United States Environmental Protection Agency
National Vehicle and Fuel Emissions Laboratory

March 30, 1999

MEMORANDUM

Subject: Photochemical Air Quality Simulations in Support of Tier 2/Sulfur

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To: Docket A-97-10

I. Introduction

Photochemical air quality simulations were used to estimate the impact of the proposed Tier 2/Sulfur controls on ozone levels in the OTAG domain. The results of this work and an outline of the methodology are presented in the Preamble (Chapter 3, Subsection B.1) and the Tier 2 Regulatory Impact Analysis (RIA) (Chapter 3, Subsection B.1). The present document provides or references detailed documentation of the photochemical air quality simulations used to estimate the effects of Tier 2/Sulfur.

II. Modeling System

We used the considerable modeling work done for the ROTR as a foundation to estimate the impact of the proposed Tier 2/Sulfur controls on ozone levels in the OTAG domain. The OTAG modeling was designed to evaluate the impact of regional precursor controls on ozone formation. The OTAG simulations use the UAM-V modeling system.[1] UAM-V is a recent, variable-grid version of the UAM (Urban Airshed Model), which has been used and developed since the early 1970s. The OTAG domain includes all or part of 37 states in the eastern half of the United States. Four historical ozone episodes, from 1988, 1991, 1993, and 1995, each about 10 days long, were used to examine regional ozone problems in the eastern U.S. Emissions inventories and meteorology were developed for each episode. When the photochemical air quality simulation was judged to satisfactorily reproduce the historical episodes, the meteorology was retained and emission inventories for various test cases (base and control) were substituted for the historical emission inventories. The test cases were applied to all four episodes. The results from base and control cases are compared with each other to estimate the effects of the control scenarios.

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[1] *User's Guide to the Variable-Grid Urban Airshed Model (UAM-V)*, October 1996, Systems Applications International, 101 Lucas Valley Road San Rafael, California 94903, 415 507-7100.

The OTAG modeling is described in the *OTAG Technical Supporting Document*, Chapter 2, "Regional and Urban Scale Modeling Workgroup," which is in Docket A-96-56, Category II-A-14. It is also on the Web at http://www.epa.gov/ttn/otag/finalrpt/. This document describes in detail the domain, grid structure, episodes, meteorology, boundary conditions, initial conditions, and chemistry.

III. Emission scenarios simulated

Seven emission scenarios were employed to analyze and evaluate the Tier 2/Sulfur proposal. They are summarized in Table 1, below. Each scenario was applied to the four OTAG episodes. Inputs for these scenarios differ from each other only in their non-biogenic emissions. Control parameters, domain, grid structure, episodes, meteorology, boundary conditions, initial conditions, biogenic emissions, and chemistry are the same for all scenarios. All UAM-V input files for these simulations plus ground-level ozone outputs are in EPA Air Docket A-97-10 on 8 mm tape under the title, "Data tapes containing input and output files for photochemical air quality simulations referenced in the Preamble and RIA of the Tier 2/Sulfur NPRM." They are also available by FTP from ftp://www.epa.gov/pub/scram001/modelingcenter/Tier_2/. The name of each file, the episode to which it applies, and the case represented are identified in an ASCII "readme" file.

Table 1. Emission scenarios simulated for the Tier 2/Sulfur analysis.

Scenario	*Description/Use*
1995/96 Base Year	For projecting 1995-1997 design values
2007 ROTR (SNPR Inventory)	Used as base case for OMS1 and OMS2
2007 ROTR (Final Inventory)	Used as base case for OMS3 and OMS4
OMS1	Exploratory run: Mobile source VOC reduction only
OMS2	Exploratory run: Mobile source NO_X reduction only
OMS3	2020 Tier 2/Sulfur benefits (VOC and NO_X)
OMS4	2007 Tier 2/Sulfur benefits (VOC and NO_X)

A. Base Cases

The base case we used for examining the effects of Tier 2/Sulfur is the ROTR in 2007. It is intended to represent ozone levels without Tier 2/Sulfur controls. We used two versions of this base case. The first was published with the ROTR's Supplemental Notice of Proposed Rulemaking (SNPR) and used the SNPR emission inventories. The second used the Final SIP Call Budget Inventory, an improved inventory based on public comments and updates from the states.

A third base case of importance in this analysis is 1995/96. This case is used in the rollback method to project 1995-1997 design values for both the 2007 ROTR base case and the various Tier 2/Sulfur control cases. These three base cases and their supporting documentation are listed below:

1. 2007 ROTR SNPR. This inventory was published with the ROTR SNPR. It was the best available inventory at the time OMS1 and OMS2 were run. The preparation of this emission inventory is documented in the "Supplemental Notice for the Findings of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone; Proposed Rule," Chapter VII, "Air Quality Assessment of the Statewide Emissions Budgets," *Federal Register*, Vol. 63, No. 90, May 11, 1998, pages 25953-25967.

2. 1995/96 Base Year. This case, combined with test cases, is used to project design values for the test cases. The method for doing this is described in the RIA, Chapter III, Section B.1.c, "The 'Rollback method' for Estimating Design Values Resulting from Control Measures". The Base Year inventories for design value projections were the "Final" Base Year emissions developed for the NOx SIP Call Final Rulemaking. The preparation of this emission inventory is documented in "Development of Modeling Inventory and Budgets for Regional NO_X SIP Call", U.S. Environmental Protection Agency Office of Air Quality Planning and Standards September 24, 1998. It is in Docket A-96-56, Category VI-B-10. This document is also available as a WordPerfect file, budg_tsd.wpd, from ftp://www.epa.gov/pub/scram001/modelingcenter/budget/.

3. 2007 ROTR (Final SIP Call Budget Inventory). This is an improved inventory based on public comments and updates from the states. The preparation of this emission inventory is described in the same document as the 1995/96 Base Year above: "Development of Modeling Inventory and Budgets for Regional NO_x SIP Call," U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, September 24, 1998.

B. Control Cases

Table 2 lists the four control cases used in our analysis. The emissions for each of these is expressed as a percent reduction in on-highway emissions from the base case. The differences between these six simulations are only in the emissions inputs. Boundary and initial conditions were not changed.

Table 2. Percent reductions for Tier 2/Sulfur ozone modeling runs.			
Run	*% Reduction in on-highway emissions from the Base Case*		*Base Case*
	NO_X	*VOC*	
OMS1	0%	30.3%	2007 ROTR (SNPR Inventory
OMS2	54.2%	0%	
OMS3	50.2%	10.5%	2007 ROTR (Final Inventory, September 1998)
OMS4	18.5%	4.3%	

To facilitate the ozone modeling, the emission reduction due to Tier 2/Sulfur controls was expressed as a percentage reduction from the 2007 post-ROTR emission inventory for all highway mobile sources. These percentage reductions were applied everywhere in the modeling domain to all on-highway emissions in the base case. The proposed Tier 2/Sulfur program would achieve almost all of its emission reductions from cars and light trucks, but converting these reductions to a percentage of all on-highway emissions greatly streamlined the process of modeling the proposed Tier 2/Sulfur controls. The method for calculating the percent reductions used in the OMS runs is described in a memorandum to Docket A-97-10, "Methodology for Developing Inventory Reductions Used in Ozone Modeling," by John W. Koupal.

Expressing the emission reduction due to Tier 2/Sulfur as a percentage reduction in all on-highway mobile sources assumes that car and light truck emissions make up the same proportion of on-highway mobile source emissions everywhere. In fact, light vehicle emissions are generally somewhat more concentrated in urban and suburban areas while heavy vehicle emissions are generally somewhat more concentrated in rural areas due to their greater share of traffic on rural interstate highways. The result is a geographic allocation that may understate some urban decreases in NO_X and VOC and overstate some rural ones resulting from Tier 2/Sulfur controls. However, on the scale of regional analysis provided by the OTAG model, we believe that these effects do not affect our overall conclusions concerning the region wide benefits of Tier 2/Sulfur controls.

The OMS3 run was intended to simulate the effects that the Tier 2 proposal would have on ozone levels in 2020. We used the technique described above to adjust the final 2007 post-ROTR inventories to reflect the emission benefits projected to result in 2020 of vehicle and fuel standards that were very close to our proposed standards.[2] We assumed that in the absence of Tier 2/Sulfur controls, total anthropogenic emissions of ozone precursors would remain unchanged between 2007 and 2020. This assumption is not unreasonable. Our best current estimate is that in the continental U.S. excluding California, anthropogenic NO_X emissions in 2020 will be 3% lower and anthropogenic VOC emissions in 2020 will be 5% higher than in

[2] They were not exactly the same because OMS3 was run before the Tier 2/Sulfur proposal was finalized. We estimated the effect of the final proposal by linear interpolation, as described in the RIA.

2007. These estimates include updated estimates of nonroad mobile source emissions, the emission effects of highway heavy-duty diesel engine defeat devices and the recent settlement reached by EPA and the manufacturers of these engines, and the emission inventory modeling changes expected at this time to be incorporated in MOBILE6. The details of these estimates are in Section A of Chapter III of the RIA, "Inventory Impacts of Tier 2/Sulfur."

IV. Ozone Metrics

A number of different ozone metrics (measures of ozone over all or a part of the modeling domain) have been developed to compare the ozone concentrations in the base case with those in the control case. One of the most useful of these, because of its relationship to measured design values used to determine attainment and nonattainment, is projected design values. The Preamble emphasizes this metric, and it is fully described and referenced in the RIA. The method for calculating this metric is described in the RIA, Chapter III, Section B.1.c, "The 'Rollback Method' for Estimating Design Values Resulting from Control Measures."

The other metric we use is "Grid Cell Days Above the Standard," which is a count of all the grid cells on all simulation days (except for 2 or 3 startup days in each episode) that the daily maximum ozone concentration (either 1- or 8-hour average, depending on the specific metric) exceeded the standard. For this concentration to exceed the standard, the daily maximum ozone concentration must equal or exceed 85 ppb for the 8-hour standard and 125 ppb for the 1-hour standard.