Approaches to Conducting PM2.5 Model Attainment Demonstrations

Paper # 429

Authors: Dr. Howard Ellis, QEP, Ganesh Srinivasan, Surya Ramaswamy, Adeel Yousuf and Dr. Allen Dittenhoefer, Enviroplan Consulting, Fairfield, New Jersey

ABSTRACT

In September 2006, U.S. EPA issued its Draft Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 and Regional Haze [(1)]. In March 2007, U.S. EPA issued its PM2.5 SIP Implementation Rule[(2)].

By April 2008, states and tribes with PM2.5 designated nonattainment areas are obligated to submit State Implementation Plan revisions demonstrating attainment of the PM2.5 annual and 24-hour National Ambient Air Quality Standards (NAAQS) as expeditiously as possible. This SIP revision must include a Model Attainment Demonstration to show that the PM2.5 NAAQS will be attained based on the SIP control measures.

This paper presents ideas for making cost effective Model Attainment Demonstrations for the PM2.5 NAAQS based on the authors' experience in this work. Examples from actual Model Attainment Demonstration work are provided. It is directed to those personnel responsible for developing and responding to government initiatives to develop the State Implementation Plans for attaining the PM2.5 NAAQS.

INTRODUCTION

In 1971, EPA established National Ambient Air Quality Standards (NAAQS) for particulate matter and revised the NAAQS in 1987, 1997, and 2006. The revised 2006 standards address both fine particles ($PM_{2.5}$), and PM_{10}. Recent revisions to the NAAQS tightened the 24-hour $PM_{2.5}$ standard from 65 micrograms per cubic meter ($\mu g/m^3$) to 35 $\mu g/m^3$. The annual $PM_{2.5}$ NAAQS and the 24-hour PM_{10} NAAQS remain unchanged. However EPA has revoked the annual PM_{10} NAAQS due to a lack of evidence linking health problems to long-term exposure to PM_{10}. [(3)]

Figure 1 shows U.S. EPA modeled projections of the PM2.5 attainment status throughout the U.S. in 2020 based on the On-the-Books controls. This figure shows that small areas of the U.S. in the Midwest, Southeast and West will still be nonattainment in 2020.

The final Staff Paper to the EPA Administrator offered two options for the annual $PM_{2.5}$ NAAQS revision as follow:

1. Retain the current annual standard of 15 $\mu g/m^3$, or

2. Lower the annual NAAQS to 12 to 14 $\mu g/m^3$

In addition to the above, EPA's Clean Air Scientific Advisory Committee recommended that the annual $PM_{2.5}$ NAAQS be lowered to 12 to 14 $\mu g/m^3$ as a future changes to the $PM_{2.5}$ NAAQS. While this poses a great threat to all major source categories, there is a significant risk that the next revision of the $PM_{2.5}$ NAAQS will lower the annual $PM_{2.5}$ NAAQS to below 15 $\mu g/m^3$.

States must submit State Implementation Plans (SIPs) to U.S. EPA by April 2008, demonstrating attainment of the $PM_{2.5}$ annual and 24-hour NAAQS. This SIP revision must include a Model Attainment Demonstration to show that the $PM_{2.5}$ NAAQS will be attained based on the control measures included in the SIP. An effective SIP should be drafted based on air quality modeling analyses that demonstrate attainment of the NAAQS with regard to specific air pollution emission controls included in the SIP.

2. LIMITATIONS WITH THE CURRENT MODEL ATTAINMENT DEMONSTRATION AND SIP DEVELOPMENT PROCESS

There are several limitations with the current Model Attainment Demonstration and SIP development process for PM2.5.

First, the Model Attainment Demonstration Guidance from U.S. EPA requires that speciated PM2.5 concentrations need to be projected at all Federal Reference Method PM2.5 monitor sites from the much more limited number of sites in which the speciated PM2.5 concentrations are actually measured. The spatial interpolation procedure offered by U.S. EPA may or may not bear a close relationship to the actual speciated concentrations occurring at each FRM monitor site for PM2.5.

Second, the PM2.5 emissions inventory and the speciation of those emissions are not based on any Reference Test Methods for PM2.5 but on emission factors from U.S. EPA's emission factor database, AP-42. This data base is based on either no PM2.5 measurement data that considers both the filterable and condensable portion of PM2.5 or only limited data using test methods recognized by U.S. EPA to contain sampling artifacts that distort measurement results. U.S. EPA is in the process of developing a Reference Test Method for PM2.5 that measures both the filterable and condensable PM2.5 emissions but this test method is yet to be finalized.

Third, U.S. EPA recognizes the potential for the organic carbon PM2.5 emissions predicted by the current emissions model, Mobile6, may undertake by several times the actual organic carbon emissions from motor vehicles. This distorts the resulting PM2.5 emissions inventories and the resulting impacts of motor vehicle control scenarios on making progress in attaining the PM2.5 NAAQS.

EPA Model Attainment Demonstration for Choosing New Emission Controls

$$\mathbf{P} = \mathbf{RRF} \times \mathbf{M}$$

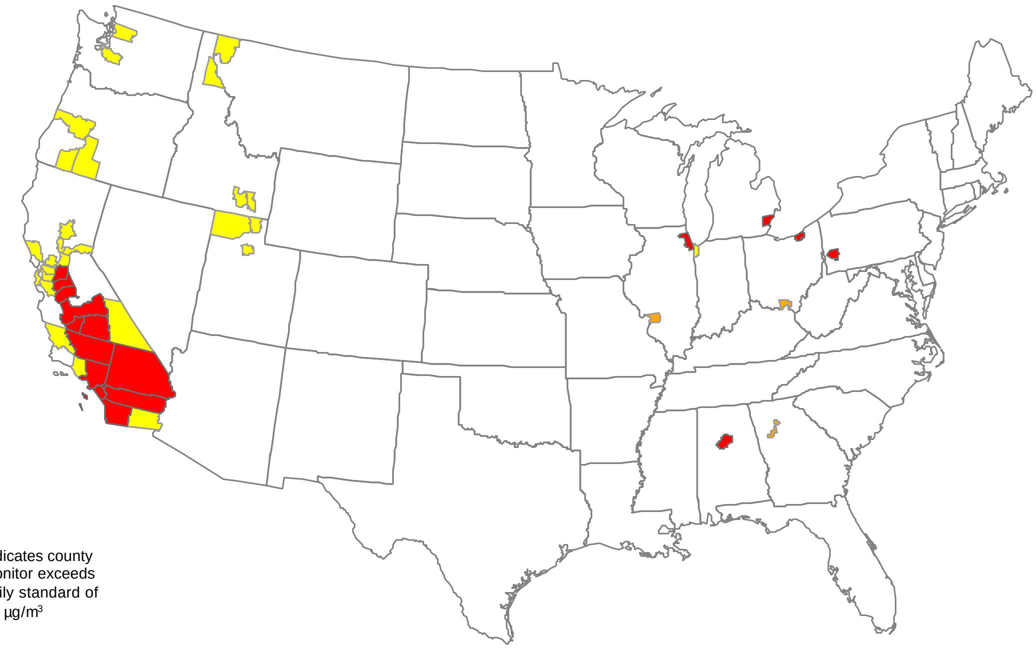
P	=	Future Predicted Design Concentration
M	=	Base Year Monitored Design Concentration
RRF	=	Ratio of Predicted Future to Base Year Design Concentration for a Given Control Scenario

Based on the air quality modeling results for the regulatory base case [(2)], several nonattainment counties for the $PM_{2.5}$ NAAQS in eastern and western States are forced to develop and adopt additional controls to attain the revised standards (Figure 1). The regulatory base case includes emissions from the power generation sector - the Clean Air Interstate Rule (CAIR), the Clean Air Mercury Rule (CAMR), and the Clean Air Visibility Rule (CAVR), and mobile sources and non-road mobile sources. [(2)]

As a first step in developing the SIP, the targeted agency should identify cost-effective controls to apply in each projected nonattainment area to attain the 1997 as well as the revised and alternative suites of standards. How will EPA and States Agencies decide what cost-effective controls from what source categories are needed to attain the Current PM2.5 NAAQS? The rest of the paper discusses and presents ideas for making cost effective Model Attainment Demonstrations for the PM2.5 NAAQS.

Counties Projected to Violate the Revised $PM_{2.5}$ NAAQS in 2020

With CAIR/CAMR/CAVR and Some Current Rules** Absent Additional Local Controls



Indicates county monitor exceeds daily standard of 35 µg/m³

Indicates county monitor exceeds annual standard of 15 µg/m³

Indicates county monitor exceeds both the annual standard of 15 µg/m³ and the daily standard of 35 µg/m³

Counties Projected to Exceed Revised Standards

	Annual and Daily	*Annual Only*	*Daily Only*
2015	18	2	32
2020	17	3	28

* Projections as of September 2006.
**Current rules include Title IV of CAA, NOx SIP Call, and some existing State rules

Figure 1: Counties Projected to Violate the Revised PM2.5 NAAQS in 2020

What Can An Electric Power Company Do?

Make Sure the Emissions Inventory Data Used for Your Facilities is Accurate

Electric Power Companies can choose to be proactive and avoid significant financial burden at a later stage to comply with EPA's new standard. The Electric Power Companies should make sure that the Emission Inventory Data used for predicting Base Year and Future Year PM2.5 values are accurate. This can be achieved by following the steps listed below:

1. Ensure that the Actual fuel use and activity levels are used in creating the Base Year Inventory.

2. Project fuel use and activity levels for the selected Future Year and make sure that it matches with EPA, your Regional Planning Organization and State projections.

3. Verify the Gram-moles per second emission rate for each of the 18 vapor phase air pollutants from each stack used in the Inventory.

4. Verify the total PM2.5 emissions from each stack.

5. Verify the total PM2.5 fugitive emissions from plant roads, storage piles, conveyors and other fugitive sources.

6. Verify the speciation of Primary PM2.5 Stack and Fugitive Emissions into Seven Components.

7. Verify Stack Gas Exit parameters.

8. Verify Fugitive emissions spatial geometry.

9. Verify other exit parameters.

Negotiate the Detailed Modeling Protocol Used to Predict Base Year and Future Year Concentrations

After completing the steps outlined above, you should negotiate the detailed modeling protocol to be used for predicting Base Year and Future Year Concentrations. Some of the points to be considered during the negotiations are listed below.

1. Predict only at PM2.5 "Population-Oriented" Monitor Sites.

2. Predict only 24-Hour Concentrations as Permitted for "Unique Population-Oriented Monitor Sites".

3. Exclude One or More of Your Power Plants from Local Scale Modeling.

   Demonstrate through local scale modeling that they are small contributors to the total PM2.5 concentration at each PM2.5 monitor site exceeding the NAAQS.

4. Increase the Organic Carbon (OC) and Other Particulate Matter (PM) Emissions from Motor Vehicles.

   EPA has suggested that the current OC emission factor used for motor vehicles may be as much as a factor of three low.

   Government/Industry test program of particulate emissions from 480 motor vehicles just completed.

   EPA expects to revise the motor vehicle emission factors for OC and other PM emissions.

EPA's upward revisions in OC and other PM emissions from motor vehicles may not be in time to affect the PM Model Attainment Demonstrations due April 2008.

Conclusion: Negotiate with EPA, your Regional Planning Organization and State to increase the Motor Vehicle Organic Carbon (OC) and other PM emission rates used in the Model Attainment Demonstrations.

5. Avoid Double Counting of Predictions from Regional and Local Scale Modeling.

Conduct Sensitivity Analyses

Ozone Sensitivity Analysis

A sensitivity analysis could be conducted to determine the impact on the Future Design Concentration (P) of zeroing out emissions from the electric utility plants and from other source categories. The PM sensitivity analysis is currently in progress; however an ozone sensitivity analysis was performed in a nonattainment area. The impact on the highest ozone concentrations of zeroing out NO_x emissions from electric generating units, motor vehicles and off-road engines are shown in Table 1.

2009 Emissions Inventory	**Highest 2009 Concentration (ppb)**
On the Books Controls	89.3
Zero Out NOx Emissions from All EGUs	89.3
Zero Out Emissions from All Non-Road Engines in Construction	86.8
Zero Out Emissions from All Motor Vehicles	86.3
National Ambient Air Quality Standard is 84.9 ppb	

Table 1: Ozone Sensitivity Analysis in a Nonattainment area

Observing the results in Table 1, it could be concluded that zeroing out NO_x emissions from local power plants have no impact on highest ozone concentrations and zeroing out local motor vehicle emissions or non-road engine emissions significantly lowers highest ozone concentrations.

PM Sensitivity Analysis

As mentioned earlier the sensitivity analysis for PM is in progress, however the expected results is discussed in this section. As shown in Figure 2, in urban areas in the East and Midwest at Population-Oriented Monitor Sites, organic carbon and sulfates are typically the largest contributors to the total annual average of $PM_{2.5}$ concentration with nitrates being a smaller contributor.

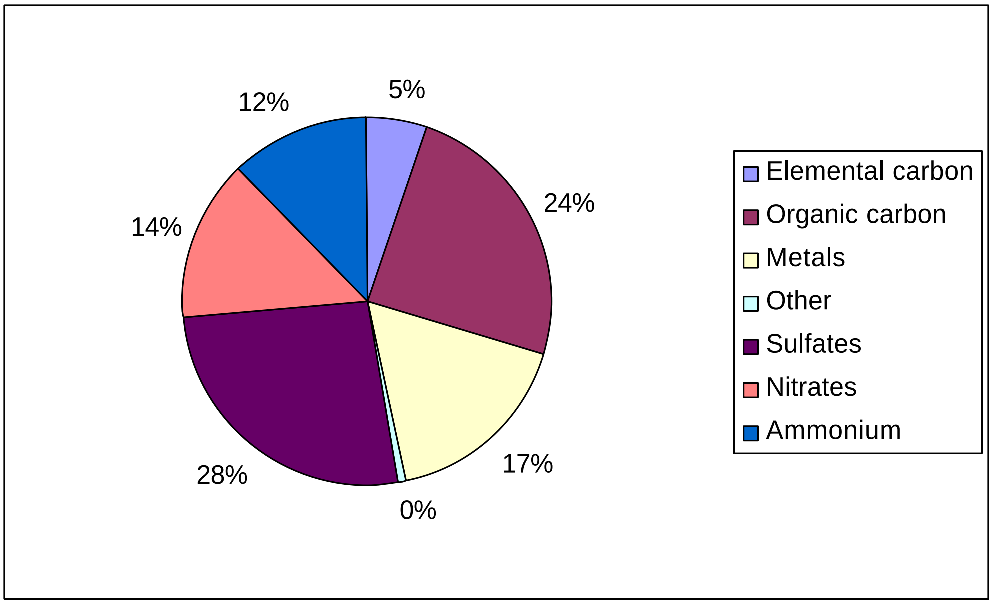


Figure 2: Composition of $PM_{2.5}$ in Urban Areas of Eastern Half of the U.S

Organic carbon (24 %), which is the dominant portion of the $PM_{2.5}$ concentrations, is typically from local motor vehicle and off-road engine emissions within the nonattainment area. Almost all of the $PM_{2.5}$ sulfate concentrations and a portion of the nitrate concentrations are from distant sources of SO_2 and NO_x emissions outside the nonattainment area. Additional controls on $PM_{2.5}$ and its precursor emissions from local power plants are not expected to help much in lowering the highest $PM_{2.5}$ concentrations in the nonattainment area. However additional controls on SO_2 and possibly NO_x from distant power plants outside the nonattainment area are expected to help more in lowering the highest $PM_{2.5}$ concentrations in the nonattainment area.

If the annual $PM_{2.5}$ concentrations are decreasing over time, the base year in the model attainment demonstration could be changed to a more recent year. A group of economically and politically feasible control scenarios could be selected for evaluation. The cost effectiveness of different control scenarios by calculating for each the reduction in $PM_{2.5}$ annual average design concentration per unit cost ($\mu g/m^3$ per $ cost) could be determined. Based on this the most feasible control scenario could be chosen.

Control Strategies

This section of the report presents the number of different emission control strategies from two major source categories: Motor Vehicles and Off-Road Engines, where each of these control strategies is evaluated to meet the goals. Clearly, control of these sources will form a crucial part of any control strategy to bring the nonattainment area into attainment of the standards. This part of the report presents the controls applied over HDDVs (Heavy-Duty Diesel Vehicles), LGVs (Light Duty Gasoline Vehicles) and non-road vehicles in Construction and Agricultural sectors.

Local Control Scenarios for On-Road Engines

Control Scenarios for HDDVs

Heavy-duty trucks and buses account for about one-quarter of PM emissions from mobile sources.[3] The large majority of Particulate Matter (PM) emissions from HDDVs are PM2.5. More than 50% of PM emissions from on-road mobile sources in 2009 typically will be from HDDVs. Following control options on HDDVs will assist the state agencies certainly in attaining the standards.

Control Option 1: Modernize Private Sector HDDV Fleets with incentives to replace older vehicles/engines with ones meeting the 2007 PM emission standards.

Control Option 2: Modernize Government Sector HDDV Fleets with incentives to replace older vehicles/engines with ones meeting the 2007 PM emission standard:

- School buses
- Refuse collection trucks
- Other HDDVs

Control Option 3: Speed limit and idling restrictions for HDDVs

Control Scenarios for LGVs

Emissions from light-duty gasoline vehicles may be significant contributors to ambient PM concentrations. Following control options on LGVs will assist the state agencies certainly in attaining the standards.

Control Option 1: Expand Inspection and Maintenance Programs

Control Option 2: Implement Vehicle Scrappage Program Incentives for Oldest public and Private Sector Vehicles.

Local Control Scenarios for Non-Road Engines

About 55% of projected 2009 non-road PM emissions were from the non-road diesel equipment and over 90% of non-road diesel engine PM emissions were $PM_{2.5.}$ The emission rates for the non road diesel engines of different capacities are given in Table 2.

Engine Size (hp)	Model Year	Emission Rates (grams/bhp-hr)
175-750	1996+	0.40
750+	2000+	0.40
175-300	2003+	0.15
300-600	2001+	0.15
600-750	2002+	0.15
750+	2006+	0.15

Table 2: PM Emission Standards for Non-Road Diesel Engines

Source: Emission Standards Reference Guide for Heavy-Duty and Nonroad Engines, US EPA, (http://www.epa.gov/otaq/cert/hd-cert/stds-eng.pdf)

Control Options

Control Option 1: Non-road engines in construction and agricultural sectors could be modernized, incentives to replace pre-2001 engines having 0.4 or higher gms/bhp with ones meeting the 0.15 gms/bhp standard could be provided.

Control Option 2: $PM_{2.5}$ after treatment device retrofits for non-road engines could be undertaken.

CONCLUSIONS

Following are the conclusions derived from this study:

- Finding economically and politically feasible $PM_{2.5}$ control scenarios that attain the $PM_{2.5}$ annual NAAQS cost effectively may be difficult.

- The above approach provides ways that will help government and the electric power industry realize this goal.

REFERENCE:

1. U.S. EPA, Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 and Regional Haze, Office of Air Quality Planning and Standards, Air Quality Modeling Group, Research Triangle Park, NC, Draft 3.2-September 2006

2. 40 CFR Part 51, Subpart Y - Provisions for Implementation of PM2.5 National Ambient Air Quality Standards, March 2007

3. U.S. EPA, See http://epa.gov/pm/naaqsrev2006.html

4.

U.S. Environmental Protection Agency (EPA). See http://www.epa.gov/ttn/ecas/regdata/RIAs/Executive%20Summary.pdf (accessed January 2007).

U.S. Environmental Protection Agency (EPA). See http://www.epa.gov/otaq/retrofit/documents/f03015.pdf (accessed January 2007).