Congestion Mitigation and Air Quality (CMAQ) Improvement Program:

CMAQ Toolkit Overview and Demo

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Andrew Eilbert

Development Team: Mark Glaze, David Kall, Karen Perritt, and Cecilia Ho (FHWA);
Andrew Eilbert, Russell Pildes, William Chupp, and Anjuliee Mittelman (Volpe)
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
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
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 Release Schedule

<table>
<thead>
<tr>
<th>Tool</th>
<th>Eligible Project Types</th>
<th>Status</th>
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| Congestion Reduction and Traffic Flow Improvements | • Intersection Improvements  
• Traffic Signal Synchronization  
• Roundabouts | Available since September 2016                                                        |
| Advanced Diesel Truck / Engine Technologies    | • 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                 | • Fueling Facilities  
• Vehicle Purchase  
• Fleet Conversion  
• Engine Replacement  
• Hybrid Vehicles | Available since May 2017                                                               |
| Carpooling and Vanpooling                       | • Carpooling  
• Vanpooling | Available since September 2017                                                        |
| Transit Bus Retrofit and Replacement           | • Diesel Engine Retrofits  
• Diesel Bus Replacement  
• Alternative Fuel Bus Replacement | Available since December 2017                                                         |
| Transit Bus Service and Fleet Expansion         | • New Transit Service  
• System or Service Expansion  
• New Vehicle Procurement  
• Fare Subsidies | Available since September 2018                                                        |
| Diesel Idle Reduction Technologies             | • Auxiliary Power Units  
• Direct-Fired Heaters  
• Truck Stop Electrification | Released in January 2019!                                                            |
| Bicycle/Pedestrian Improvements                | • 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                                 | • Street Sweeping  
• Chemical or Water Treatments  
• Paving | Coming Soon!                                                                           |
| Managed Lanes                                   | • New HOV or HOT Lane  
• Conversion of HOV to HOT Lane | Coming Soon!                                                                           |
Tool and Documentation Files

- 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

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.
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

Traffic Signal Synchronization

- This calculator will estimate the emission reductions resulting from synchronizing the traffic signals along a previously unsynchronized corridor.
- Take To Default Values
- Calculate Output
Example 1: 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, 2010:

$$t_R = N_i \frac{6.0 - l_i}{(0.0025L)5280} f_x + \frac{3600L}{S_{pl}} f_v + N_i d_i$$  (6)

where:

- $l_i = \text{start-up lost time} = 2.0$ for signalized intersections,
- $L = \text{corridor length (miles)}$,
- $f_x = 1.00$ for signalized through movement,
- $S_{pl} = \text{posted speed limit (miles per hour)}$,
- $f_v = \text{traffic volume proximity factor, defined previously}$,
- $N_i = \text{number of signals along project corridor}$,
- $d_i = \text{calculated delay (seconds), defined previously}$.

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

$$S_i = \frac{3600L}{t_R}$$  (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
Example 2: Trip Diversion Methodology

\[ VMT_{\text{before}_i} = N_{\text{before}_i} \cdot D_i \]

\[ VMT_{\text{after}_i} = N_{\text{after}_i} \cdot D_i \]

\[ D_i = \sum_{j \in J} \left( d_{\text{midpoint}_j} \cdot k_{i,j} \right) = \sum_{j \in J} \left( \frac{d_{\text{max}_j} + d_{\text{min}_j}}{2} \right) \cdot k_{i,j} \]

For all \( i \) and \( j \) where:

- \( N_{\text{before}_i} \): number of trips before project completion for mode \( i \),
- \( N_{\text{after}_i} \): 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,
- \( d_{\text{midpoint}_j} \): midpoint distance of each bin \( j \) in the trip distance distribution, i.e., 0.5, 1.5, 2.5, 3.5, 4.5
- \( d_{\text{max}_j} \): maximum value of distance bin \( j \) in the distance distribution, i.e., 1, 2, 3, 4, 5
- \( d_{\text{max}_j} \): maximum 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

Andrew Eilbert
US DOT / Volpe Center
andrew.eilbert@dot.gov

Anjuliee Mittelman
US DOT / Volpe Center
anjuliee.mittelman@dot.gov

Mark Glaze
US DOT / FHWA
mark.glaze@dot.gov

Cecilia Ho
US DOT / FHWA
cecilia.ho@dot.gov

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