Methods for Calculating Cost Effectiveness of Funding Air Quality Projects

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Overview of the Congestion Mitigation and Air Quality Improvement Program (CMAQ)

CMAQ Funding

CMAQ provides a flexible funding source to State and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act.

CMAQ funds are federal Highway Trust Fund dollars apportioned to the States.

CMAQ Funding Process

- Highway Trust Fund dollars are apportioned by US DOT to the State (Caltrans) by formula in statute.
- Caltrans Programming apportions the State share (by formula in State law) to MPOs in areas that do not attain or are maintenance for federal air quality standards.
- MPOs/RTPAs call for projects; projects are evaluated against several criteria including cost effectiveness MPOs/RTPAs report statistics including cost effectiveness on funded projects to Caltrans, then to FHWA.
- Cost effectiveness is the Funding divided by the emissions reduced.

Project Eligibility and the Role of Cost Effectiveness in CMAQ

From FHWA:

Eligible activities

Funds may be used for transportation projects likely to contribute to the attainment or maintenance of a national ambient air quality standard, *with a high level of effectiveness* in reducing air pollution, and be included in the Metropolitan Planning Organization's (MPO's) current transportation plan and transportation improvement program (TIP) or the current state transportation improvement program (STIP) in areas without an MPO. (emphasis added)

FHWA is required to maintain a database of cost effectiveness for use by MPOs in project selection, and periodically evaluate funded projects for emissions reduced and cost effectiveness.

Methods and Emission Factors

Methods - Background

Original methods document was developed by ARB and Caltrans and probably issued in late 90's. Methods have remained essentially unchanged. ARB creates database tool.

Since 2005, ARB has issued revisions to emission factors as our models have changed. Latest revision in May 2013 replaced PM10 rates with PM2.5.

ARB posts PM conversion factors in July 2013.

Methods

- Each method contains the following information:
  - A list of the information needed to evaluate cost-effectiveness.
  - “Defaults” that may be used when data are not available.
  - Formulas to calculate vehicle emission reductions for four major pollutants:

    Reactive organic gases (ROG)

    Nitrogen oxides (NOx)

    Particulate Matter (PM2.5)

    CO is given for most gasoline engines/vehicles

    CO and ROG are not usually relevant for diesel engines

  PM10 can be estimated from size fraction table.

Methods (cont'd)

- Each method contains:
  - Formula for calculating cost effectiveness
  - Sample calculations.
- Methods are not to be used to calculate mobile source emission reduction credits that are traded or sold.

Examples for Today

- Signal synchronization/Interconnect
- CNG Sanitation Truck Purchase
- Bike Lanes
- Alternative fueling station (Discussion)
- Shoulder Paving (Discussion)

Signal coordination/Interconnect

Signal coordination/Interconnect

- How emissions are reduced:
  - Increasing average traffic speeds to up to 36 mph. (NOx emissions start increasing when average speeds are over 36 mph.)
- Travel growth degrades project performance over time.
  - Method averages speed improvements over the effectiveness period by taking one-half of the first day benefits

Signal coordination/Interconnect

- Need to know:
  - Funding dollars
  - Number of operating days per year
  - Project life
  - Traffic volumes for the congested periods of the day (trips per day)
  - Length of the roadway segment impacted by the project
  - Before and after average traffic speeds

Signal coordination/Interconnect Example

- Need to know:
  - Funding : $36,000 CMAQ $5,000 local match
  - Project Life: 5 years (default)
  - Operating days per year: 250 (Default, number of weekdays).
  - Congested traffic volume: 18,125
  - Length of the roadway segment: 0.31 miles
  - Before and after average traffic speeds:
    - Before Project: 27.6 mph
    - After Project: 32.7 mph

Signal coordination/Interconnect Emission Factors

- Emission factors dependent on speed. Use Table 4, 1-5 year project life. Interpolate or round up; just do the same for all the rates in your analysis. Rates are in grams per mile.
  - Before: 27.6 mph
    - ROG 0.10
    - CO 2.53
    - NOX 0.33
    - PM2.5 0.004
  - After: 32.7 mph
    - ROG 0.09
    - CO 2.33
    - NOX 0.32
    - PM2.5 0.003

Signal coordination/Interconnect Formula – Emissions Reduced

- Project VMT =
    - Operating days * Project Length * Trips
    - 250 * 0.31 * 18,125
- = 1,404,687.5 miles
- Emissions Reduced (lbs) =
    - 0.5 * [(VMT)*(Before Speed Factor - After Speed Factor)]/454
    - Calculate each pollutant separately
- Reductions in pounds per year:
    - ROG – 30.9
    - CO – 618.8
    - NOx – 30.9
    - PM2.5 – 3.1

Signal coordination/Interconnect Cost Effectiveness Calculation

- Cost effectiveness in dollars per pound =
  - Capital Recovery Factor (CRF)*Funding /
  - Sum of ROG+CO/7+NOx+PM2.5 reduced.
- CRF from Table on page 2 = 0.22 (5 yr project life)
- Cost effectiveness = $50.20 per pound.
- What about CO/7?
- Convert to Kg if needed. Kg = lbs/2.2
- Questions?

Cleaner Emissions Vehicle
CNG Sanitation Truck

Cleaner Vehicle Purchase

How emissions are reduced:

Emission reductions are the emissions associated with a new, more polluting vehicle minus the emissions associated with a new, less polluting vehicle.

Need to know:

Funding dollars

Annual vehicle miles traveled (VMT)

Engine certification rates or cleaner vehicle classification

Cleaner Vehicle Purchase
The Search for Information

Principle is the same: Before and After emission rates.

Before case is the vehicle that would have been purchased. After case is the cleaner (CNG) vehicle.

Most difficult part will probably be finding the right information about the trucks.

Cleaner Vehicle Purchase
Certification rates and Executive Orders

Engines are certified to a particular pollution rate standard by ARB. ARB certifies engines by Executive Order. Most EOs are online.

Example: New Cummins CNG engine (pdf)

Other sources of emissions data:

- Truck dealerships
- Engine/Truck manufacturers

Same for the before case (i.e. cert or EO), or use Table 5 in Guide.

Consult with MPO or ARB staff.

Cleaner Vehicle Purchase
Example

Assumptions:

Annual mileage: 15,000

Cost: $283,612.50

Before - Heavy duty diesel engine.

After - Cummins ISL G-320 CNG engine.

Emission Rates

Before: Nox = 1.27 g/mi PM2.5 = 0.03 g/mi

ROG 0.19 g/mi (Table 5-D)

After: Nox = 0.80 g/mi PM2.5 = 0.04 g/mi

ROG 0.25 g/mi

(Based on 0.2 cert standard and tables 5F and 5B)

Cleaner Vehicle Purchase
Calculations

Annual Emission Reductions, lbs (for each pollutant):

(ROG, NOx, and PM2.5) = (VMT)*[(Before Emission Factor) - (After Emission Factor)]/454

Emissions Reductions :

ROG -2.0 Nox 15.5 PM2.5 -0.3

Note: A negative reduction is an *increase*.

Cost Effectiveness:

Funding Dollars = (CRF * Funding) / (ROG + NOx + PM2.5)

CRF = 0.10 From page 2, 12 year project life

Cost effectiveness = $2,146.00 per pound reduced

Bike Lanes

Bike Lanes

- Project definition: Bicycle paths (Class 1) or bicycle lanes (Class 2) that are targeted to reduce commute and other non-recreational auto travel. Class 1 facilities are paths that are physically separated from motor vehicle traffic. Class 2 facilities are striped bicycle lanes giving preferential or exclusive use to bicycles. Bike lanes should meet Caltrans' full-width standard depending on street facility type.
- How emissions are reduced: Emission reductions result from the decrease in emissions associated with auto trips replaced by bicycle trips for commute or other non-recreational purposes.
- The likelihood that trips will be diverted, and amount of diverted trips are modeled with Adjustment factors and Activity Center credits.

Bike Lanes
Need to Know:

- Funding dollars
- Number of operating days per year (Consider local climate)
- Average length of bicycle trips
- Average daily traffic volume on roadway parallel to bicycle project
- City population
- Project class (1 or 2)
- Types of activity centers in the vicinity of the bicycle project
- Length of bicycle path or lane

Bike Lanes
Method Inputs and Defaults

Funding Dollars (**Funding**)		Dollars	
Effectiveness Period (**Life**)	15	Years	Class 1 projects - 20 years Class 2 projects - 15 years
Days (**D**)	200	Days of use/year	Consider local climate in number of days used.
Average Length (**L**) of bicycle trips	1.8	Miles per trip in one direction	Default is based on the National Personal Transportation Survey
Annual Average Daily Traffic (**ADT**)		Trips per day	Two-direction traffic volumes on roadway parallel to bike project. MAXIMUM IS 30,000.
Adjustment (**A**) on ADT for auto trips replaced by bike trips from the bike facility.	.0020		See Adjustment Factors table on the next page. Adjustments are based on facility class, ADT, project length, and community characteristics.
Credit (**C**) for Activity Centers near the project.	.0005		See Activity Centers table on the next page.

Bike Lanes
Adjustment Factors

ADJUSTMENT FACTORS				
BIKE FACILITY CLASS	**AVERAGE DAILY TRAFFIC (ADT)**	**LENGTH OF BIKE PROJECT** (one direction)	**ADJUSTMENT FACTORS FOR CITIES WITH POP. ≥ 250,000** and non-university towns < 250,000	**ADJUSTMENT FACTORS FOR UNIVERSITY TOWNS WITH POP. < 250,000**
Class 1 (bike path) & Class 2 (bike lane)	ADT ≤ 12,000 vehicles per day	≤ 1 mile	.0019	.0104
		>1 & ≤ 2 miles	.0029	.0155
		> 2 miles	.0038	.0207
Class 1 (bike path) & Class 2 (bike lane)	12,000< ADT ≤24,000 vehicles per day	≤ 1 mile	.0014	.0073
		>1 & ≤ 2 miles	.0020	.0109
		> 2 miles	.0027	.0145
Class 2 bike lane	24,000< ADT ≤30,000 vehicles per day Maximum is 30,000	≤ 1 mile	.0010	.0052
		>1 & ≤ 2 miles	.0014	.0078
		> 2 miles	.0019	.0104

Bike Lanes
Activity Center Credits

ACTIVITY CENTERS CREDITS		
Types of Activity Centers: *Bank, church, hospital or HMO, light rail station (park & ride), office park, post office, public library, shopping area or grocery store, university or junior college.*		
Count your activity centers. If there are…	**Credit (C)**	**Credit (C)**
	Within 1/2 mile	**Within 1/4 mile**
Three (3)	.0005	.001
More than 3 but less than 7	.001	.002
7 or more	.0015	.003

Bike Lanes

Emission Factor Inputs for Auto Travel

From Table 3

Emission Factor Inputs for Auto Travel

	Default **Auto Trip End Factor**	Units	Default **Auto VMT Factor**	Units
ROG Factor	1.020	grams/trip	0.266	grams/mile
NOx Factor	0.458	"	0.319	"
PM Factor	0.016	"	0.219	"

Rates based on project life.

Note that the rates shown are from the 2005 guide and obsolete. They are for illustration only.

Bike Lanes
Calculation Formula

Annual Auto Trip Reduced = (D) * (ADT) * (A + C) (trips/year)

Annual Auto VMT Reduced = (Auto Trips) * (L) (miles/year)

Annual Emission Reductions (ROG, NOx, and PM10) = lbs./year

=

[(Annual Auto Trips Reduced)*(Auto Trip End Factor)

+ (Annual Auto VMT Reduced)*(Auto VMT Factor)]/454

Bike Lanes
Cost Effectiveness

- Once reductions calculated, apply the same formula as before:
  - CRF is selected based on project life
  - Default project life is 15 years
  - From table on page 2, CRF = 0.08

Paving Shoulders

Paving Shoulders Method

- No method in guide
- Principle would be the same:
  – Estimate emissions for a before case
  – Estimate emissions for an after case
  – Difference is the net reduction
  – Divide reduction by funding
  – Don’t forget to use a CRF
- Key is to research a viable method that all agree on.
- Consult with MPO/ARB staff if you need to do an analysis of shoulder paving.

Infrastructure Projects

Infrastructure Projects
Alternative Fueling Stations

- Infrastructure projects necessary for some kinds of emission reduction projects to succeed.
- Other types of infrastructure projects:
  - EV charging stations
  - Public outreach
  - Multi-modal projects
  - Automated transit schedule information
- Very difficult to evaluate just the infrastructure project itself
- Should be qualitatively evaluated for its consistency with local clean air plans, sustainable communities strategies, etc.

Discussion