

# Connecticut Department of Transportation's CMAQ Program Guide for the Regional Council of Governments

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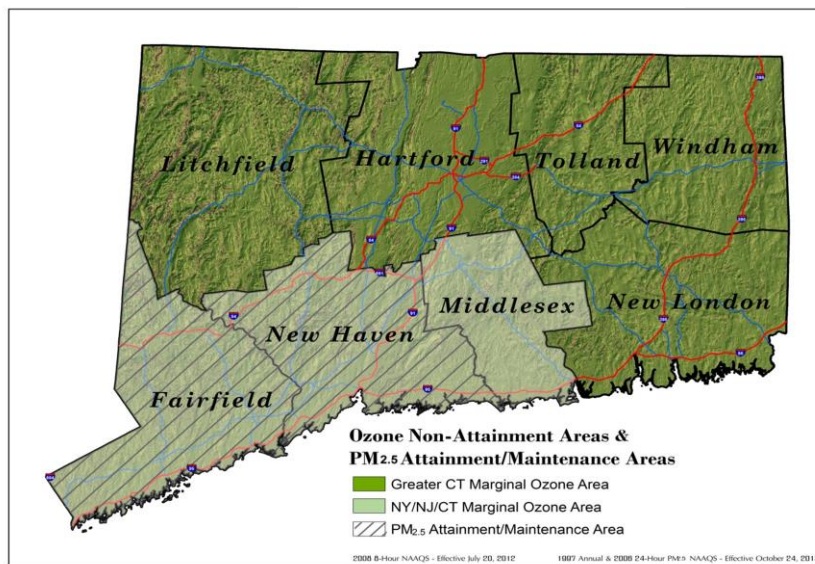
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# Introduction

The Congestion Mitigation and Air Quality (CMAQ) Improvement Program is a Federal program that funds transportation projects and programs that contribute to the attainment or maintenance of National Ambient Air Quality Standards (NAAQS) in non-attainment or air quality maintenance areas for ozone, carbon monoxide, or particulate matter under provisions in the Clean Air Act (CAA), Title 42, United States Code. The CMAQ Program was established by the 1991 Federal Intermodal Surface Transportation Efficiency Act (ISTEA) and was reauthorized with subsequent transportation bills including the more recent Moving Ahead for Progress in the 21<sup>st</sup> Century Act (MAP-21).

As a non-attainment area for ozone and an attainment/maintenance area for particulate matter (PM<sub>2.5</sub>), Connecticut receives Federal CMAQ Improvement Program funds based on the population in the non-attainment and maintenance areas of the state and the severity of air quality problems. As shown in Figure 1, Connecticut has two separate nonattainment areas for the 8-hour ozone standard, embodying the entire state. The Greater Connecticut area is classified as marginal nonattainment and consists of Hartford County, Litchfield County, New London County, Tolland County, and Windham County. The Connecticut portion of the New York/Northern New Jersey/Long Island, NY-NJ-CT area is also classified as marginal nonattainment and consists of Fairfield County, Middlesex County, and New Haven County. In addition, Fairfield and New Haven Counties were part of the New York/Northern New Jersey/Long Island, NY-NJ-CT nonattainment area for PM<sub>2.5</sub>. Effective October 24, 2013, the Connecticut portion of the NY-NJ-CT area was re-designated to attainment when the U.S. Environmental Protection Agency (EPA) approved Connecticut's maintenance plan that ensures continued attainment through the year 2025. Attachment C on page 18 contains an air emissions glossary describing targeted pollutants in the country along with their health effects.

**FIGURE 1**



This document was created for the State's Regional Councils of Governments (MPOs/Rural COGs) to assist their member municipalities and organizations that are interested in the CMAQ Program as a potential funding source. This document provides information on the CMAQ Program, outlines the procedures used by the Connecticut Department of Transportation (the Department) to select projects that are eligible for CMAQ funding, and also provides instructions for completing the Department's CMAQ application. The goal of the Department's CMAQ Program for the MPOs/Rural COGs is to deliver quality projects on budget that expand or initiate transportation services with air quality benefits for the State of Connecticut.

## Eligibility Criteria

Project and program eligibility have evolved through a series of federal guidelines that were developed and issued following the passage of ISTEA. With the passage of MAP-21, the Federal Highway Administration (FHWA) has provided new guidance under its Interim Program Guidance issued in November 12, 2013. FHWA's guidance is quite comprehensive and discusses all aspect of the CMAQ program. Please review this guidance before developing project proposals to ensure that the desired activities are CMAQ-eligible. In addition to the Interim Program Guidance, the FHWA has issued a number of guidance on specific issues, such as eligibility of freight projects and diesel retrofit programs. All of these guidance documents are available on FHWA's website at:

*[http://www.fhwa.dot.gov/environment/air\\_quality/cmaq/policy\\_and\\_guidance/](http://www.fhwa.dot.gov/environment/air_quality/cmaq/policy_and_guidance/)*

A wide and diverse variety of projects and programs are eligible for CMAQ funding. The principal requirement for determining project eligibility through the CMAQ program is that the proposed CMAQ project be located within a nonattainment area or attainment area with a maintenance plan (maintenance area) for a national ambient air quality standard and produce a reduction of mobile on-road emissions for the pollutant or precursor of concern. Furthermore, since the CMAQ program is funded by the FHWA, all CMAQ projects must follow Federal laws and regulations. CMAQ projects and programs fall into one of the following general project types:

- Diesel Engine Retrofits & Other Advanced Truck Technologies
- Transportation Control Measures (TCMs)
- Extreme Low-Temperature Cold Start Programs
- Transit Improvements
- Transportation Management Associations
- Carpooling and Vanpooling
- Carsharing
- Training
- Congestion Reduction & Traffic Flow Improvements
- Travel Demand Management

- Pedestrian and Bicycle Facilities and Programs
- Public Education and Outreach Activities
- Freight/Intermodal
- Idle Reduction
- Inspection/Maintenance (I&M) Programs
- Innovative Projects

FHWA's Interim Program Guidance provides an explanation of the types of projects likely to be implemented in each of the categories and also a list of ineligible activities. Basically each CMAQ project must meet three criteria: it must be a transportation project, it must generate an emissions reduction, and it must be located in or benefit a nonattainment or maintenance area.

Alternative fuel vehicle projects will not be accepted under this program. These types of projects should be submitted through the Department's Clean Fuel Program. For more information on this program or how to qualify, please contact Kevin Peak at (860) 594-2807 or kevin.peak@ct.gov.

### **Other Eligibility Considerations**

In addition to federal eligibility requirements, the following is a list of additional guidelines for the Department's CMAQ Program for the MPOs/Rural COGs, which are utilized when considering project proposals for funding:

1. Applicants must submit, with their completed applications, letters of commitment or resolutions to identify who will own, operate and maintain the project after it is completed, and for all matching funds. Failure to submit these letters will cause the project to be dropped from consideration.
2. The Department's System Engineering Analysis FORM (SEAFORM) should be completed and submitted with the applications for all ITS projects.
3. All candidate project proposals require endorsement by the associated COG. Endorsement can be in the form of a letter of support or a resolution. A single letter or resolution endorsing all candidate project proposals within the COG is acceptable.
4. The Department will not accept candidate project proposals directly from individual localities or project sponsors. All candidate project proposals must be submitted through the COG.
5. Operating cost for certain types of CMAQ projects are eligible for funding, and is limited to three years' worth of federal funding. Under MAP-21, the 3 years of operating assistance allowable under the CMAQ program may now be spread over a longer period, for a total of up to 5 sequential years of support. Projects which fall into this category must include a plan for continuing the service beyond the operation assistance years. This should indicate what the planned source of funds

will be that will supplant CMAQ funding, and/or how the service will become self-supporting.

6. For those projects that are selected for funding, changes to the project scope after the Department's project selection process has been completed may disqualify the project for funding.
7. Lack of progress on a project may result in the project being cancelled by the Department.
8. Project sponsors will be responsible for carrying out any required studies and/or obtaining necessary permits and approvals, including but not limited to historic and archaeological surveys and reports, state inland wetland and tidal wetland permits, and Coastal Area Management and Corps of Engineers permits.
9. Selected projects will be administered as federal-aid projects. As such, project sponsors must comply with all federal requirements, including but not limited to Disadvantage Business Enterprise contract set-asides, consultant selection procedures, and the competitive bid process. Please refer to the Department's website using the following link for additional guidance on overseeing a variety of federal and state-funded improvements on town-owned roadways that are designed by municipal staff or consultants retained by the municipality:

<http://www.ct.gov/dot/cwp/view.asp?a=2303&q=300830>

10. Projects must be designed to conform to the American with Disabilities Act requirements.
11. All projects must be constructed to federal standards with the estimated cost in the application reflecting those standards.

## Project Selection Process

In an effort to improve upon the Department's CMAQ program for the MPOs/Rural COGs, a determination was made by program administrators that there was a need to revamp the current program processes. This has been accomplished by increasing the funding level for the program to provide greater participation from the MPOs/Rural COGs, and develop and document a more transparent project selection process to provide a better understanding of the program and assist in the selection of the most cost-effective CMAQ projects.

This section of the document provides information on the Department's selection process that includes information on funding considerations, cost overruns, the solicitation process, solicitation schedule, and project selection criteria.

### **Funding Considerations**

The Department has earmarked \$10 million each year in CMAQ funds, prior to matching requirements, to fund CMAQ project proposals from the MPOs/Rural COGs. This amount will be reviewed for each solicitation period on the basis of funds provided and projects programmed.

Generally, the Federal share for CMAQ projects under this program is 80%. Projects that qualify for 100% federal funding will be funded with 100% federal share. The project sponsor is responsible for the local share for all phases. Total project cost should be between \$200,000 and \$3 million. The total cost of the project (federal and local share) includes design, ROW acquisition, construction engineering, and operating cost if applicable. Non-construction projects, such as purchasing equipment, must have a total cost of at least \$50,000 (\$40,000 federal share).

The funds provided by this program are on a cost reimbursement basis. The CMAQ Program is not a grant program. The sponsor does not receive grant funds to start the project; rather, the sponsor is reimbursed for costs incurred after receiving funding authorization for the project and a notice to proceed. Cost incurred prior to project selection and a notice to proceed will not be reimbursed.

The Department's administrative cost for overseeing the projects will not be drawn down from the project budget.

### **Cost Overruns**

Cost overruns on selected projects, whether due to poor estimates or unforeseen circumstances, will be the responsibility of the project sponsors; therefore, good cost estimating is critical, and applicants should not expect additional funding from the program. The latest Department weighted unit bid prices for project cost should be used. The Department's cost estimating guidelines can be located at the following website:

<http://www.ct.gov/dot/cwp/view.asp?a=3886&q=459664>

### **Solicitation Process**

The Department will solicit projects from all of the MPOs/Rural COGs. The MPOs/Rural COGs will be responsible for soliciting and prioritizing projects from stakeholders located within their boundaries. Each COG should review and verify project eligibility for CMAQ funding. Using its own ranking process, each COG must then submit its top **three applications** to the Department in priority order. The COG board must endorse the list of prioritized projects. Project applications received that are incomplete or deemed ineligible will not be considered.

For transit projects, the organization proposing the project must either be a designated grant recipient with the Federal Transit Administration (FTA) or there must be a designated grant recipient willing to apply on their behalf. Although private and non-profit groups may apply, the Department will only enter into an agreement with a public agency

to fund CMAQ projects. Therefore, a private or non-profit entity applying for CMAQ funds must coordinate with its respective municipality or another appropriate public sponsor.

The Department's CMAQ application (Attachment A, page 10) must be used by project sponsors to provide project and applicant information. All applications, including all supporting documentation, must be submitted to the Department's Bureau of Policy and Planning for eligibility review and rating. All applications should be submitted electronically via email to the Bureau's contact person for the CMAQ Program. The CMAQ Program Contact information is located in Attachment B on page 15. Each project proposal received will be screened for eligibility and feasibility. Those found to be eligible and feasible will be analyzed for air quality benefits by the Department's Travel Demand and Air Quality Modeling unit. The project will then be evaluated and prioritized by the Department using the Department's project rating criteria.

A copy of the application along with the emissions report for those projects that are selected for funding will then be submitted to the USDOT for final eligibility determination and approval. Project proposals that are eligible for the CMAQ program but not selected for funding will have to be resubmitted for future consideration. Projects that are determined to be eligible by FHWA will be advanced to scoping.

### **Solicitation Schedule**

Project sponsors will be provided three years within which to prepare their projects for obligation after the project has been selected for funding by the Department's selection committee. If funding for a project is not obligated within this three year period, then the project sponsor will not be allowed to submit a project for the next round of solicitation. Project sponsors may be able to request time extension due to extenuating circumstances.

### **Project Selection Criteria**

All proposed projects from the MPOs/Rural COGs utilizing CMAQ funding will be rated using the project rating criteria described below. Cost effectiveness is the primary measure that will be used in the project selection process to establish priority. Projects that provide the most cost-effective emissions reductions will be the most competitive and will rank highest overall – increasing the likelihood of being funded.

Criteria are shown with the maximum points that could be awarded. Each project can earn up to a maximum of 100 Points on the basis of the following three criteria: cost effectiveness, regional rankings and operation and maintenance plan. Project proposals will be awarded points based on a sliding scale of zero to the maximum points allowed. Two of the three criteria are provided with a table containing a sliding scale as a guide for ranking CMAQ projects.



**Rating Criteria**

- 1. Cost Effectiveness** **60 points maximum**
- 2. Regional Rankings** **20 points maximum**
- 3. Operation and Maintenance Plan** **20 points maximum**

**Total Possible Points:** **100 points maximum**

1. **Cost Effectiveness (up to 60 points):** Cost effectiveness will be assessed on the basis of annualized project cost/annual emission benefits. The cost used in this calculation will be limited to the federal share of the project. The cost/benefits ratio will be measured against all of the other applications by rank with the best ratio ranking first. Points will then be assigned to the top ten projects as follows:

<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>
<b>60</b>	<b>55</b>	<b>50</b>	<b>45</b>	<b>35</b>	<b>30</b>	<b>25</b>	<b>20</b>	<b>15</b>	<b>10</b>

2. **Regional Rankings (up to 20 points):** Projects will be given points based on the priority ranking by the MPOs/Rural COGs. The regional ranking points will be assigned as identified below:

<b>Rank</b>	<b>Points</b>
<b>1</b>	<b>20</b>
<b>2</b>	<b>10</b>
<b>3</b>	<b>5</b>

3. **Operation and Maintenance Plan (up to 20 points):** A proposal can only be effective if the agencies responsible for permitting, implementing, operating and maintaining the project have agreed to advance it. Points will be awarded based on the sponsor’s commitment to operate and manage the project/program beyond the construction and/or implementation stage. **For ITS projects, a completed System Engineering Analysis FORM (SEAFORM) is required with the applications.**

# ATTACHMENT A

## **CTDOT's CMAQ Application**

All information requested below must be furnished by the project sponsor to ensure complete processing of the application. If the information requested below does not apply to your project, indicate so by writing "NA" next to the question being asked. Submit an electronic copy of your completed application to Mr. Grayson A. Wright at grayson.wright@ct.gov.

Attach additional sheets of paper if you are unable to fit the information on the application.

### **1. Project Title**

Provide a descriptive title for the project that provides enough information to identify the project.

### **2. Project Sponsor**

Provide the name of the group or agency requesting the CMAQ activity or project.

### **3. Date**

Provide the application submittal date.

### **4. Contact Information**

Include name, title, agency, address, telephone, FAX number and email address of the individual who will be responsible for directing this project on a daily basis.

### **5. Town**

Provide the name of the town where the project is located.

### **6. Metropolitan Planning Organizations (MPOs)/Rural Council of Governments (COGs)**

Provide the name of the MPO/Rural COG that serves the area where the project will be located.

### **7. County**

Provide the name of the County where the project will be located.

### **8. CMAQ Eligible Activities**

Identify the category under which the proposed project qualifies for CMAQ funding. Indicate the category for CMAQ Eligibility from the following list. Reference FHWA's Interim Program Guidance issued in November 12, 2013 for qualifying information for

each of the headings listed below. Not all possible requests for CMAQ funding are covered. To be eligible, projects must demonstrate air quality benefits.

- Diesel Engine Retrofits & Other Advanced Truck Technologies
- Transportation Control Measures (TCMs)
- Extreme Low-Temperature Cold Start Programs
- Transit Improvements
- Transportation Management Associations
- Carpooling and Vanpooling
- Carsharing
- Training
- Congestion Reduction & Traffic Flow Improvements
- Travel Demand Management
- Pedestrian and Bicycle Facilities and Programs
- Public Education and Outreach Activities
- Freight/Intermodal
- Idle Reduction
- Inspection/Maintenance (I&M) Programs
- Innovative Projects

Additional information regarding project eligibility may also be found on-line in the federal Highway Administration's (FHWA) Final Program Guidance located here:  
[http://www.fhwa.dot.gov/environment/air\\_quality/cmaq/policy\\_and\\_guidance/](http://www.fhwa.dot.gov/environment/air_quality/cmaq/policy_and_guidance/)

## **9. Project Description**

Provide a written description of the proposed project that identifies (as appropriate):

- a. Project Location: Indicate the street or facility name and also the project limits. For roadway projects indicate the northernmost/southernmost and/or westernmost/easternmost point of the project. For transit station, transfer center or parking projects indicate the nearest intersections. Accurate descriptions are extremely important since the emissions benefits depend on the location.
- b. Identify project objectives, and why the project is needed.
- c. If the project will require operation and maintenance three years after initial construction, submit a "systems engineering analysis" indicating how the project will be maintained and operated.
- d. Specify if project will be designed in-house or by an outside consultant. If an outside consultant will be used, please follow the Department's consultant selection process. This can be located at the following link:

[http://www.ct.gov/dot/lib/dot/documents/dconsultantpubs/Consultant\\_Selection\\_Guidelines\\_December\\_2011.pdf](http://www.ct.gov/dot/lib/dot/documents/dconsultantpubs/Consultant_Selection_Guidelines_December_2011.pdf)

- e. For ITS projects, a consultant with ITS expertise should be used.
- f. If applicable, indicate how the project contributes to a reduction in congestion, i.e.

reduction in vehicular delay, increased travel speeds, etc.

Additionally, on a separate sheet(s), provide a map of the project area that shows the proposed project location.

## **10. Operations & Maintenance Plan**

- a. Identify funding and policies supporting on-going operation & maintenance
- b. Identify the aspects of the project/program needing operation or maintenance
- c. Identify the manuals [users, administrators, and maintenance], configuration records, and procedures that are to be used in operation & maintenance
- d. Identify the personnel who will be responsible for operations & maintenance
- e. Identify initial and on-going personnel training procedures, special skills, tools, and other resources
- f. Identify operations& maintenance related data to be collected and how it is to be processed and reported
- g. Identify methods to be used to monitor the effectiveness of operations & maintenance

For ITS projects, a completed System Engineering Analysis FORM (SEAFORM) is required with the applications.

## **11. Project Schedule**

Provide the project schedule for all phases, including the start and completion dates, and project milestones. Also, provide the federal fiscal year in which each phase will begin.

## **12. Estimated Budget**

Provide the total cost of the project with a breakdown by phases – Preliminary Engineering, Right-of-Way and Construction/Implementation. This includes, for example, construction estimates, equipment purchases, in-house services, and consultant services. Please use “implementation” to denote the completion of a non-construction project (e.g., purchasing buses). Good cost estimating is critical because the project sponsors will be responsible for cost overruns on selected projects. Utilize the latest CTDOT weighted unit bid prices for project cost. The Department’s cost estimating guidelines can be located at the following website:

<http://www.ct.gov/dot/cwp/view.asp?a=3886&q=459664>

## **13. Documentation of Local Match**

Provide the source of the local match. This cannot be other federal funds. **If the local government will be providing the match, complete and attach a Resolution of Intent to Provide a Local Match. The local match must be a cash match.**

## **14. Project Assessment**

To facilitate the air quality emission analysis and scoping for the proposed project, please provide the information requested below (as appropriate):

- a.** If the project involves the **purchase of vehicles** the following must be included:
  - I.** Number and type of vehicles (passenger car, school bus, truck [weight, type])
  - II.** Annual average mileage anticipated per vehicle
  - III.** Average number of days per week in service
  - IV.** Type of alternative fuel (if applicable)
  - V.** Percent time such fuel will be used (hybrids)
  - VI.** Type and fuel of vehicles being replaced if known
  
- b.** For **signal system updates**, please provide:
  - I.** Estimated completion date
  - II.** The number and location of signals
  - III.** Average Daily Traffic (ADT) by lane for each intersection for Build and No-Build Scenarios
  
- c.** For **Diesel fuel particulate filters** and other **diesel retrofit** devices, please provide:
  - I.** The type of filter
  - II.** Number and type of vehicles (bus, tractor trailer)
  - III.** Annual mileage per vehicle
  - IV.** Percent of idle time
  
- d. Alternative Fuel Vehicles:**
  - I.** Number and type of Vehicles (passenger car, school bus, truck (weight, type))
  - II.** Type of fuel for each vehicle
  - III.** Percentage of time, if hybrid, of each fuel usage
  - IV.** Number of annual average miles per vehicle
  - V.** Average number of days per week vehicle will be used
  
- e.** If **additional parking spaces** or **new parking lots** are constructed near mass transit stations, provide:
  - I.** Location of new parking spaces/lot
  - II.** The number of parking spaces or new spaces (if an existing lot)
  - III.** Any existing survey data which would provide O/D data from station area.
  
- f. Incident Management:**
  - I.** Location of project
  - II.** Estimated Build and No-Build ADT or VMT
  - III.** Length of roadway where equipment will be used (if only ADT is given)
  
- g.** For **bicycle lockers or paths:**
  - I.** Location of project
  - II.** Length of facility
  - III.** Number of potential users

- IV.** Number of lockers
- V.** Survey results if available
- VI.** Does facility have an end point in a Central Business Area?

**h. Transit Projects:**

- I.** Project type (System start-up, service and equipment, facility improvement)
- II.** Auto trips eliminated per day (round trips)
- III.** Trip length

Keep in mind, the following types of projects do not historically provide enough data to prepare a quantitative analysis; therefore they will require some subjective judgments about their potential benefits, hence they are analyzed qualitatively:

- o Marketing of Transit Services
- o Telecommuting
- o Research and Support programs
- o Variable Message Signs

In all cases, please provide all necessary data (even if not listed above) to facilitate emission analysis procedures. The nature of the project defines what is needed to complete an analysis.

Signature of Authorized Representative: \_\_\_\_\_ Date: \_\_\_\_\_

Name: \_\_\_\_\_

Title: \_\_\_\_\_

## ATTACHMENT B

### **CMAQ Program Contacts**

#### CTDOT's Contacts

##### **Program Administrator**

Maribeth Wojenski  
Transportation Assistant Planning Director  
Connecticut Department of Transportation  
Bureau of Policy and Planning  
2800 Berlin Turnpike  
P.O. Box 317546  
Newington, CT 06111  
**maribeth.wojenski@ct.gov**  
(860) 594-2045  
Fax: (860) 594-2056

##### **Contact Person**

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Transportation Planner 2  
Connecticut Department of Transportation  
Bureau of Policy and Planning  
2800 Berlin Turnpike  
P.O. Box 317546  
Newington, CT 06111  
**grayson.wright@ct.gov**  
(860) 594-2154  
Fax: (860) 594-2056

#### Contacts for the MPOs/Rural COGs

Capitol Region Council of Governments  
241 Main Street  
Hartford, CT 06106  
(860) 522-2217  
Fax: (860) 724-1274  
Lyle Wray – Executive Director  
[lwrap@crcog.org](mailto:lwrap@crcog.org)

Central Connecticut MPO  
C/O Tim Malone  
241 Main Street  
Hartford, CT 06106  
[tmalone@crcog.org](mailto:tmalone@crcog.org)

Lower Connecticut River Valley Council of Governments  
145 Dennison Road  
Essex, CT 06426  
(860) 581- 8554  
Fax: (860) 581-8543  
Samuel Gold – Executive Director  
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COG of the Central Naugatuck Valley  
Valley COG  
49 Leavenworth Street, Suite 303  
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Dave Hannon – Executive Director  
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Northwest Hills Council of Governments  
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Goshen, CT 06756  
(860) 491-9884  
Fax: (860) 491-3729  
Richard Lynn – Executive Director  
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Dayville, CT 06241  
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John Filchak – Executive Director  
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South Central Regional Council of Governments  
127 Washington Avenue – 4<sup>th</sup> Floor-West



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(203) 234-7555  
Fax: (203) 234-9850  
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South Western CT MPO  
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[jbutler@seccog.org](mailto:jbutler@seccog.org)

# ATTACHMENT C

## *Air Emissions Glossary*

**Carbon Monoxide (CO)** - Carbon monoxide is a colorless, odorless gas produced whenever incomplete fuel combustion occurs. In the United States, more than two-thirds of the carbon monoxide emissions come from transportation sources. In urban areas, motor vehicle contributions to carbon monoxide pollution can exceed ninety percent.

When inhaled, the gas forms carboxyhemoglobin, a compound that disrupts normal respiration by inhibiting the transfer of oxygen to specialized blood cells that transport the oxygen throughout the body. Symptoms from exposure include impairments in visual perception, manual dexterity, learning functions and the ability to perform complex tasks. Sensitive individuals, such as infants, the elderly or respiratory patients may be highly susceptible to acute symptoms of carbon monoxide poisoning.

**Particulate Matter (PM<sub>10</sub> and PM<sub>2.5</sub>)** - Particulate matter consists of airborne solid particles and liquid droplets. These particles are classified as "coarse" if they are smaller than 10 microns or "fine" if they are smaller than 2.5 microns. Coarse airborne particles are produced during grinding operations or from the physical disturbance of dust by natural air turbulence processes, such as wind. Fine particles can be a byproduct of fossil fuel combustion, such as diesel and bus engines.

Fine particles can easily reach remote lung areas, and their presence in the lungs is linked to serious respiratory ailments such as asthma, chronic bronchitis and aggravated coughing. Exposure to these particles may aggravate other medical conditions such as heart disease and emphysema and may cause premature death. In the environment, particulate matter contributes to diminished visibility and particle deposition (soiling).

**Ozone (O<sub>3</sub>)** - Ozone is a chemically unstable molecule composed of three oxygen atoms. Ground level ozone is formed by sunlight and heat acting upon fuel combustion by products such as nitrogen oxides and hydrocarbons. Ozone occurs naturally in the upper atmosphere and shields the Earth from ultraviolet radiation. However, at ground level, ozone is a severe irritant and the primary component of "smog". In urban areas, at least half of the ozone producing components comes from transportation sources such as automobiles. Because ozone formation is directly related to atmospheric temperatures, problematic ozone levels occur most frequently on hot summer afternoons.

Ozone exposure is linked to respiratory illnesses such as asthma and lung inflammation. Extended ozone exposure can exacerbate existing respiratory ailments such as chronic bronchitis and emphysema. Ozone pollution can severely damage vegetation including agricultural crops and forest habitats.

**Nitrogen Oxides (NO<sub>x</sub>)** - Nitrogen oxides form when nitrogen and oxygen atoms chemically react inside the high pressure and temperature conditions in an engine.

Nitrogen oxides are precursors for ozone, and in the environment, they contribute to the formation of acidic rain.

**Hydrocarbons (HC) or Volatile Organic Compounds (VOC)** - Hydrocarbon emissions are a product of partial fuel combustion, fuel evaporation and refueling losses caused by spillage and vapor leakage. Hydrocarbons react with nitrogen oxides and sunlight to form ozone. Some hydrocarbons are toxic and may be carcinogenic.