MoSERS VS CMAQ TOOLKIT

Jenny Narvaez

Technical Working Group Meeting

March 5, 2020

North Central Texas
Council of Governments

BICYCLE AND PEDESTRIAN IMPROVEMENTS

MoSERS

- Calculations are based on the total number of trips where the facility is utilized
- Locally specific

CMAQ Toolkit

- Calculations are based on the number of passenger vehicle trips that were reduced by project implementation
- National default values

USER INTERFACE: BICYCLE AND PEDESTRIAN IMPROVEMENTS

MoSERS

Variables:		Source		NO_X	VOC
EF_B:	Speed-based running exhaust emission factor for participants' trip before participating in the bike/pedestrian program (NO_x or VOC) (grams/mile) *(assume 34 mph, LDV and arterial roadway types)*	MOVES2014a	EF_B:	0.09	0.03
TEF_{AUTO}:	Auto trip-end emission factor (NOx or VOC) (grams/trip)	MOVES2014a	TEF_{AUTO}:	0.59	0.71
TL_B:	Average auto trip length before implementation (miles)	COG default	TL_B:	1.00	1.00
N_{BW}:	Number of trips utilizing the bike/pedestrian facility Where, NBW is calculated using bike needs indices (BNI) and pedestrian needs indices (PNI). The BNI is determined by the percentage of total trips that are five miles or less, employment density, population density, and medium income. Each of the Transportation Analysis Process (TAP) zones within the Dallas-Fort Worth Metropolitan Planning Area are ranked for each factor of the BNI and PNI. These rankings are compared against the regional value to generate an "index-to-region" score. Index-to-region scores greater than 1.00 indicate higher than average levels, and scores lower than 1.00 indicate lower than average levels. A ranking weight is then applied to each index-to-region score and summed for each TAP zone. The TAP zone area, population, and scores are compared against a site-specific radius for each bike/pedestrian facility to quantify the number of facility users (NBW) above, with exceptions. Natural and manmade barriers are also considered, including rivers, highways, and other incompatible land uses and street patterns.	BP team	N_{BW}:	1,633.00	1,633.00
Conversion Factor:	Convert grams per mile of emissions to pounds per mile of emissions		Conversion Factor:	453.6	453.6

Results:		NO_X	VOC
Daily Emissions Reduction = (N_{BW} * TL_B * EF_B) + (N_{BW} * TEF_{AUTO})/ Conversion Factor	Daily Emission Reduction (lbs/day) =	2.45	2.66
	Emission Reduction (tons/day) =	0.00	0.00

CMAQ 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.

INPUT [User Guide]

[Reset Interface]

(1) What is your project evaluation ye 2019

(2) Estimate the shift in daily motorized passenger vehicle trips to non-motorized travel due to the bicycle and pedestrian project.

Daily Passenger Vehicle Trips		
Before	After	Change
2633	1000	1633

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

Trip Distance Source: Average [<- Fill National Values]

(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 t

Typical Trip Distance (miles one way): 1

Distribution of Trip Distances (daily fraction per mileage bin)					
x < 1	1 ≤ x < 2	2 ≤ x < 3	3 ≤ x < 4	4 ≤ x ≤ 5	Sum

OUTPUT [Calculate Output]

EMISSION REDUCTIONS

*Units in kg/day unless otherwise noted

Pollutant	Total		
Carbon Monoxide (CO)	15.661		
Particulate Matter <2.5 µm ($PM_{2.5}$)	0.031		
Particulate Matter <10 µm (PM_{10})	0.078		
Nitrogen Oxide (NOx)	1.479	* 2.205 lbs	= 3.151 lbs/day
Volatile Organic Compounds (VOC)	1.429	* 2.205 lbs	= 3.261 lbs/day
Carbon Dioxide Equivalent (CO_2e)	751.431		
Total Energy Consumption (MMBTU/day)	9.594		

FORMULA COMPARISON: BICYCLE AND PEDESTRIAN IMPROVEMENTS

MoSERS

Daily emissions reduction = $(N_{BW} * TL_B * EF_B) + (N_{BW} * TEF_{AUTO})$/ Conversion Factor

CMAQ Toolkit

$$E_{i,p} = (VMT_{before_i} - VMT_{after_i})e_{i,p} = \Delta VMT_i * e_{i,p}$$

Total emissions reduced$_p$ = $\sum_{iEI} E_{i,p} = \sum_{iEI} \Delta VMT_i * e_{i,p}$

FORMULA COMPARISON: BICYCLE AND PEDESTRIAN IMPROVEMENTS

MoSERS Variables

N_{BW} : Number of trips utilizing the bike/pedestrian facility

TL_B : Average auto trip length before implementation (miles)

EF_B : Speed-based running exhaust emission factor for participants' trip before participating in the bike/pedestrian program (NO_X or VOC) (grams/mile) (assume 34 mph, Light Duty Vehicles and arterial roadway types)

TEF_{AUTO} : Auto trip-end emission factor (NO_X or VOC) (grams/trip)

CMAQ Toolkit Variables

$E_{i,p}$: Emissions by mode *i* and pollutant *p*

iEI : Mode *i* across all modes *I*, currently includes passenger vehicles only

$e_{i,p}$: Emission rate by mode *i* and pollutant *p*

p : Pollutant, including the five criteria pollutant above (CO, PM2.5, PM10, NO_X, VOC) as well as CO2e and total energy consumption

VMT_{before_i} : Vehicle miles traveled (VMT) before project completion for mode *I*

VMT_{after_i}: Vehicle miles traveled (VMT) before project completion for mode *i*

INTERSECTION IMPROVEMENTS

MoSERS

- Less data intensive
- Calculations yield positive emission benefits
- Locally specific

CMAQ Toolkit

- More data intensive
- Negative emission benefits when running current projects
- National default values

USER INTERFACE: INTERSECTION IMPROVEMENTS

MoSERS

7.0 Traffic Flow Improvements -- TTI Equation

7.2 Traffic Operations: Intersection Improvements

Strategy: Reduce congestion in corridors and intersections, improving traffic speeds and reducing idling times, leading to lower emission and improved traffic system

Project Year: 2018

Description: Traffic operation improvements, similar to traffic signalization improvements primary focus on reducing congestion on local and arterial streets by improving the systems efficiency. Generally, each action will improve traffic flow and safety. Many roadway changes require only signage and pavement marking changes with little new construction and are relatively quick to implement.

Project Description:

Application: Major arterials or high capacity roadways.

Project Code:

Variables:		Source		NO_x	VOC
EF_I':	Idling emission factor (NOx or VOC) (grams/mile) *(equal to the emission factor at 2.5 mph, all vehicles types on arterials)*	MOVES2014a	EF_I':	0.64	0.33
EF_I:	Idling emission factor (NOx or VOC) (grams/hour) *(equal to the emission factor at 2.5 mph, multiplied by 2.5 miles to get units of grams/hour)*		EF_I:	1.60	0.83
D_B:	Time delay before project implementation (seconds)	COG Default	D_B:	31.00	31.00
D_A:	Time delay after project implementation (seconds)	COG Default	D_A:	25.00	25.00
V:	Bi-directional arterial volume for analysis period	Project Specific	V:	38,912.00	38,912.00
$P.H_R$	Peak Hour Ration	COG Default	$P.H_R$	0.46	0.46
$V_{D,P}$:	Average daily volume during the peak period		$V_{D,P}$:	17,899.52	17,899.52
$V_{D,OP}$:	Average daily volume during the off-peak period		$V_{D,OP}$:	21,012.48	21,012.48
DR:	Reduction in time delay (seconds)	COG Default	DR:	6.00	6.00
Conversion Factor:	Convert grams per mile of emissions to pounds per mile of emissions	Standard	Conversion Factor:	453.60	453.60

Equation:			NO_x	VOC
$A = (D_B - D_A) * EF_I'$	Change in exhaust emissions from improved speed during the peak and off-peak periods.	A:	47.73	24.61
$B = (D_B - D_A) * EF_I'$	Change in idling exhaust emissions from improved traffic flow during the peak and off-peak periods.	B:	56.03	28.89

Results:		NOx	VOC
Daily Emission Reduction = (A + B)/Conversion Factor	Daily Emission Reduction (lbs/day) =	0.23	0.12
	Daily Emission Reduction (tons/day) =	0.00	0.00

CMAQ Toolkit

This calculator will estimate the emission reductions resulting from improving traffic signals at a four-way intersection

INPUT

EXISTING CONDITIONS (User Guide)

Reset to Default Values

Evaluation Year	2019
Area Type	Urban
Business District	No
Total peak hours per day(AM+PM)	6
Existing Intersection is	Signalized

	Roadway 1	Roadway 2	
Average Annual Daily Traffic volume (AADT) (both directions)	30,406	8,506	veh/day
Peak-hour Volume (both directions)	2,331	652	veh/hr
Number of Lanes (one direction)	3	2	
Truck Percentage	0%	0%	
Existing Delay per Vehicle	6	6	sec/veh
Existing Left-turn Phase	Yes	Yes	
Existing Right-turn Phase	No	Yes	

Use the table below to estimate delay (HCM 2010, Exhibit 21-1)

vel of Service Reference Tal

LOS	Delay (s/veh) Unsignalized	Delay (s/veh) Signalized
A	0 - 10	0 - 10
B	>10 - 15	>10 - 20
C	>15 - 25	>20 - 35
D	>25 - 35	>35 - 55
E	>35 - 50	>55 - 80
F*	>50	>80

*LOS F typically indicates that traffic demand has exceeded capacity

PROPOSED CONDITIONS

Cycle Length: 110 seconds

	Roadway 1	Roadway 2
Number of Left-Turn Lanes to Add (one direction)	0	0
Left-turn Phase	Yes	Yes
Right-turn Phase	Yes	Yes
Ratio of Green Time per Cycle Time	0.5	0.5

OUTPUT

Calculate Output

PERFORMANCE

Roadway	PEAK-HOUR 1	PEAK-HOUR 2	OFF-PEAK 1	OFF-PEAK 2	
Existing Capacity (both directions)	5,143	2,906	5,143	2,906	veh/hr
Proposed Capacity (both directions)	4,358	2,906	4,358	2,906	veh/hr
Volume (both directions)	2,331	652	912	255	veh/hr
Delay Reduction per vehicle	-12.8	-9.5	-0.3	0.0	sec/veh

Roadway	1	2	
Roadway Intersection Delay Reduction per day	-50.8	-10.3	hours
Total Intersection Delay Reduction per day	-61.1		hours

EMISSION REDUCTIONS

Pollutant	Peak Hours Kilograms/day	Off-Peak Hours Kilograms/day	Daily Total Kilograms/day
Carbon Monoxide (CO)	-0.378	0.000	-0.378
Particulate Matter <2.5 µm	-0.003	0.000	-0.003
articulate Matter <10 µm (PM₁₀	-0.003	0.000	-0.003
Nitrogen Oxide (NOx)	-0.034	0.000	-0.034
Volatile Organic Compounds	-0.027	0.000	-0.027
Carbon Dioxide Equivalent	-196.524	-0.004	-196.528
Total Energy Consumption	-2.590	0.000	-2.590

FORMULA COMPARISON: INTERSECTION IMPROVEMENTS

MoSERS

A = (DB – DA) ∗ EFI ∗ $VD_{,P}$
Change in exhaust emissions from improved speed during the peak and off-peak periods.

B = (DB – DA) ∗ EFI ∗ $VD_{,OP}$
Change in idling exhaust emissions from improved traffic flow during the peak and off-peak periods.

Daily Emission Reduction = (A + B)/Conversion Factor

CMAQ Toolkit

$$d_1 = \frac{0.5C(1-\frac{g}{C})^2}{1-[\min(1,x)\frac{g}{C}]}$$

$$X = \frac{v}{c} = \frac{v}{Ns\frac{g}{C}}$$

$$s = s_0 f_{HV} f_a f_{RT} f_{LT}$$

$$v_{off-peak} = \frac{AADT - h_{peak}v_{peak}}{24 - h_{peak}}$$

FORMULA COMPARISON: INTERSECTION IMPROVEMENTS

MoSERS Variables

D_B : Time delay before project implementation (seconds)

D_A : Time delay after project implementation (seconds)

EF_I : Idling emission factor (NOx or VOC) (grams/hour) (equal to the emission factor at 2.5 mph, multiplied by 2.5 miles to get units of grams/hour)

$V_{D,P}$: Average daily volume during the peak period

$V_{D,OP}$: Average daily volume during the off-peak period

CMAQ Toolkit Variables

d_1 : uniform delay

C : cycle length (seconds)

$\frac{g}{C}$: green light duration to total cycle duration ratio

min(1, X) : function to limit the volume to capacity ratio to a maximum of 1.0 by choosing the smallest value of 1 or X

X : highest volume to capacity ratio of any turning movement or lane group at intersection

v : volume (vehicles/hour) (one direction)

c : capacity

N : number of throughput lanes + 0.5*number of added left-turn lanes, (one direction)

FORMULA COMPARISON: INTERSECTION IMPROVEMENTS

CMAQ Toolkit Variables (continued)

s : saturation flow rate/lane (passenger cars/lane/hour)

s_o = base saturation rate/lane (passenger cars/lane/hour)

f_{HV} = adjustment factor for heavy-duty trucks = $\frac{100}{100 + P_{HV}(ET - 1)}$

P_{HV} = percent trucks

E_T = car equivalency = 2.0

f_a = adjustment factor for area type = 0.90 for a central business district and 1.00 otherwise

f_{RT} = adjustment factor for protected right-turns = $\frac{1}{E_R}$

E_R = the equivalent number of through cars for a protected right-turning vehicle = 1.18

f_{LT} = adjustment factor for protected left-turns = $\frac{1}{E_L}$

E_L = the equivalent number of through cars for a protected left-turning vehicle = 1.05

AADT = annual average daily traffic (vehicles/day)

h_{peak} = the number of peak hours in a day (hours)

v_{peak} = peak-hour hourly volume (vehicles/hour)

COMMENTS AND CONCERNS

- The CMAQ toolkit provides a forum and means of evaluation and comparison that can be leveraged by agencies of all sizes. One of the main perks is that national values are readily available in the models to bolster unknown/unsure data. This also allows for quick and consistent estimations when used as an initial screening, or for "ball-park" figures
- Uses national default values (emission factors, delay in turn, truck percentage, cycle length, and ratio of green time per cycle time)
- Emission factors are not user friendly to view or change
- Data intensive

CMAQ TOOLKIT

The purpose of the Congestion Mitigation and Air Quality Improvement Program Emissions Calculator Toolkit (CMAQ Toolkit) is to provide users a standardized approach to estimating emission reductions from the implementation of a CMAQ-funded project. The CMAQ Toolkit uses emission rates for highway vehicles based on a series of project-scale and national-scale runs of the Motor Vehicle Emission Simulator (MOVES) as well as other data sources. For each tool in the Toolkit, the inputs and methodology are described in user guides along with some example cases. Emission estimates from the CMAQ Toolkit are not intended to meet specific requirements for State Implementation Plans (SIPs) or transportation conformity analyses. Information regarding the development of default emission rates and guidance on incorporating user-supplied emission rates can be found in the accompanying documentation of the emissions data.

STRATEGIES

MoSERS

(mostly used at NCTCOG)

- Bicycle and Pedestrian Improvements
- Grade Separations - Rail
- Grade Separations - Roadway
- High-Occupancy Vehicle Facilities
- Intersection Improvements
- Traffic Speeds Improvements
- Park and Ride
- Signal Improvement - Individual
- Signal Improvement - Corridor
- Transit - Buses
- Transit-RAIL
- Vanpool

CMAQ Toolkit

- Advanced Diesel Truck/Engine Technologies
- Alternative Fuels and Vehicles
- Bicycle and Pedestrian Improvements
- Carpooling and Vanpooling
- Congestion Reduction and Traffic Flow Improvements
- Diesel Idle Reduction Technologies
- Dust Mitigation
- Managed Lane Facilities and Conversions
- Transit Bus Retrofits and Replacement
- Transit Bus Service and Fleet Expansion

THANK YOU

Jenny Narvaez
Program Manager
817-608-2342
JNarvaez@nctcog.org

Chris Klaus
Senior Program Manager
817-695-9286
CKlaus@nctcog.org

Vivek Thimmavajjhala
Transportation System Modeler
817-704-2504
VThimmavajjhala@nctcog.org

Nick Van Haasen
Air Quality Planner
817-608-2335
NVanHaasen@nctcog.org