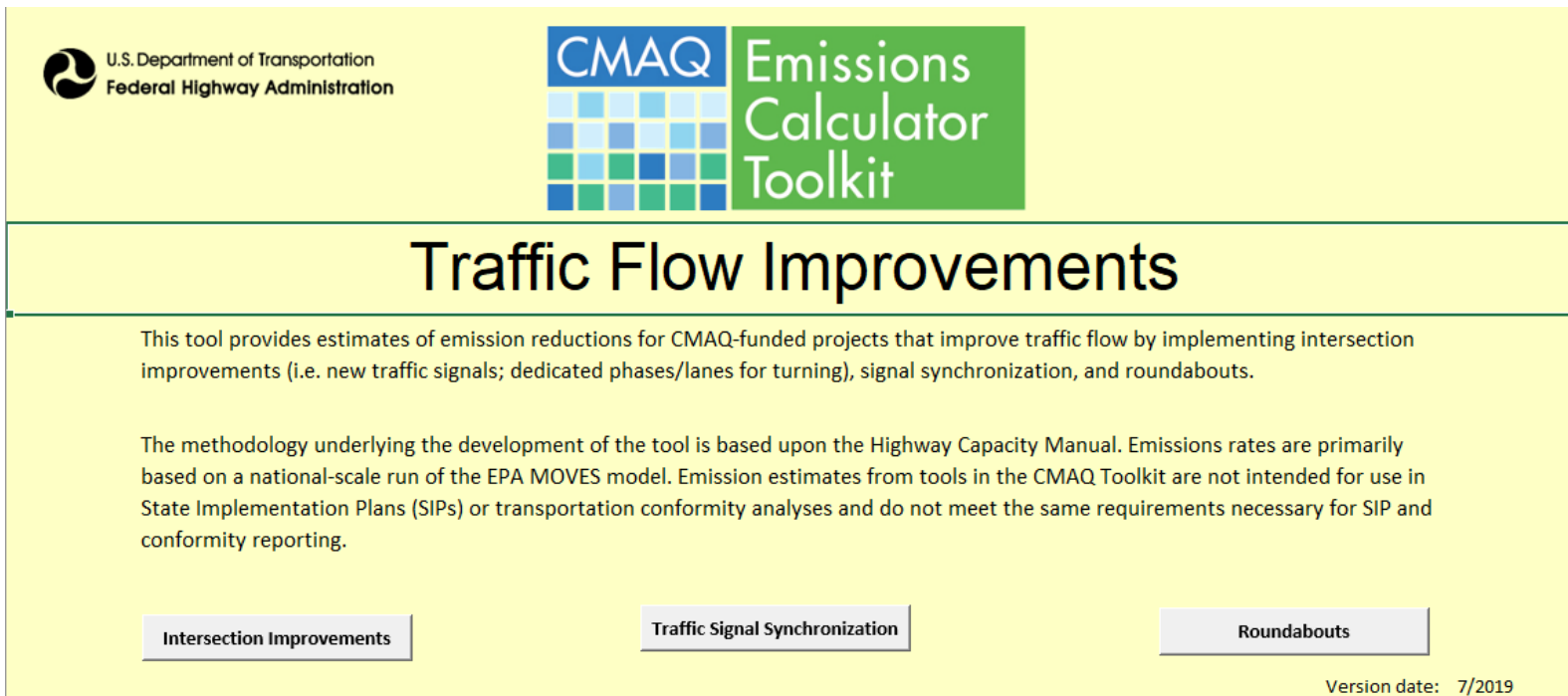
- FHWA maintains the [CMAQ Public Access System](#) with many thousands of funded projects dating back to 1992
- Most common project types:
 - Traffic flow improvements
 - Transit improvements
 - Bicycle-pedestrian facilities & programs

Tool Release Schedule

- Volpe has assisted FHWA in CMAQ Toolkit development since 2015:
 - 8 tools have been publicly released
 - 2 tools are pending release this year
 - All tools are currently being updated to extend through analysis year 2030
 - Nonroad tools are under development
 - Similar methodology to existing onroad tools

Tool	Eligible Project Types	Status
Congestion Reduction and Traffic Flow Improvements	<ul style="list-style-type: none"> • Intersection Improvements • Traffic Signal Synchronization • Roundabouts 	Available since September 2016
Advanced Diesel Truck / Engine Technologies	<ul style="list-style-type: none"> • Vehicle / Engine Replacement • Heavy Duty Vehicle Retirement • Engine Rebuilding / Exhaust Retrofit • After Treatment Hardware/Devices • On-Board Emissions Control Devices 	Available since January 2017
Alternative Fuels and Vehicles	<ul style="list-style-type: none"> • Fueling Facilities • Vehicle Purchase • Fleet Conversion • Engine Replacement • Hybrid Vehicles 	Available since May 2017
Carpooling and Vanpooling	<ul style="list-style-type: none"> • Carpooling • Vanpooling 	Available since September 2017
Transit Bus Retrofit and Replacement	<ul style="list-style-type: none"> • Diesel Engine Retrofits • Diesel Bus Replacement • Alternative Fuel Bus Replacement 	Available since December 2017
Transit Bus Service and Fleet Expansion	<ul style="list-style-type: none"> • New Transit Service • System or Service Expansion • New Vehicle Procurement • Fare Subsidies 	Available since September 2018
Diesel Idle Reduction Technologies	<ul style="list-style-type: none"> • Auxiliary Power Units • Direct-Fired Heaters • Truck Stop Electrification 	Released in January 2019!
Bicycle/Pedestrian Improvements	<ul style="list-style-type: none"> • New Bicycle Lanes/Trails • New Sidewalks/Paved Shoulders • Bicycle Parking/Transit Storage • Maps for Bicyclists/Pedestrians • Lighting/Signs/Signal Improvements 	Released in January 2019!
Dust Mitigation	<ul style="list-style-type: none"> • Street Sweeping • Chemical or Water Treatments • Paving 	Coming Soon!
Managed Lanes	<ul style="list-style-type: none"> • New HOV or HOT Lane • Conversion of HOV to HOT Lane 	Coming Soon!

Tool and Documentation Files



The screenshot shows the header of the CMAQ Emissions Calculator Toolkit. On the left is the U.S. Department of Transportation Federal Highway Administration logo. In the center is the CMAQ logo, a grid of colored squares. To the right of the grid is the text "Emissions Calculator Toolkit". Below this is a yellow banner with the title "Traffic Flow Improvements". Underneath the banner is a paragraph of text: "This tool provides estimates of emission reductions for CMAQ-funded projects that improve traffic flow by implementing intersection improvements (i.e. new traffic signals; dedicated phases/lanes for turning), signal synchronization, and roundabouts." Below this is another paragraph: "The methodology underlying the development of the tool is based upon the Highway Capacity Manual. Emissions rates are primarily based on a national-scale run of the EPA MOVES model. Emission estimates from tools in the CMAQ Toolkit are not intended for use in State Implementation Plans (SIPs) or transportation conformity analyses and do not meet the same requirements necessary for SIP and conformity reporting." At the bottom of the page are three buttons: "Intersection Improvements", "Traffic Signal Synchronization", and "Roundabouts". In the bottom right corner, it says "Version date: 7/2019".

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CMAQ Emissions Calculator Toolkit

Traffic Flow Improvements

This tool provides estimates of emission reductions for CMAQ-funded projects that improve traffic flow by implementing intersection improvements (i.e. new traffic signals; dedicated phases/lanes for turning), signal synchronization, and roundabouts.

The methodology underlying the development of the tool is based upon the Highway Capacity Manual. Emissions rates are primarily based on a national-scale run of the EPA MOVES model. Emission estimates from tools in the CMAQ Toolkit are not intended for use in State Implementation Plans (SIPs) or transportation conformity analyses and do not meet the same requirements necessary for SIP and conformity reporting.

Intersection Improvements Traffic Signal Synchronization Roundabouts

Version date: 7/2019

- Each CMAQ tool consists of:
 - Excel macro file (.xlsm) with modules for related but distinct eligible projects
 - User guide documentation that lays out tool inputs, emission calculations, and example projects
- Document of emissions data and its sources
 - Most tools utilize MOVES for onroad emission estimates

Example 1: Synchronizing Traffic Signals

- The Traffic Flow Improvements tool has a module for estimating the benefits of adopting synchronized traffic signals:
 - Increase average speeds
 - Decrease travel time & idling
 - Reduce emissions
 - Alleviate congestion

CMAQ Emissions Calculator Toolkit

Traffic Signal Synchronization

This calculator will estimate the emission reductions resulting from synchronizing the traffic signals along a previously unsynchronized corridor.

INPUT User Guide

Reset to Default Values

Evaluation Year	Select	
Area Type	Select	
Corridor Length	1	miles
Number of Signalized Intersections	2	
Number of Lanes (one direction)	1	
Posted Speed Limit	0	miles per hour (1 - 75 MPH)
Average Cycle Length	90	seconds
Truck Percentage	6%	
Annual Average Daily Traffic (AADT) (both directions)	0	veh/day
Peak-hour Volume (both directions)	0	veh/hr
Existing Corridor Travel Time	0	minutes
Total peak hours per day (AM+PM)	4	

OUTPUT Calculate Output

PERFORMANCE

	PEAK-HOUR	OFF-PEAK	
Volume (both directions)			veh/hr
Existing Average Speed			miles per hour
Travel Time Savings			minutes
Proposed Average Speed			miles per hour

EMISSION REDUCTIONS

Pollutant	Peak-hour Kilograms/day	Off-Peak Kilograms/day	Total Kilograms/day
Carbon Monoxide (CO)	0.000	0.000	0.000
Particulate Matter <2.5 µm (PM _{2.5})	0.000	0.000	0.000
Particulate Matter <10 µm (PM ₁₀)	0.000	0.000	0.000
Nitrogen Oxide (NOx)	0.000	0.000	0.000
Volatile Organic Compounds (VOC)	0.000	0.000	0.000

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Example I: Signal Synchronization Methodology

Off-Peak Existing Average Speed Calculation Methodology

Assuming that the mid-segment (roadway between signals) travel speed is the free-flow speed along the corridor, the corridor travel time, t_R , in seconds, is expressed in the following equation from the Highway Capacity Manual, 2010⁹:

$$t_R = N_s \frac{6.0 - l_1}{(0.0025L)5280} f_x + \frac{3600L}{S_{PL}} f_v + N_s d_1 \quad (6)$$

where:

l_1 = start-up lost time = 2.0 for signalized intersections,

L = corridor length (miles),

f_x = 1.00 for signalized through movement,

S_{PL} = posted speed limit (miles per hour),

f_v = traffic volume proximity factor, defined previously,

N_s = number of signals along project corridor,

d_1 = calculated delay (seconds), defined previously.

The existing travel speed along the corridor, S_1 , is then given by the equation:

$$S_1 = \frac{3600L}{t_R} \quad (7)$$

- Users calculate average speeds before and after signal synchronization based on the Highway Capacity Manual
- Project-level MOVES emission rates are generated and then queried according to speed
- Tool estimates delta of emissions for:
 - Existing average speed, and
 - Average speed achieved after synchronization

Example 2: Striping New Bicycle Lane

- Users can estimate benefits from installing bicycle infrastructure:
 - Divert passenger vehicle trips to non-motorized trips
 - Reduce emissions and energy consumption
 - Mitigate roadway congestion

CMAQ Emissions Calculator Toolkit

Bicycle and Pedestrian Improvements

This calculator will estimate the reduction in emissions resulting from improvements to bicycle and pedestrian infrastructure and associated mode shift from passenger vehicles to bicycling or walking, including but not limited to sidewalks, dedicated bicycle infrastructure, improved wayfinding, mid-block crossing installations, bike share systems, and bike parking improvements.

Navigator
Bicycle and Pedestrian Improvements

INPUT User Guide

(1) What is your project evaluation year? Reset Interface

(2) Estimate the change in daily motorized passenger vehicle trips due to the bicycle and pedestrian project.

Daily Trips

Before	After	Change
<input type="text"/>	<input type="text"/>	<input type="text"/>

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

Trip Distance Source

(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)					Sum
	$x < 1$	$1 \leq x < 2$	$2 \leq x < 3$	$3 \leq x < 4$	$4 \leq x \leq 5$	
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

OUTPUT Calculate Output

EMISSION REDUCTIONS

Pollutant	Total	*Units in kg/day unless otherwise noted
Carbon Monoxide (CO)	0.000	
Particulate Matter <2.5 μm (PM _{2.5})	0.000	
Particulate Matter <10 μm (PM ₁₀)	0.000	
Nitrogen Oxide (NOx)	0.000	
Volatile Organic Compounds (VOC)	0.000	
Carbon Dioxide Equivalent (CO ₂ e)	0.000	
Total Energy Consumption (MMBTU)	0.000	

Example 2: Trip Diversion Methodology

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

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

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

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_{min_j}	minimum 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.

- Using the National Household Travel Survey, the distribution of average trip distances is calculated by mode
- The number of trips by mode is projected before and after the bicycle lane is created
- Average trip distance and number of trips per day multiplied to find the vehicle miles travelled (VMT)
- Difference in passenger vehicle emissions is estimated for before and after project completion

Stakeholder Outreach

- Seeking partners at federal agencies, state DOTs, and MPOs to participate in CMAQ tool beta testing
- Regularly provide updates on Toolkit to various stakeholder groups, such as the Transportation Research Board (TRB) Air Quality Committee Webinars to introduce tools to potential users
 - FHWA plans to provide more webinars later this year
- Investigating tool adoption and usage for better support and outreach

For More Information

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CMAQ Emissions Calculator Toolkit

What is the CMAQ Toolkit?

The FHWA Office of Natural Environment is developing a series of tools to provide technical support and resources for the implementation of the Congestion Mitigation and Air Quality Improvement (CMAQ) Program.

Why should my agency use the CMAQ Toolkit?

CMAQ project justifications, as well as annual reporting, require the development of reliable air quality benefit estimates. Realizing that every potential project sponsor may not have the capacity for developing independent air quality benefit estimates, the FHWA has undertaken the initiative of developing a series of spreadsheet-based tools to facilitate the calculation of representative air quality benefit data.

Is the CMAQ Toolkit required?

CMAQ emissions calculators are offered only as an additional resource to assist DOTs, MPOs and project sponsors in the project justification and reporting process. Agencies and individuals using an existing methodology to generate emissions benefit information are welcome to continue their current practice.



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