Chapter 2: Defining the $PM_{2.5}$ Air Quality Problem

Synopsis

This chapter characterizes the nature, scope and magnitude of the current and future-year $PM_{2.5}$ problem. It includes 1) a summary of the spatial and temporal distribution of the major chemical components of $PM_{2.5,}$ and their likely origin from direct emissions or atmospheric transformations of gaseous precurors; 2) brief summary insights from recent U.S. studies that attempt to apportion components of $PM_{2.5}$ mass to various emission sources; 3) an overview of 'current' and projected emissions inventories that we used to estimate air quality impacts for our regulatory base case and control cases; and 4) estimates of projected air quality in 2015 and 2020, which form the regulatory base cases for this analysis.

2.1 Composition of $PM_{2.5}$

Particulate matter (PM) is a highly complex mixture of solid particles and liquid droplets distributed among numerous atmospheric gases which interact with solid and liquid phases. Particles range in size from those smaller than 1 nanometer (10^{-9} meter) to over 100 micrometer (µm, or 10^{-6} meter) in diameter (for reference, a typical strand of human hair is 70 um in diameter and a grain of salt is about 100 um). Atmospheric particles can be grouped according to several classes according to their aerodynamic and physical sizes, including ultrafine paticles (<0.1 um), accumulation mode or 'fine' particles (< 1 to 3 um), and coarse particles (>1 to 3 um). For regulatory purposes, fine particles are measured as $PM_{2.5}$ and inhalable or thoracic coarse particles are measured as $PM_{10-2.5}$, corresponding to their size (diameter) range in micrometers and referring to total particle mass under 2.5 and between 2.5 and 10 micrometers, respectively. The EPA currently has standards that measure $PM_{2.5}$ and PM_{10}.

Particles span many sizes and shapes and consist of hundreds of different chemicals. Particles are emitted directly from sources and are also formed through atmospheric chemical reactions; the former are often referred to as "primary" particles, and the latter as "secondary" particles. Particle pollution also varies by time of year and location and is affected by several weather-related factors, such as temperature, clouds, humidity, and wind. A further layer of complexity comes from particles' ability to shift between solid/liquid and gaseous phases, which is influenced by concentration and meteorology, especially temperature.

- Particles are made up of different chemical components. The major chemical components include carbonaceous materials (carbon soot and organic compounds), and inorganic compounds including, sulfate and nitrate compounds that usually include ammonium, and a mix of substances often apportioned to crustal materials such as soil and ash (Figure 2-1). The different components that make up particle pollution come from specific sources and are often formed in the atmosphere. As mentioned above, particulate matter includes both "primary" PM, which is directly emitted into the air, and "secondary" PM, which forms indirectly from fuel combustion and other sources. Primary PM consists of carbonaceous materials (soot and accompanying organics)—emitted from cars, trucks, heavy equipment, forest fires, some industrial processes and burning waste—and both combustion and process related fine metals and larger crustal material from unpaved roads, stone crushing, construction sites, and metallurgical operations. Secondary PM forms in the atmosphere from gases. Some of these reactions require sunlight and/or water vapor. Secondary PM includes:

- Sulfates formed from sulfur dioxide emissions from power plants and industrial facilities;
- Nitrates formed from nitrogen oxide emissions from cars, trucks, industrial facilities, and power plants; and
- Organic carbon formed from reactive organic gas emissions from cars, trucks, industrial facilities, forest fires, and biogenic sources such as trees.

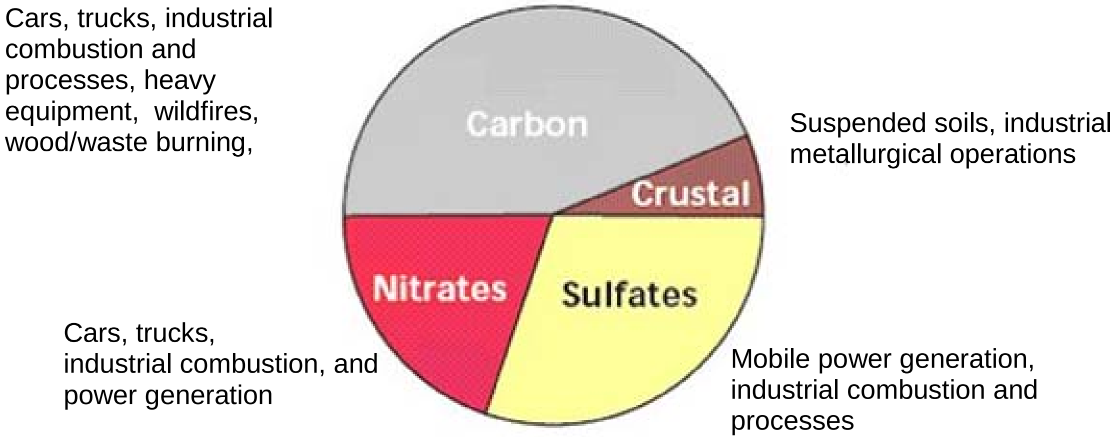


Figure 2-1. National Average of Source Contribution to Fine Particle Levels

Source: The Particulate Matter Report, USEPA 454-R-04-002, Fall 2004. Carbon reflects both organic carbon and elemental carbon. Organic carbon accounts for emissions from automobiles, biogenics, gas-powered off-road vehicles, and wildfires. Elemental carbon is mainly from diesel powered sources.

In addition, ammonia from sources such as fertilizer and animal feed operations contributes to the formation of sulfates and nitrates that exist in the atmosphere as ammonium sulfate and ammonium nitrate. As noted in Chapter 1, EPA recognizes that data on ammonia emissions from animal operations are currently very uncertain, and are likely inadequate for making specific regulatory and/or control decisions for these emissions in some locations. EPA anticipates that the National Air Emissions Monitoring Study (NAEMS) for animal operations will provide a more scientific basis for estimating emissions, as well as defining the scope of air quality impacts, from these sources.

Note that fine particles can be transported long distances by wind and weather and can be found in the air thousands of miles from where they formed. The chemical makeup of particles varies across the United States, as illustrated in Figure 2-2. For example, the higher regional emissions of SO_2 in the East result in higher absolute and relative amounts of sulfates as compared to the western U.S. Fine particles in southern California generally contain more nitrates than other areas of the country. Carbon is a substantial component of fine particles everywhere.

2.1.1 Seasonal and Daily Patterns of $PM_{2.5}$

Fine particles often have a seasonal pattern. As shown in Figure 2-3, $PM_{2.5}$ values in the eastern half of the United States are typically higher in the third calendar quarter (July-September) when meteorological conditions are more favorable for the formation and build up of sulfates from the higher sulfur dioxide (SO_2) emissions from power plants in that region. Fine particle concentrations tend to be higher in the first (January -March) and fourth (October through December) calendar quarters urban areas in the West, in part because fine particle nitrates and carbonaceous particles are more readily formed in cooler weather, and wood stove and fireplace use increases direct emissions of carbon.

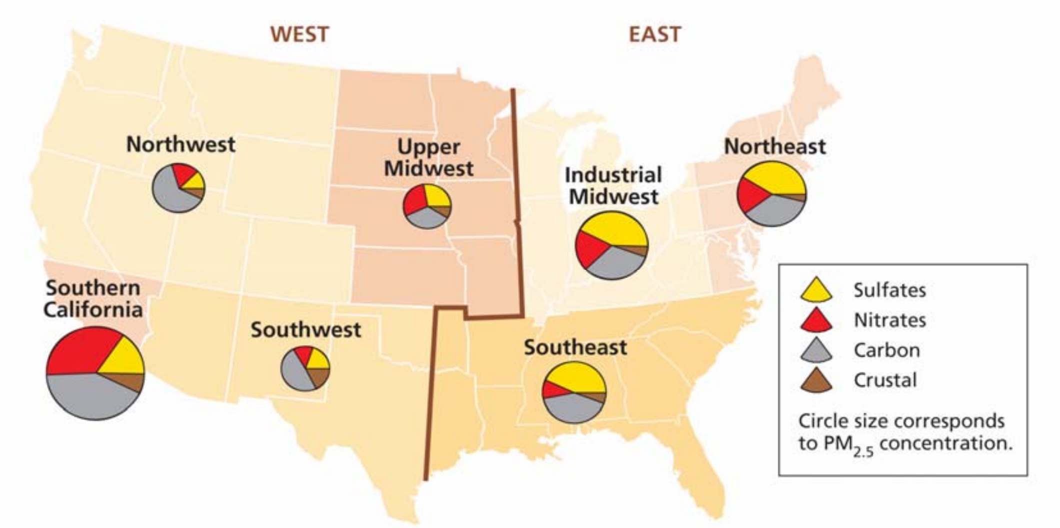


Figure 2-2. Average $PM_{2.5}$ Composition in Urban Areas by Region, 2003

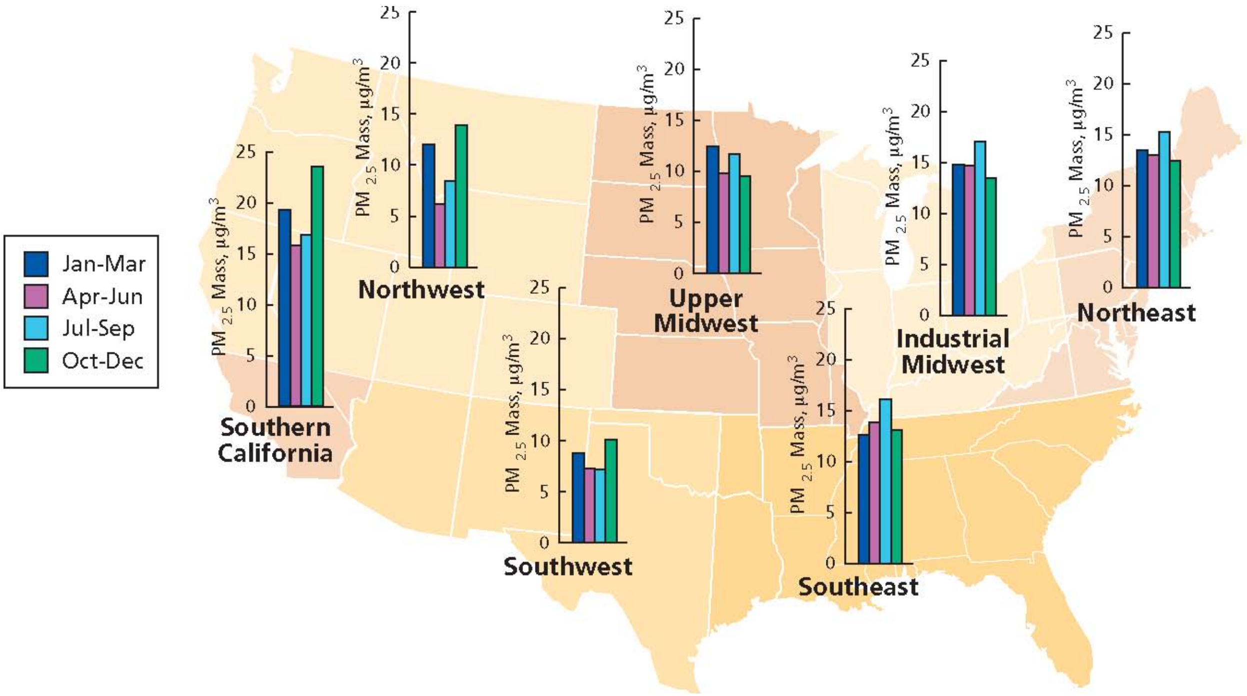


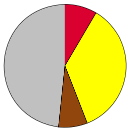
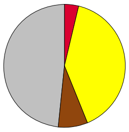
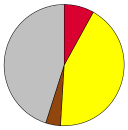
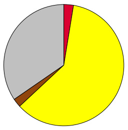
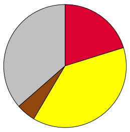
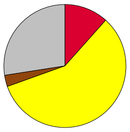
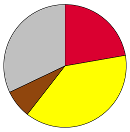
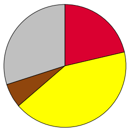
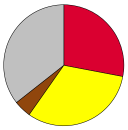
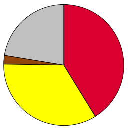
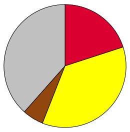
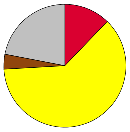
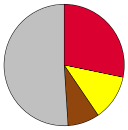
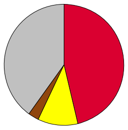
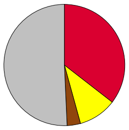
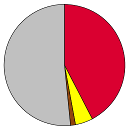
Figure 2-3. Seasonal Averages of $PM_{2.5}$ Concentration by Region, 1999–2003

Seasonal patterns are also present in the concentrations and composition of the highest daily values of $PM_{2.5}$. Unlike daily ozone levels, which are usually elevated in the summer, daily $PM_{2.5}$ values at some locations can be high at any time of the year. Table 2-1 provides 2003 data on daily $PM_{2.5}$ values and their composition on high mass days for various urban sites within large metropolitan areas (in the East: Birmingham, AL; Atlanta, GA; New York City, NY; Cleveland, OH; Chicago, IL; and St. Louis, MO; in the West: Salt Lake City, UT; and Fresno, CA). Mass is proportioned into four categories: sulfates, nitrates, crustal, and total carbonaceous mass (TCM, the sum of elemental carbon (EC) and organic carbon mass (OCM)). For each site, the table shows the 2003 annual average speciation pattern, the profile for the five highest $PM_{2.5}$ mass days in that year—both individually and averaged together—and corresponding Federal Reference Method (FRM) mass values (annual average, five highest days, and average of five highest). The table shows some notable differences in the percentage contribution of each of the species to total mass when looking at the high end of the distribution versus the annual average; this information can have implications for the types of controls that may be more effective in meeting the daily versus the annual standard in each projected nonattainment area. In all of the eastern city sites, the percentage of sulfates is somewhat higher on the five high days as compared to the annual averages. In the two western cities, the percentage of nitrates is higher on the five high days as compared to the annual averages. TCM constitutes a somewhat lower percentage on the five high days compared to the annual averages in most cities.

2.1.2 Composition of $PM_{2.5}$ as Measured by the Federal Reference Method

The speciation measurements in the preceding analyses represented data from EPA’s Speciation Trends Network, along with adjustments to reflect the fine particle mass associated with these ambient measurements. In order to more accurately predict the change in $PM_{2.5}$ design values for particular emission control scenarios, EPA characterizes the composition of $PM_{2.5}$ as measured by the Federal Reference Method (FRM). The current $PM_{2.5}$ FRM does not capture all ambient particles measured by speciation samplers as presented in the previous sections. The FRM-measured fine particle mass reflects losses of ammonium nitrate (NH_4NO_3) and other semi-volatile organic compounds (SVOCs; negative artifacts). It also includes particle-bound water (PBW) associated with hygroscopic species (positive artifacts) (Frank, 2006). Comparison of FRM and collocated speciation sampler NO_3^- values in Table 2-2 show that annual average NO_3 retention in FRM samples for six cities varies from 15% in Birmingham to 76% in Chicago, with an annual average loss of 1 g/m^3. The volatilization is a function of temperature and relative humidity (RH), with more loss at higher temperatures and lower RH. Accordingly, nitrate is mostly retained during the cold winter days, while little may be retained during the hot summer days.

Table 2-1: $PM_{2.5}$ Composition on High Mass Days in Select Urban Areas, 2003

Urban Area	Statistic*	Composition Percents (%)				$PM_{2.5}$ mass** (µg/m3)	Annual average	Average of 5 highest days
		Amm. Nitrate	Amm. Sulfate	Crustal	TCM			
Birmingham, AL	• Annual average	8.5	35.6	7.6	48.3	**17.9**		
	• Average of 5 highest $PM_{2.5}$ mass days	3.8	40.0	7.8	48.3	**40.7**		
	• Highest $PM_{2.5}$ mass day	1.9	55.1	5.5	37.4	**46.6**		
	• 2nd highest $PM_{2.5}$ mass day	4.2	26.9	11.0	57.9	**40.4**		
	• 3rd highest $PM_{2.5}$ mass day	15.3	15.7	10.7	58.4	**39.2**		
	• 4th Highest $PM_{2.5}$ mass day	2.7	51.1	7.4	38.7	**39.1**		
	• 5th Highest $PM_{2.5}$ mass day	2.6	34.6	6.4	56.3	**38.3**		
Atlanta, GA	• Annual average	8.1	42.8	4.0	45.0	**15.2**		
	• Average of 5 highest $PM_{2.5}$ mass days	2.6	60.1	2.3	34.3	**35.2**		
	• Highest $PM_{2.5}$ mass day	2.0	70.5	1.9	25.6	**37.8**		
	• 2nd highest $PM_{2.5}$ mass day	2.0	47.8	2.5	47.8	**37.1**		
	• 3rd highest $PM_{2.5}$ mass day	2.4	67.6	2.1	27.9	**36.8**		
	• 4th Highest $PM_{2.5}$ mass day	3.2	50.8	2.9	43.1	**35.0**		
	• 5th Highest $PM_{2.5}$ mass day	3.6	67.5	1.9	27.0	**29.3**		
New York City, NY	• Annual average	20.2	38.3	5.1	36.4	**13.1**		
	• Average of 5 highest $PM_{2.5}$ mass days	11.6	57.9	3.0	27.4	**40.5**		
	• Highest $PM_{2.5}$ mass day	3.6	58.3	5.5	32.6	**45.9**		
	• 2nd highest $PM_{2.5}$ mass day	5.0	69.0	1.4	24.6	**45.8**		
	• 3rd highest $PM_{2.5}$ mass day	27.8	42.1	3.1	27.0	**38.2**		
	• 4th Highest $PM_{2.5}$ mass day	5.1	59.4	4.6	30.9	**36.4**		
	• 5th Highest $PM_{2.5}$ mass day	9.7	62.2	2.0	26.1	**36.0**		
Cleveland, OH	• Annual average	22.3	38.3	7.4	32.1	**17.6**		
	• Average of 5 highest $PM_{2.5}$ mass days	21.4	42.5	6.3	30.0	**44.1**		
	• Highest $PM_{2.5}$ mass day	32.7	43.2	2.3	21.7	**57.9**		
	• 2nd highest $PM_{2.5}$ mass day	25.1	41.5	4.0	29.3	**46.4**		
	• 3rd highest $PM_{2.5}$ mass day	4.8	64.4	8.7	22.1	**45.5**		
	• 4th Highest $PM_{2.5}$ mass day	8.8	37.5	14.7	39.0	**35.7**		
	• 5th Highest $PM_{2.5}$ mass day	31.4	20.5	4.0	44.0	**35.0**		
Chicago, IL	• Annual average	28.0	31.8	4.6	35.6	**15.2**		
	• Average of 5 highest $PM_{2.5}$ mass days	41.2	34.0	2.3	22.4	**34.4**		
	• Highest $PM_{2.5}$ mass day	46.0	30.7	1.2	22.1	**38.3**		
	• 2nd highest $PM_{2.5}$ mass day	49.2	36.4	0.8	13.6	**35.3**		
	• 3rd highest $PM_{2.5}$ mass day	51.8	27.7	1.2	19.3	**35.1**		
	• 4th Highest $PM_{2.5}$ mass day	5.6	61.7	3.8	28.9	**32.5**		
	• 5th Highest $PM_{2.5}$ mass day	47.8	16.1	5.3	30.8	**30.7**		
St. Louis, MO	• Annual average	20.0	36.0	5.6	38.4	**14.5**		
	• Average of 5 highest $PM_{2.5}$ mass days	12.2	61.9	3.9	22.0	**35.9**		
	• Highest $PM_{2.5}$ mass day	6.2	69.1	3.6	21.0	**50.6**		
	• 2nd highest $PM_{2.5}$ mass day	5.0	67.0	2.0	26.0	**36.0**		
	• 3rd highest $PM_{2.5}$ mass day	6.4	69.2	3.2	21.3	**33.1**		
	• 4th Highest $PM_{2.5}$ mass day	5.0	58.9	8.2	28.1	**30.8**		
	• 5th Highest $PM_{2.5}$ mass day	40.2	42.3	2.7	14.7	**28.9**		
Salt Lake City, UT	• Annual average	28.3	12.2	8.5	51.1	**10.0**		
	• Average of 5 highest $PM_{2.5}$ mass days	46.3	10.8	2.9	40.0	**40.6**		
	• Highest $PM_{2.5}$ mass day	50.6	6.3	2.5	40.5	**59.5**		
	• 2nd highest $PM_{2.5}$ mass day	43.5	11.9	2.6	42.0	**52.1**		
	• 3rd highest $PM_{2.5}$ mass day	42.4	13.5	3.7	40.4	**34.2**		
	• 4th Highest $PM_{2.5}$ mass day	48.2	5.9	4.7	41.3	**28.7**		
	• 5th Highest $PM_{2.5}$ mass day	45.4	20.2	1.5	32.8	**28.4**		
Fresno, CA	• Annual average	35.5	10.2	3.6	50.7	**18.0**		
	• Average of 5 highest $PM_{2.5}$ mass days	42.4	4.7	1.3	51.6	**54.2**		
	• Highest $PM_{2.5}$ mass day	55.2	4.6	2.1	38.2	**59.0**		
	• 2nd highest $PM_{2.5}$ mass day	58.4	8.5	0.9	32.2	**56.3**		
	• 3rd highest $PM_{2.5}$ mass day	17.5	1.5	1.3	79.7	**54.4**		
	• 4th Highest $PM_{2.5}$ mass day	35.1	5.3	1.0	58.6	**52.6**		
	• 5th Highest $PM_{2.5}$ mass day	44.6	3.7	1.3	50.3	**50.0**		

* The 5 highest days shown (and aggregated) for each site actually represent the 5 highest days (based on collocated FRM mass; see next bullet) that the speciation monitor sampled. FRM monitors at different locations in the metropolitan area and/or collocated FRM measurements on days that the speciation sampler did not record valid data may have had higher values than some or all of the 5 high values shown. Event-flagged data were omitted from this analyses.

** '$PM_{2.5}$ mass' concentration represents the collocated (w/ speciation monitor) same-day FRM measurement unless not available, in which case the speciation monitor gravimetric mass was substituted.

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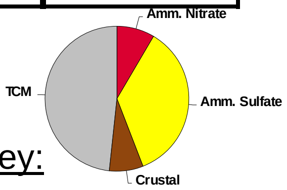

Table 2-2: Annual average FRM and STN $PM_{2.5}$ NO_3^- and NH_4NO_3 concentrations at six sites during 2003

			NO_3^- (µg/m^3)			NH_4NO_3 (µg/m^3)		Percent of NH_4NO_3 in $PM_{2.5}$ FRM Mass	
Sampling Site Location	*No. of Observations*	*FRM Mass*	*STN*[a]	*FRM*[b]	*Difference (STN – FRM)*	*STN*	*FRM*	*STN*	*FRM*
Mayville, WI	100	9.8	2.5	1.5	1.0	3.2	1.9	33%	19%
Chicago, IL	76	14.4	2.8	2.1	0.7	3.7	2.8	25%	19%
Indianapolis, IN	92	14.8	2.5	1.3	1.3	3.2	1.6	22%	11%
Cleveland, OH	90	16.8	2.9	1.7	1.2	3.7	2.2	22%	13%
Bronx, NY	108	15.0	2.4	1.1	1.3	3.1	1.4	21%	9%
Birmingham, AL	113	17.0	1.1	0.2	0.9	1.4	0.2	8%	1%

[a] On denuded nylon-membrane filters for al sites except for Chicago, where denuded Teflon-membrane followed by nylon filters were used.

[b] On undenuded Teflon-membrane filters.

$PM_{2.5}$ FRM measurements also include water associated with hygroscopic aerosol. This is because the method derives fine particle concentrations from sampled mass equilibrated at 20–23 °C and 30–40% RH. At these conditions, the hygroscopic aerosol collected at more humid environments will retain their particle-bound water. The water content is higher for more acidic and sulfate-dominated aerosols. Combining the effects of reduced nitrate and hydrated aerosol causes the estimated nitrate and sulfate FRM mass to differ from the measured ions simply expressed as dry ammonium nitrate and ammonium sulfate. The composition of FRM mass is denoted as SANDWICH based on the Sulfate, Adjusted Nitrate Derived Water and Inferred Carbon approach from which they are derived. The $PM_{2.5}$ mass estimated from speciated measurements of fine particles is termed ReConstructed Fine Mass (RCFM). The application of SANDWICH adjustments to speciation measurements at six sites is illustrated in Table 2-2 and Figure 2-4. EPAs modeling incorporates these SANDWICH adjustments thru the Speciated Modeling Attainment Test (SMAT).

2.1.3 Current and Projected Composition of Urban $PM_{2.5}$ for Selected Areas

Based on our CMAQ modeling, a local perspective of $PM_{2.5}$ levels and composition is provided in this section in order to further elaborate further on the nature of the $PM_{2.5}$ air quality problem after implementation of the CAIR/CAMR/CAVR rules, the national mobile rules for light and heavy-duty vehicles and nonroad mobile sources, and current state programs that were on the books as of early 2005.[1] As an illustrative example, a localized analysis of current ambient and future-year speciation is provided for two cities, one in the East and one in the West.

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[1] Multi-pollutant legislation modeling. (Multi-pollutant analyses and technical support documents. http://www.epa.gov/airmarkets/mp/.)

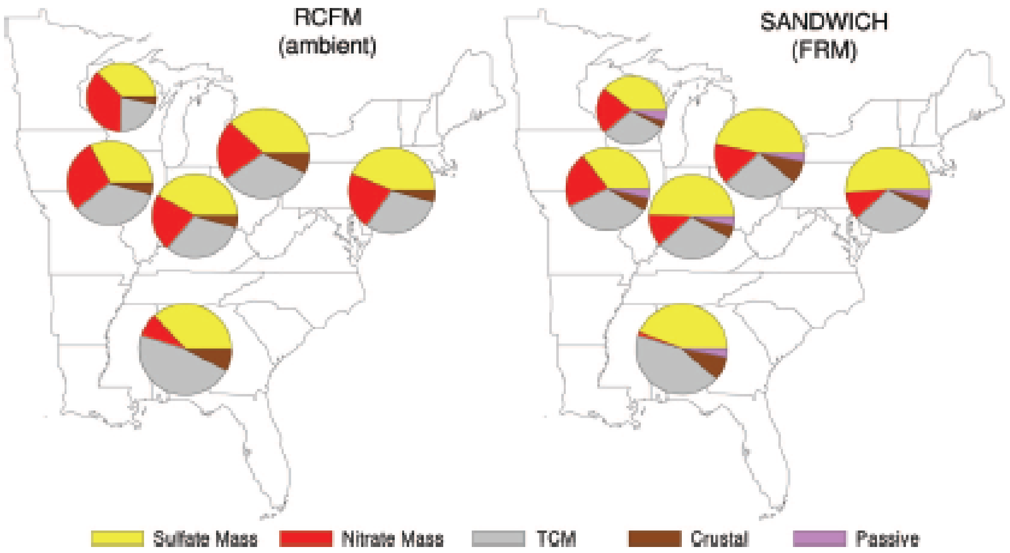

Figure 2-4. RCFM (left) versus SANDWICH (right) Pie Charts Comparing the Ambient and $PM_{2.5}$ FRM Reconstructed Mass Protocols on an Annual Average Basis

Estimated NH_4* and PBW for SANDWICH are included with their respective sulfate and nitrate mass slices. Circles are scaled in proportion to $PM_{2.5}$ FRM mass.

Figure 2-5 shows projected $PM_{2.5}$ component species concentrations (i.e., sulfate, nitrate, elemental carbon, organic aerosols, crustal, and uncontrollable $PM_{2.5}$) for current ambient data (5 year weighted average, 1999–2003) and a 2020 regulatory base case with the addition of the controls mentioned in the previous paragraph. Note that organic aerosols include directly emitted organic carbon and organic carbon particles formed in the atmosphere from anthropogenic sources and biogenic sources. Uncontrollable $PM_{2.5}$ is based upon a 0.5 $\mu g/m^3$ $PM_{2.5}$ blank mass correction used in the Speciated Modeled Attainment Test (SMAT) approach, in which a number of adjustments and additions were made to the measured species data to provide for consistency with the chemical components retained on the FRM Teflon filter.[2] The analysis provided here specifically looks at one area in the East (Detroit), and one in the West (Salt Lake City).

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[2] Procedures for Estimating Future $PM_{2.5}$ Values for the CAIR Final Rule by Applications of the Speciated Modeling Attainment Test (SMAT), Updated November 8, 2004 (EPA Docket #: OAR-2003-0053-1907).

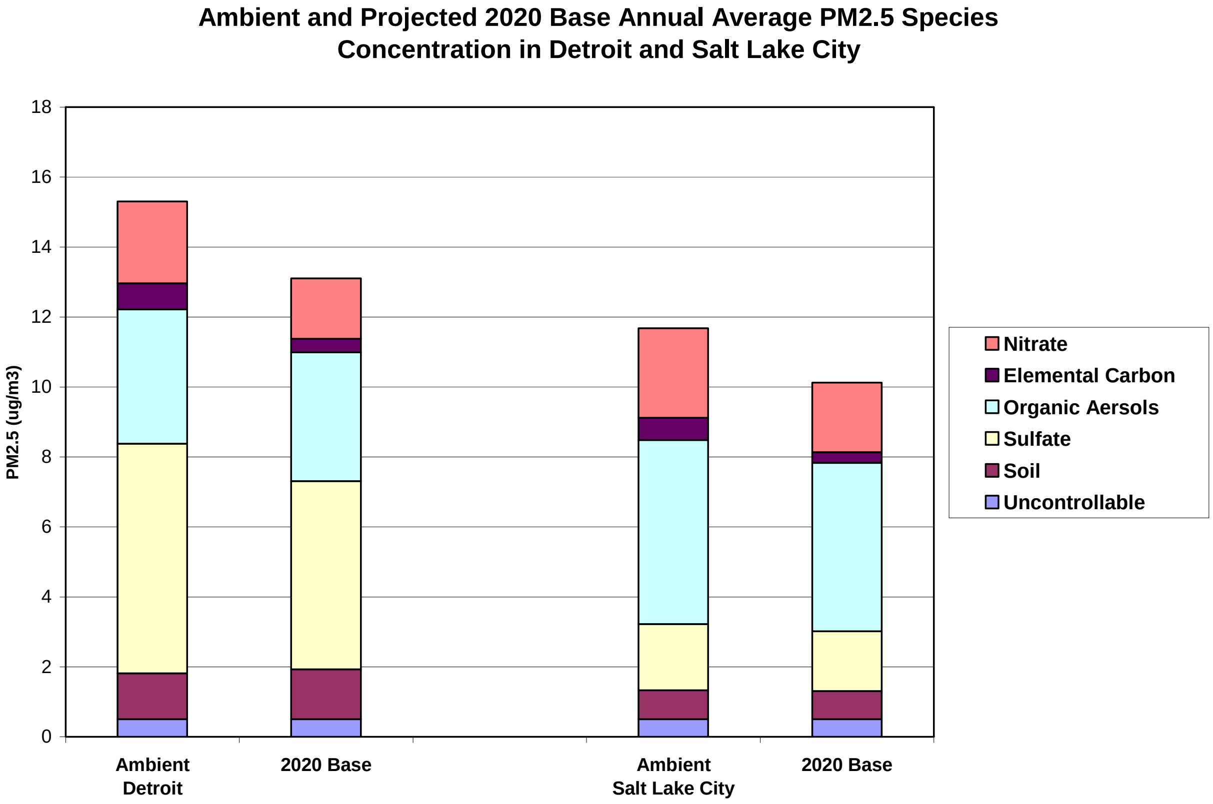

Figure 2-5. Base Case and Projected $PM_{2.5}$ Component Species Concentrations in Detroit and Salt Lake City

Note: The ambient and projected 2020 base case annual design values above are averages taken across multiple urban area monitors. Thus, while the average 2020 Detroit base case design value reflected above is lower than the projected base case design values at certain Detroit monitors.

Notably, organic aerosols constitute a large fraction of the overall remaining $PM_{2.5}$ mass in Detroit and Salt Lake City. Sulfate is a considerable part of the total $PM_{2.5}$ mass in both cities and is the largest contributor to $PM_{2.5}$ mass in Detroit. Nitrate is a relatively small source of $PM_{2.5}$ for Detroit but nitrate is the second largest contributor to the remaining $PM_{2.5}$ problem in Salt Lake City; the exception is that on higher days, nitrate represents the largest contributor in Salt Lake City. The relatively large contribution of sulfate to $PM_{2.5}$ mass in Detroit is characteristic of the urban air pollution mixture in the East, while the nitrate contribution to $PM_{2.5}$ mass in Salt Lake City is characteristic of that found in the West.

Both local and regional sources contribute to particle pollution. Figure 2-6 shows how much of the $PM_{2.5}$ mass can be attributed to local versus regional sources for 13 selected urban areas. In each of these urban areas, monitoring sites were paired with nearby rural sites. When the average rural concentration is subtracted from the measured urban concentration, the estimated local and regional contributions become apparent. Urban and nearby rural $PM_{2.5}$ concentrations suggest substantial regional contributions to fine particles in the East. The measured $PM_{2.5}$ concentration is not necessarily the maximum for each urban area. Regional concentrations are derived from the rural IMPROVE monitoring network.[3]

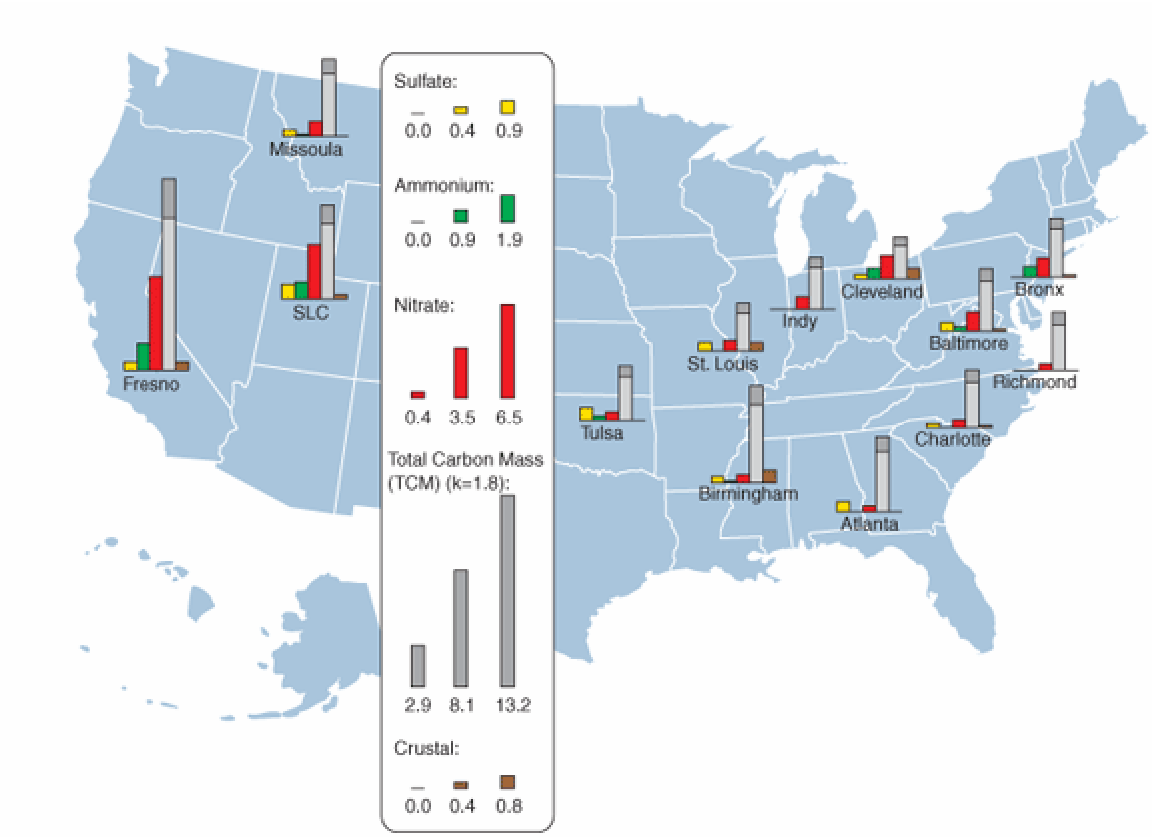

Figure 2-6. Estimated “Urban Excess” of 13 Urban Areas by $PM_{2.5}$ Species Component
The urban excess is estimated by subtracting the measured $PM_{2.5}$ species at a regional monitor location (assumed to be representative of regional background) from those measured at an urban location.

Note: Total Carbon Mass (TCM) is the sum of Organic Carbon (OC) and Elemental Carbon (EC). In this graph, the light grey is OC and the dark grey is EC. See: Turpin, B. and H-J, Lim, 2001: Species contributions to $PM_{2.5}$ mass concentrations: Revisiting common assumptions for estimating organic mass, Atmospheric Environment, 35, 602-610.

As shown in Figure 2-6, we observe a large urban excess across the U.S. for most $PM_{2.5}$ species but especially for total carbon mass. All of these locations have consistently high urban excess for total carbon mass with Fresno, CA and Birmingham, AL having the largest observed measures. Larger urban excess of nitrates is seen in the western U.S. with Fresno, CA and Salt Lake City, UT significantly higher than all other areas across the nation. These results indicate that local sources of these pollutants are indeed contributing to the $PM_{2.5}$ air quality problem in these areas. As expected for a predominately regional pollutant, only a modest urban excess is observed for sulfates.[4]

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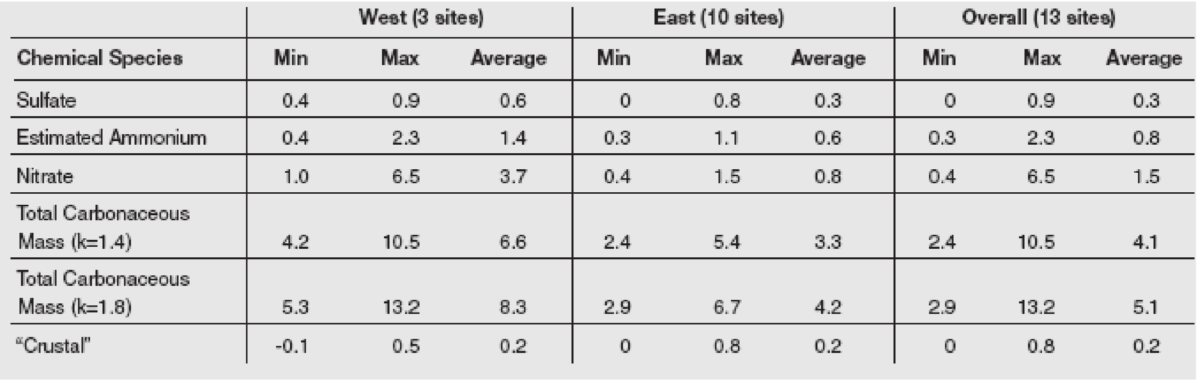
[3] Interagency Monitoring of Protected Visual Environments (IMPROVE) http://vista.cira.colostate.edu/improve

[4] Pittsburgh provides an exception to this observation, as our air quality analysis indicated that sulfates are directly emitted.

In the East, regional pollution contributes more than half of total $PM_{2.5}$ concentrations. Rural background $PM_{2.5}$ concentrations are high in the East and are somewhat uniform over large geographic areas. These regional concentrations come from emission sources such as power plants, natural sources, and urban pollution and can be transported hundreds of miles and reflects to some extent the more dense clustering of urban areas in the East as compared to the West. The local and regional contributions for the major chemical components that make up urban $PM_{2.5}$ are sulfates, carbon, and nitrates. Implementation of the promulgated CAIR-CAVR-CAMR program, mobile source regulations, and current state and local programs will address regional contribution to $PM_{2.5}$ associated with NO_x and SO_2. Nitrates and sulfates formed from NOx and SO2 are generally transported over wide areas leading to substantial background contributions in urban areas. Carbonaceous emissions are also transported but to a far lesser degree. Mobile source regulations which apply on a national basis will also help address the local contribution of carbonaceous PM. However, states will clearly need to consider local emission control measures to address the local contribution to $PM_{2.5}$.

A tabular summary of urban excess amounts by species is shown below in Table 2-3. This table represents a regional summary of Figure 2-6. It clearly shows the predominance of urban excess levels of carbon across the USA. In the West, nitrates also contribute to local urban excess levels.

Table 2-3: Summary of Urban Excess Amounts by Species



	West (3 sites)			East (10 sites)			Overall (13 sites)		
Chemical Species	Min	Max	Average	Min	Max	Average	Min	Max	Average
Sulfate	0.4	0.9	0.6	0	0.8	0.3	0	0.9	0.3
Estimated Ammonium	0.4	2.3	1.4	0.3	1.1	0.6	0.3	2.3	0.8
Nitrate	1.0	6.5	3.7	0.4	1.5	0.8	0.4	6.5	1.5
Total Carbonaceous Mass (k=1.4)	4.2	10.5	6.6	2.4	5.4	3.3	2.4	10.5	4.1
Total Carbonaceous Mass (k=1.8)	5.3	13.2	8.3	2.9	6.7	4.2	2.9	13.2	5.1
"Crustal"	-0.1	0.5	0.2	0	0.8	0.2	0	0.8	0.2

Because this RIA addresses control strategies to meet alternative standards that are implemented in future years, it is important to examine the extent to which the concentration and composition patterns found in the data summarized above would change as a result of regulations that have already been adopted at the national, state, and local level. This section provides results from CMAQ modeling to forecast the nature of the $PM_{2.5}$ air quality problem in 2020, taking into account the net reductions expected from implementation of the CAIR/CAMR/CAVR rules, the national mobile rules for light and heavy-duty vehicles and nonroad mobile sources, and current state programs that were on the books as of early 2005.[5] The national changes in PM2.5 levels are summarized and presented in Chapter 3.

2.2 Source Apportionment Studies of $PM_{2.5}$

Determining sources of fine particulate matter is complicated in part because the concentrations of various components are influenced by both primary emissions and secondary atmospheric reactions. As described earlier, when attempting to characterize the sources affecting $PM_{2.5}$ concentrations, it is important to note that both regional and local sources impact ambient levels. In the eastern US, regional fine particles are often dominated by secondary particles including sulfates, organics (primary and secondary) and nitrates. These are particles which form through atmospheric reactions of emitted sulfur dioxide, oxides of nitrogen and ammonia, and are transported over long distances. Conversely, local contributions to fine particles are likely dominated by directly emitted particulate matter from sources such as gasoline and diesel vehicles[6], industrial facilities (e.g., iron and steel manufacturing, coke ovens, or pulp mills), and residential wood and waste burning.

Development of effective and efficient emission control strategies to lower $PM_{2.5}$ ambient concentrations can be aided by determining the relationship between the various types of emissions sources and elevated levels of $PM_{2.5}$ at ambient monitoring sites. Source apportionment analyses such as receptor modeling are useful in this regard by both qualifying and quantifying potential fine particulate regional and local source impacts on a receptor's ambient concentrations. The goal is to apportion the mass concentrations into components attributable to the most significant sources. Receptor modeling techniques are observation-based models which utilize measured ambient concentrations of $PM_{2.5}$ species to quantify the contribution that regional and local sources have at a given receptor which, in this case, is an ambient monitoring location.[7] These techniques are very useful in characterizing fine particulate source contributions to ambient $PM_{2.5}$ levels; however, there are inherent limitations including but not limited to the adequacy (e.g., vintage and representativeness) of existing source profiles in identifying source groups or specific sources, availability and completeness of ambient datasets to fully inform these techniques, and current scientific understanding and measured data to relate tracer elements to specific sources, production processes, or activities. Additionally, commingling of similar species from different sources in one "factor" can make it difficult to relate the "factor" to a particular source.

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[5] Multi-pollutant legislation modeling. (Multi-pollutant analyses and technical support documents. http://www.epa.gov/airmarkets/mp/.)

[6] Note that while we believe that the mobile source sector is a substantial contributor to total $PM_{2.5}$ mass; our current mobile source inventory is likely significantly underestimated and information on control measures is incomplete. For this reason, we believe there are more mobile source reductions available than those that we model in our controls analysis.

[7] Currently, two established receptor models are widely used for source apportionment studies: the Chemical Mass Balance (CMB) model and Positive Matrix Factorization (PMF). The CMB receptor model relies on measured source profiles as well as ambient species measurements to produce a source contribution estimate at the receptor location, while the PMF technique decomposes the ambient measurement data matrix into source profiles and contributions by utilizing the underlying relationship (i.e., correlations) between the individually measured species.

A literature compilation summarizing 27 source apportionment studies was conducted as part of a research and preparation program for the CAIR (EPA, 2005) rule, which was focused on $PM_{2.5}$ transport).[8] Literature selected in this compilation represented key source apportionment research, focusing primarily on recent individual source apportionment studies in the eastern U.S. The sources identified are grouped into seven categories: secondary sulfates, mobile, secondary nitrates, biomass burning, industrial, crustal and salt, and other/not identified. Some of these studies are based on older ambient databases and more recent ambient data have shown improvement and reduced levels of ambient $PM_{2.5}$ concentrations across the U.S., especially in the East, which affects the quantitative conclusions one may draw from these studies. Notably, the relative fraction of sulfates has continued to decrease with the implementation of the acid rain program and removal of sulfur from motor vehicle fuels. More routine monitoring for specific tracer compounds that are unique to individual sources can lead to better separation of blended "factors" such as secondary commingled sulfates and organic aerosols which are more attributed to emissions from vehicles and vegetation. Western studies have focused on sources impacting both high population areas such as Seattle, Denver, the San Joaquin Valley, Los Angeles, San Francisco as well as national parks.[9,10,11,12,13,14,15,16,17,18] More routine monitoring for specific tracer compounds that are unique to individual sources can lead to better separation of blended "factors" such as secondary commingled sulfates and organic aerosols which are more attributed to emissions from vehicles and vegetation.

As mentioned previously, the sources of $PM_{2.5}$ can be categorized as either direct emissions or contributing to secondary formation. The results of the studies showed that approximately 20 to 60% of the fine particle mass comes from secondarily formed nitrates and sulfates depending on the area of the country, with nitrates predominantly affecting the West, sulfates in the East and a mixture of the two in the Industrial Midwest. The precursors of these particles are generally gaseous pollutants such as sulfur dioxide or oxides of nitrogen, which react with ammonia in the atmosphere to form ammonium salts. Dominant sources of SO_2 include power generation facilities, which, along with motor vehicles, are also sources of NO_x. The result of recent and future reductions in precursor emissions from electrical generation utilities and motor vehicles,

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[8] Second Draft Technical Report (Revision 1), Compilation of Existing Studies on Source Apportionment for $PM_{2.5}$, August 22, 2003 (Contract No. 68-D-02-061; Work Assignment 1-05). http://www.epa.gov/oar/oaqps/pm25/docs/compsareports.pdf

[9] Chow, J. C.; Fairley, D.; Watson, J. G.; de Mandel, R.; Fujita, E. M.; Lowenthal, D. H.; Lu, Z.; Frazier, C. A.; Long, G.; Cordova, J. J. Environ. Eng. 1995, 21, 378-387.

[10] Magliano, K. L.; Hughes, V. M.; Chinkin, L. R.; Coe, D. L.; Haste, T. L.; Kumar, N.; Lurmann, F. W. Atmos. Environ. 1999, 33 (29), 4757-4773.

[11] Schauer, J. J.; Cass, G. R. Environ. Sci. Technol. 2000, 34 (9), 1821-1832.

[12] Chow, J. C.; Watson, J. G.; Lowenthal, D. H.; Countess, R. J. Atmos. Environ. 1996, 30 (9), 1489-1499.

[13] South Coast Air Quality Management District. 1997 air quality maintenance plan: Appendix V, Modeling and attainment demonstrations. Prepared by South Coast Air Quality Management District: Diamond Bar, CA, 1996.

[14] Chow, J. C.; Watson, J. G.; Green, M. C.; Lowenthal, D. H.; Bates, B. A.; Oslund, W.; Torres, G. Atmos. Environ. 2000, 34 (11), 1833-1843.

[15] Chow, J. C.; Watson, J. G.; Green, M. C.; Lowenthal, D. H.; DuBois, D. W.; Kohl, S. D.; Egami, R. T.; Gillies, J. A.; Rogers, C. F.; Frazier, C. A.; Cates, W. JAWMA 1999, 49 (6), 641-654.

[16] Watson, J. G.; Fujita, E. M.; Chow, J. C.; Zielinska, B.; Richards, L. W.; Neff, W. D.; Dietrich, D. Northern Front Range Air Quality Study. Final report. Prepared for Colorado State University, Fort Collins, CO, by Desert Research Institute: Reno, NV, 1998.

[17] Malm, W. C.; Gebhart, K. A. JAWMA 1997, 47 (3), 250-268.

[18] Eatough, D. J.; Farber, R. J.; Watson, J. G. JAWMA 2000, 50 (5), 759-774

however, will lead to a reduction in precursor contributions which would aid in limiting the production of secondary sulfates and nitrates. Also, reductions in gasoline and diesel fuel sulfur will reduce mobile source SO_2 emissions. In addition, secondary organic carbon aerosols (SOA) also make a large contribution to the overall total $PM_{2.5}$ concentration in both the Eastern and Western United States. For many of the receptor modeling studies, the majority of organic carbon is attributed to motor vehicle emissions (including both gasoline and diesel). While vehicles emit organic carbon particulate, the various organic gases also emitted by these sources react in the atmosphere to form SOA which shows a correlation to the other secondarily formed aerosols due to common atmospheric reactions. Other common sources of the organic gases which form SOA include vegetation, vehicles, and industrial VOC and SVOC emissions. However, due to some limits on data and a lack of specific molecular markers, current receptor modeling techniques have some difficulty attributing mass to SOA. Therefore, currently available source apportionment studies may be attributing an unknown amount of SOA in ambient PM to direct emissions of mobile sources; concurrently, some secondary organic aerosol found in ambient samples may, as mentioned above, be coming from mobile sources and not be fully reflected in these assessments. Research is underway to improve estimates of the contribution of SOA to total fine particulate mass.

While gaseous precursors of $PM_{2.5}$ are important contributors, urban primary sources still influence peak local concentrations that exceed the NAAQS, even if their overall contributions are smaller. The mixture of industrial source contributions to mass vary across the nation and include emissions from heavy manufacturing such as metal processing (e.g., steel production, coke ovens, foundries), petroleum refining, and cement manufacturing, among others. Other sources of primary $PM_{2.5}$ are more seasonal in nature. One such source is biomass burning, which usually contributes more during the winter months when households burn wood for heat, but also contributes episodically during summer as a result of forest fires. Other seasonal sources of primary PM include soil, sea salt and road salting operations that occur in winter months. The extent of these primary source contributions to local $PM_{2.5}$ problems varies across the U.S. and can even vary within an urban area. The key for individual areas is to understand the nature of the problem (i.e., determining the relationship between various types of emissions sources and elevated levels of $PM_{2.5}$ at ambient monitoring) in order to develop effective and efficient emission control strategies to reduce $PM_{2.5}$ ambient concentrations through local control program scenarios.

2.3 Emissions Inventories Used in this RIA

The next step in our analysis was to develop the emission inventories that we would use to model the projected air quality of our regulatory base case. This section summarizes the projection years we used as our regulatory base case and the key attributes of the emission inventories we used to model this base case.

2.3.1 Targeted Projection Years

We have chosen 2015 as our base year of analysis to assess the costs and benefits of attaining the 1997 standards and 2020 for analyzing attainment with the revised daily, and the alternative more stringent annual standards. 2015 serves as a logical base year for the 1997 $PM_{2.5}$ NAAQS because according the Clean Air Act, it is the final date by which States would implement controls to attain the current $PM_{2.5}$ standards (15 $\mu g/m^3$ annual, 65 $\mu g/m^3$ daily). 2020 is the final year by which states would implement controls to attain revised standards.

The following nationally implemented rules will either take effect between 2015 and 2020 or will take effect before 2015 and continue to provide additional emission benefits between 2015 and 2020 due to factors such as additional fleet turnover: the Clean Air Interstate Rule (CAIR), the Clean Air Visibility Rule (CAVR) and the Clean Air Mercury Rule (CAMR), the Clean Air Non-Road Diesel Rule, the Heavy Duty Diesel Rule, Light-Duty Vehicle Tier 2, and the NO_x SIP Call. These rules will produce substantial reductions in SO_2, NO_x and directly emitted $PM_{2.5}$, thereby reducing the target reductions many states will set during implementation of the revised $PM_{2.5}$ NAAQS below the levels that would otherwise need to set.

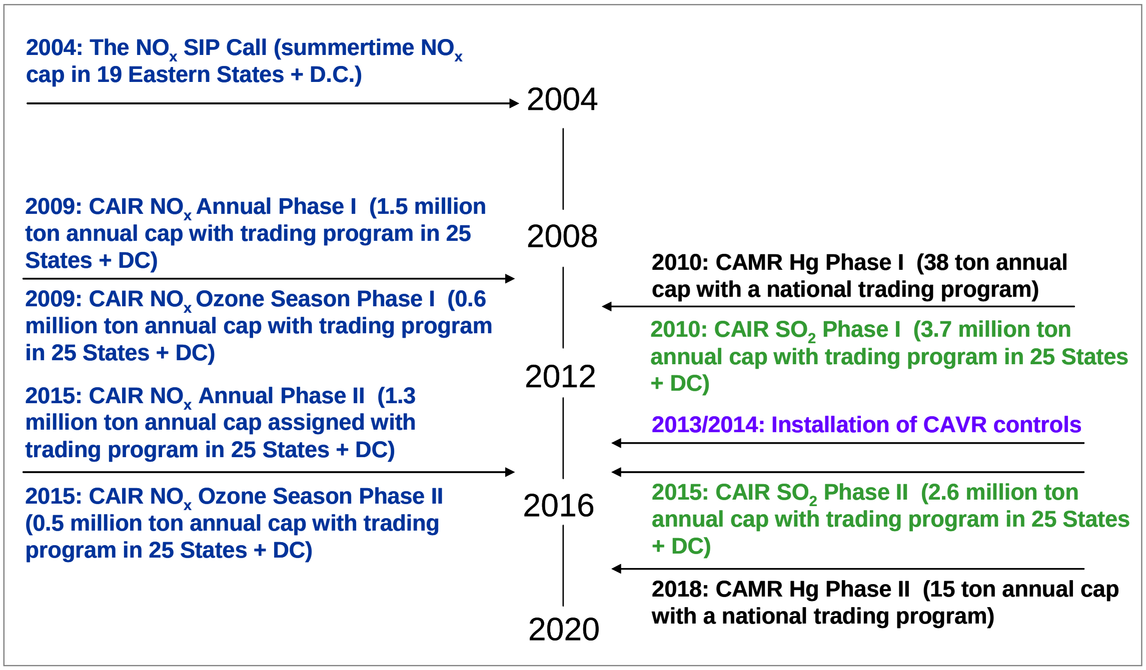
2.3.2 Rules Included in 2015 and 2020 Baselines

We have included nearly all national rules and many local rules and consent decrees in our preparation of emissions for 2015 and 2020. These rules can be divided into three categories: EGUs, non-EGU stationary sources, and mobile sources. The following 3 subsections provide details on the rules included.

EGU Emission Sources

The power sector emission projections include title IV of the Clean Air Act (the Acid Rain Program), the NO_x SIP Call, various New Source Review (NSR) settlements, and several State rules affecting emissions of SO_2, NO_x, Hg, and CO_2 that were finalized prior to April of 2004. The NSR settlements include agreements between EPA and Southern Indiana Gas and Electric Company (Vectren), Public Service Enterprise Group, Tampa Electric Company, We Energies (WEPCO), Virginia Electric & Power Company (Dominion), and Santee Cooper. The Integrated Planning Model (IPM) also includes various current and future State programs in Connecticut, Illinois, Maine, Massachusetts, Minnesota, New Hampshire, North Carolina, New York, Oregon, Texas, and Wisconsin. IPM includes State rules that have been finalized and/or approved by a State's legislature or environmental agency as of April, 2004.

In addition, the power sector modeling includes three recently finalized rules; CAIR, CAMR, and CAVR. These rules begin to come into effect in 2009 and will result in significant reductions of SO_2, NO_x, and Hg from the power sector. Figure 2-7 illustrates the emission cap levels for the power sector under CAIR, CAMR and CAVR. Figure 2-8 illustrates the historical and projected state-wide emissions from EGU's.



2004: The NO_x SIP Call (summertime NO_x cap in 19 Eastern States + D.C.)

2009: CAIR NO_x Annual Phase I (1.5 million ton annual cap with trading program in 25 States + DC)

2009: CAIR NO_x Ozone Season Phase I (0.6 million ton annual cap with trading program in 25 States + DC)

2015: CAIR NO_x Annual Phase II (1.3 million ton annual cap assigned with trading program in 25 States + DC)

2015: CAIR NO_x Ozone Season Phase II (0.5 million ton annual cap with trading program in 25 States + DC)

2010: CAMR Hg Phase I (38 ton annual cap with a national trading program)

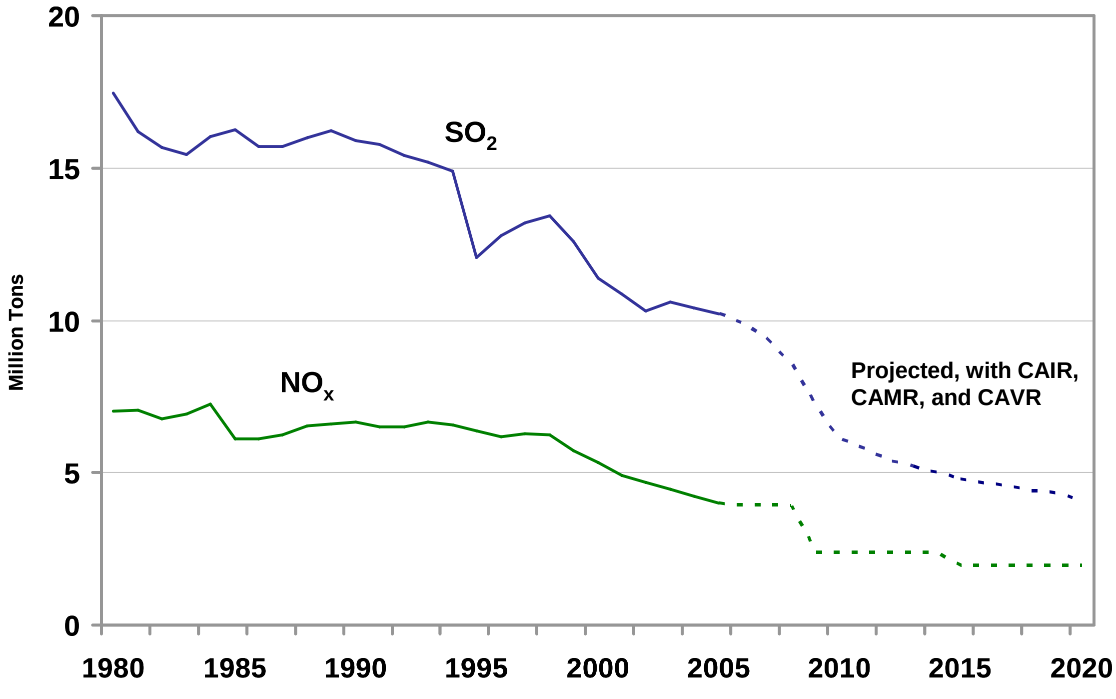
2010: CAIR SO_2 Phase I (3.7 million ton annual cap with trading program in 25 States + DC)

2013/2014: Installation of CAVR controls

2015: CAIR SO_2 Phase II (2.6 million ton annual cap with trading program in 25 States + DC)

2018: CAMR Hg Phase II (15 ton annual cap with a national trading program)

Figure 2-7. Emission Cap Levels and Timing for the Electric Power Sector under CAIR/CAMR/CAVR



Source: EPA's National Emissions Inventory and the Integrated Planning Model

Figure 2-8. Historical and Projected Nationwide SO_2 and NOx Emissions from EGUs (million tons)

Reductions from Stationary non-EGU emission sources

The non-EGU point and stationary area source emissions category include reductions from most national rules, with the exception of the Clean Air Visibility Rule (CAVR) which was included in the EGU emissions. Although we anticipate that CAVR will impact some non-EGU point sources, the information needed to determine which sources are affected by this rule was not available in time for our modeling work. Since that time, Regional Planning Organizations have in some cases determined which facilities are affected by CAVR.

The rules which become effective between 2015 and 2020 contain controls we used for projecting future non-EGU point and stationary area emissions are listed in Table 2-4, along with the pollutants reduced by each. A "X" in a cell of the table indicates that we assumed some reduction from the control described. The reductions in some cases were facility-specific; therefore, it is not possible to include the exact reductions assumed here. The "All" column indicates that all criteria pollutants were reduced; this only happens in the case of plant closures.

Table 2-4: List of emissions reduction types included for non-EGU stationary sources

Type	*Summary Description*	*All*	*VOC*	*NO$_x$*	*SO$_2$*	*PM$_{10}$*	*PM$_{2.5}$*
Local	Atlanta SIP: Control on large nonEGU Point sources			X			
	Bay Area SIP: Foam Product Manufacturing		X				
	Bay Area SIP: Fugitive Emisssions, Refinery		X				
	Bay Area SIP: Prohibition of Contaminated Soil		X				
	Bay Area SIP: Surface Prep and Cleanup Standard		X				
	Dallas SIP: Cement Kiln Emission Limits			X			
	Dallas SIP: Point Source NOx Rules			X			
	St. Louis SIP: Industrial Surface Coating Manufacturing		X				
Closures	Auto plant closures	X					
	Coke oven closures	X					
	Libby MT closures	X					
	Medical Waste Combustor closures	X					
	Pulp and paper closures	X					
	Refinery closure	X					
Settlements	DOJ Settlements			X	X		
	Refinery consent decrees			X	X	X	X
National	NOX SIP Call, all affected nonEGUs			X			
	NOX SIP Call, Cement plant review			X			
	Hospital/Medical/Infectious Waste Incineration (HMIWI) Rule			X	X	X	X
	MACT: Asphalt Processing & Roofing		X				
	MACT: Auto & Light Duty Truck Surface Coating		X				
	MACT: Cellulose Products Manufacturing (Rayon production)		X				
	MACT: Combustion Sources at Kraft, Soda and Sulfite Pulp & Paper Mills		X				
	MACT: Commercial Sterilizers		X				
	MACT: Fabric Printing, Coating and Dyeing		X				
	MACT: Gas Distribution (Stage 1)		X				
	MACT: General MACT (Spandex production)		X				
	MACT: Generic MACT (Ethylene manufacture)		X				
	MACT: Hazardous Organic NESHAP (SOCMI industry)		X				
	MACT: Industrial, Commercial, and Institutional Boilers and Process Heaters					X	X
	MACT: Iron & Steel Foundries		X				
	MACT: Large Appliances Surface Coating		X				
	MACT: Lime Manufacturing				X	X	X
	MACT: Metal Can Surface Coating		X				
	MACT: Metal Coil Surface Coating		X				
	MACT: Metal Furniture Surface Coating		X				

Type	Summary Description	All	VOC	NO_x	SO_2	PM_{10}	$PM_{2.5}$
	MACT: Misc. Metal Parts & Products Surface Coating		X				
	MACT: Miscellaneous Coating Manufacture		X				
	MACT: Miscellaneous Organic Chemical Manufacturing (Alkyd resins)		X				
	MACT: Miscellaneous Organic Chemical Manufacturing (Chelating Agents)		X				
	MACT: Miscellaneous Organic Chemical Manufacturing (Explosives)		X				
	MACT: Miscellaneous Organic Chemical Manufacturing (Phthalate plasticizers)		X				
	MACT: Miscellaneous Organic Chemical Manufacturing (Polyester resins)		X				
	MACT: Municipal Solid Waste Landfills		X				
	MACT: Oil and natural gas		X				
	MACT: Paper and Other Web Surface Coating		X				
	MACT: Petroleum Refineries		X				
	MACT: Pharmaceutical Production		X				
	MACT: Plastic Parts and Products Surface Coating		X				
	MACT: Plywood & Composite Wood Products		X				
	MACT: Polymers & Resins III (phenol resins)		X				
	MACT: Polymers and Resins IV, Acrylonitrile manufacture		X				
	MACT: Polyvinylidene chloride		X				
	MACT: Portland Cement Manufacturing					X	X
	MACT: Publicly Owned Treatment Works		X				
	MACT: Reinforced Plastics Composites Production		X				
	MACT: Rubber tire manufacture		X				
	MACT: Secondary Aluminum					X	X
	MACT: Taconite Iron Ore Processing					X	X
	MACT: Wet Formed Fiberglass Mat Production		X				
	MACT: Wood Building Products		X				

On-Road and Nonroad Mobile Emission Sources

The on-road and nonroad mobile projected base case emissions used for this work include emissions reductions achieved by all national rules through August 4, 2006, including:

- Nonroad Diesel Rule
  - http://www.epa.gov/nonroad-diesel/2004fr/420f04029.htm
- NonRoad Engine Rule
  - http://www.epa.gov/otaq/regs/nonroad/2002/f02037.pdf
- Tier 2 Vehicle and Gasoline Sulfur Program
  - http://www.epa.gov/otaq/regs/ld-hwy/tier-2/index.htm
- Heavy Duty Diesel (Trucks & Buses) Rule
  - http://www.epa.gov/otaq/regs/hd-hwy/2000frm/f00026.pdf

There have been no new OTAQ rules finalized since the mobile inventories developed for this work were created in 2006.

For a complete set of OTAQ's rules affecting nonroad equipment, readers should refer to the EPA web site http://www.epa.gov/nonroad. For a complete set of OTAQ's rules affecting onroad vehicles, readers should refer to the EPA web site http://www.epa.gov/otaq/hwy.htm.

2.3.3 Emission Inventory Platform Changes

In Section 1.4.1, we provided an overview about the updates to the emissions inventory platform as compared to the platform used for CAIR. This section describes these changes in more detail.

Changes in Non-EGU Sectors

As described previously, an "emissions inventory platform" is made up of the collection of emissions data and emissions processing assumptions used to create inputs to the CMAQ and AERMOD models. The platform used for this RIA is based on the emissions work originally prepared for the Clean Air Interstate Rule. Since then, EPA has made a number of updates to the platform in order to improve the technical basis for the modeling work done for the current RIA. This section provides details on those updates.

Natural Gas Combustion PM Emissions. In June 2005, EPA released new emission factors for PM_{10} and $PM_{2.5}$ emissions from natural gas combustion that were significantly lower than those used to compute the inventories used for CAIR. For this RIA, we used ratios of the new emission factors to the old emission factors to adjust the CAIR 2001 emissions. For PM_{10} the resulting adjustment decreased emissions from these sources by 93% to 95%, depending on the process. For $PM_{2.5}$ the resulting emissions from these sources decrease by 94% to 97%, depending on the processes. The net result of these adjustments was a significant decrease in $PM_{2.5}$ and PM_{10} emissions from all natural gas combustion sources for EGUs, non-EGU point sources, and stationary area sources.

Facility-Specific Inventory Updates. Several facility-specific inventory updates were made, some of which were based on comments received during development of CAIR. These are listed here:

- We lowered SO_2 emissions from the Alumnitec plant in Garland County, Arkansas to reduce 2001 emissions from 34,350 tons/yr to 1.2 tons/yr, based on CAIR comments from the State of Arkansas about a permit limit for this facility. This had impacts on 2015 and 2020 emissions. Although the reduction as compared to CAIR in those years is confounded by other changes made to the non-EGU point projections, they are at least as large as the 2002 reduction.

- We updated non-EGU point emissions for eleven North Dakota facilities based on CAIR comments. These updates inserted new SO_2 and $PM_{2.5}$ emissions as provided by North Dakota, resulting in the following significant emissions changes:
    - NO_X increased 3,178 tons/year
    - $PM_{2.5}$ increased 1,058 tons/year
    - SO_2 decreased 44,550 tons/year
- We reduced overestimated 2001 NH_3 emissions from 3,276 tons/yr to 472 tons/yr at the IMC Phosphates Company's Faustina Plant in St. James Parrish, Louisiana, based on the 2002 NEI. This change also reduced future-year emissions from the CAIR platform by a similar percentage (in combination with other changes documented here).

- We reduced overestimated 2001 $PM_{2.5}$ and SO_2 emissions at the Blue Circle Cement, Atlanta Plant (now known as the Lafarge Plant) in Fulton County, Georgia; SO_2 emissions were reduced from 8,863 to 1,617 tons/year, and. $PM_{2.5}$ emissions were reduced from 4,829 to 27 tons/year. We reduced PM_{10} emissions by the same fraction as the $PM_{2.5}$ emissions, though these emissions have little impact on this analysis. These changes were based on the 2002 NEI emissions for the plant documented in that inventory as the Lafarge Plant.

- There were a number of other non-EGU point changes that were not made to the modeled inventories, but were accounted for in the analysis of control strategies, where the affected counties were in the controlled regions. The county totals of these changes are shown in Table 2-5, below.

Table 2-5: Non-EGU Point Changes Accounted for in the Selection of Controls But Not Made to the Emissions Inventory Used for Modeling

State	*County*	*$PM_{2.5}$ Used*	*Improved $PM_{2.5}$ Estimate*
California	San Bernardino Co	2,368	1,228
Connecticut	New London Co	494	74
Florida	Escambia Co	7,564	2,533
Florida	Okaloosa Co	5,299	0
Florida	Polk Co	2,410	28
	Florida Subtotal	15,273	2,561
Georgia	De Kalb Co	1,029	1
Georgia	Floyd Co	5,776	96
Georgia	Fulton Co	12,519	39
Georgia	Glynn Co	485	11
	Georgia Subtotal	19,808	147
Maine	Aroostook Co	4,049	88
Minnesota	Koochiching Co	1,741	92
New Mexico	San Juan Co	1,363	791
Wyoming	Laramie Co	1,115	0
	Total	46,210	4,981

Year 2000-based future-year Canadian emissions. We incorporated newly-provided Canadian emissions for the year 2000, the latest publicly available data provided by Canada. We had used 1996-specific data for the CAIR modeling. The new data includes both 2000-specific data that we used in modeling 2001, as well as data projected to 2015 and 2020 that we used for our 2015 and 2020 modeling cases. These 2000-based data are available at http://www.epa.gov/ttn/chief/net/canada.html#data. The primary impacts of these data are shown in Table 2-6, which shows Canadian emissions for the base and future baseline runs. These impacts included increasing the coverage of the Canadian point source inventory to the western and northern Provinces.

Table 2-6: Comparison of base and future Canadian emissions data used for CAIR with data used for PM NAAQS platform.

Year and platform	Sector	VOC	NO_X	CO	SO_2	PM_{10}	PM_{25}	NH_3
2001 CAIR	point	168,510	165,379	745,280	1,531,262			1,046
	oarea	1,534,896	266,846	1,179,560	229,949	1,348,873	321,025	532,747
	onroad	642,127	1,076,261	5,835,996	24,721	44,033	40,999	20,876
	nonroad	389,189	872,434	3,511,506	97,051	65,736	57,372	1,295
2001 PM NAAQS	point	292,001	722,372	1,333,091	2,298,482	257,818	139,611	26,185
	oarea	1,697,011	396,215	1,802,167	202,456	1,538,716	393,076	591,848
	onroad	446,357	936,741	6,311,110	28,004	21,181	19,432	19,691
	nonroad	354,704	773,868	2,915,516	63,258	68,737	60,054	997
% Differences	point	73%	337%	79%	50%			2403%
	oarea	11%	48%	53%	-12%	14%	22%	11%
	onroad	-30%	-13%	8%	13%	-52%	-53%	-6%
	nonroad	-9%	-11%	-17%	-35%	5%	5%	-23%
2015 CAIR	point	168,510	165,379	745,280	1,531,262			1,046
	oarea	1,702,479	273,048	1,290,294	184,471	1,755,401	407,052	532,786
	onroad	184,525	425,252	1,846,188	1,894	10,564	9,758	20,704
	nonroad	279,865	834,120	4,193,585	92,432	54,228	45,917	1,295
2015 PM NAAQS	point	352,933	936,225	1,779,640	2,263,622	313,445	192,427	36,539
	oarea	1,980,323	546,792	2,580,300	217,318	2,029,769	521,416	334,398
	onroad	161,610	303,018	3,868,575	29,758	2,789	4,614	4,269
	nonroad	309,134	725,271	3,425,397	1,100	45,839	53,584	45,454
% Differences	point	109%	466%	139%	48%			3393%
	oarea	16%	100%	100%	18%	16%	28%	-37%
	onroad	-12%	-29%	110%	1471%	-74%	-53%	-79%
	nonroad	10%	-13%	-18%	-99%	-15%	17%	3410%
2020 CAIR	point	168,510	165,379	745,280	1,531,262			1,046
	oarea	1,702,479	273,048	1,290,294	184,471	1,755,401	407,052	532,786
	onroad	184,525	425,252	1,846,188	1,894	10,564	9,758	20,704
	nonroad	279,865	834,120	4,193,585	92,432	54,228	45,917	1,295
2020 PM NAAQS	point	363,753	947,153	1,837,407	2,246,305	325,113	198,792	38,923
	oarea	1,961,958	540,043	2,060,965	361,421	216,806	2,152,792	500,377
	onroad	142,543	198,910	3,803,189	33,237	3,112	3,568	3,376
	nonroad	309,134	725,271	3,425,397	1,100	45,839	53,584	45,454
% Differences	point	116%	473%	147%	47%			3621%
	oarea	15%	98%	60%	96%	-88%	429%	-6%
	onroad	-23%	-53%	106%	1655%	-71%	-63%	-84%
	nonroad	10%	-13%	-18%	-99%	-15%	17%	3410%

Residential Wood Combustion. We replaced earlier data on residential wood combustion emissions with data from the 2002 National Emission Inventory (final, February 2006) for that sector. This included all emissions from fireplaces and woodstoves, much of which was submitted after extensive and thorough preparation of these data by the states. This update extensively affected VOC and $PM_{2.5}$ emissions. Table 2-6 lists residential wood combustion VOC and $PM_{2.5}$ emissions by state, and compares the data used for the CAIR analysis with the numbers we used for the current RIA. In addition, we modified the projection method for this sector to no longer use DOE estimates of wood fuel usage and instead use a 1% growth rate in new woodstoves and a 1% decrease in old woodstoves. These rates were applied nationally and result in an overall decrease in emissions from 2001 to 2020 using the new approach, since new woodstoves emit far less than old ones. The data to support this change was collected as part of the woodstove change-out program development in OAQPS. These changes affects both current and projected emissions from this source category.

Table 2-7: Changes to 2001 and 2020 emissions from residential wood combustion sector

	2001 VOC		**2020 VOC**		**2001 PM2.5**		**2020 PM2.5**	
State	*CAIR*	*PMNAAQS*	*CAIR*	*PMNAAQS*	*CAIR*	*PMNAAQS*	*CAIR*	*PMNAAQS*
Alabama	11,210	54,987	4,206	44,540	4,271	4,009	2,804	2,748
Arizona	5,369	7,224	1,879	6,158	1,794	2,066	1,099	1,552
Arkansas	7,411	6,178	2,075	5,004	2,815	2,485	1,379	2,013
California	57,849	19,193	17,979	16,416	19,615	39,756	10,668	34,779
Colorado	14,234	35,495	4,982	36,285	4,752	11,388	2,910	10,511
Connecticut	9,044	82,136	2,355	81,725	3,664	8,521	1,670	6,902
Delaware	2,848	5,952	1,029	4,821	1,306	1,228	826	995
District of Columbia	704	247	254	229	217	84	137	64
Florida	24,163	12,030	8,728	10,840	10,268	4,398	6,490	3,276
Georgia	21,945	15,633	7,926	13,254	9,588	6,499	6,060	4,706
Idaho	5,241	14,979	1,834	12,133	1,891	2,263	1,158	1,833
Illinois	29,187	33,473	10,542	33,924	9,127	7,517	5,769	5,692
Indiana	46,732	10,932	16,880	9,347	16,351	4,259	10,336	2,998
Iowa	13,928	13,632	2,847	11,348	4,313	5,864	1,543	4,217
Kansas	14,568	18,535	2,978	19,159	4,538	4,464	1,623	3,720
Kentucky	19,568	17,305	7,342	14,345	7,473	7,501	4,907	5,385
Louisiana	7,772	5,582	2,176	4,734	3,162	2,319	1,549	1,679
Maine	11,862	59,816	3,089	48,451	5,346	12,570	2,436	10,181
Maryland	17,297	39,434	6,248	31,942	7,643	8,194	4,831	6,637
Massachusetts	16,965	66,217	4,418	53,636	7,303	13,689	3,328	11,088
Michigan	41,525	32,539	14,999	31,760	17,142	8,139	10,836	5,773
Minnesota	36,113	38,159	7,381	37,464	11,986	11,312	4,287	9,062
Mississippi	6,515	22,689	2,444	20,837	2,732	4,829	1,794	3,445
Missouri	28,962	25,201	5,920	20,114	9,916	11,580	3,547	8,166
Montana	7,082	7,488	2,479	6,349	2,561	3,025	1,569	2,169
Nebraska	4,101	4,935	838	4,107	1,299	2,124	465	1,527
Nevada	1,837	3,532	643	3,560	629	1,083	386	932
New Hampshire	9,133	38,652	2,378	31,308	3,777	8,019	1,721	6,496
New Jersey	26,977	40,494	7,478	34,147	11,413	9,361	5,537	7,786
New Mexico	4,810	3,989	1,684	3,456	1,704	1,565	1,044	1,133
New York	90,283	366,610	25,027	296,950	38,875	60,584	18,858	49,073

	2001 VOC		2020 VOC		2001 PM2.5		2020 PM2.5	
State	*CAIR*	*PMNAAQS*	*CAIR*	*PMNAAQS*	*CAIR*	*PMNAAQS*	*CAIR*	*PMNAAQS*
North Carolina	27,724	24,321	10,014	20,231	11,732	10,477	7,416	7,531
North Dakota	5,071	4,904	1,036	4,199	1,669	2,000	597	1,454
Ohio	30,882	14,962	11,154	12,119	11,626	8,937	7,349	7,239
Oklahoma	7,391	7,148	2,070	5,885	2,629	3,136	1,288	2,246
Oregon	14,919	125,937	4,637	134,065	5,223	36,859	2,841	34,229
Pennsylvania	39,109	25,537	10,841	22,002	16,795	10,286	8,147	7,497
Rhode Island	1,986	1,097	517	1,016	665	375	303	284
South Carolina	12,326	48,863	4,452	54,721	5,596	5,261	3,537	3,649
South Dakota	5,976	5,844	1,222	5,027	2,034	2,361	728	1,720
Tennessee	19,238	16,844	7,218	13,973	7,486	7,048	4,915	5,074
Texas	24,904	22,760	6,973	19,379	8,417	8,554	4,124	6,155
Utah	4,489	4,471	1,571	3,622	1,456	1,465	892	1,187
Vermont	5,268	9,944	1,372	9,171	2,416	3,663	1,101	2,983
Virginia	24,542	53,825	8,864	43,598	9,736	9,885	6,154	7,123
Washington	18,514	77,346	5,754	67,641	6,850	19,479	3,725	17,011
West Virginia	9,974	7,303	3,603	6,067	4,062	3,026	2,568	2,116
Wisconsin	39,802	98,891	14,377	107,994	13,808	20,802	8,728	19,857
Wyoming	3,750	3,772	1,312	3,342	1,190	1,432	728	1,058
US Total	**891,097**	**1,657,038**	**278,024**	**1,482,394**	**340,858**	**425,744**	**186,708**	**344,949**

Growth and Control Changes. Improving the emissions inventory and modeling platform for regulatory analyses is an ongoing process. One improvement made for this analysis is the method used to estimate future-year emissions for stationary non-EGU point and non-point sources. After observing a disconnect between our emissions forecasts and the historical record, we recognized the need to modify future-year emissions forecasts for these specific source categories. An examination of the historical data suggests our previous methods have over-predicted emissions especially in the longer-forecast periods required for the NAAQS and other programs. To address this issue, we developed an ‘interim’ emission projection approach that assumes no growth to emissions for many stationary non-EGU sources in estimating future-year emissions. This change does not impact mobile sources and EGUs future-year emission estimates. We believe this methodology better aligns our forecasts of future growth in the stationary non-EGU sectors with historical trends. It is our intent that this interim forecasting approach provides some understanding of the potential uncertainties implied by the past methodology and the historical record for the stationary non-EGU source categories. In the future, we intend to pursue improved methods and models that provide more consistency with the historical record and reasonable assumptions regarding future conditions. More information is provided in Appendix D on the interim approach and a sensitivity analysis of the implications of this method relative to our previous forecasting methods.

Assumptions regarding the projection of the emissions inventory have implications for our estimates of emission control cost and monetized human health benefits. To the extent that we over-estimate growth in future emissions, then we apply emission controls to reduce emissions beyond a level necessary to meet attainment. This “over-control” would then bias control costs upwards; it would also bias estimated benefits high, as we would monetize the human health benefits of achieving a larger increment of air quality change than necessary to reach attainment.

Conversely, if we under-estimate future emissions growth, then we fail to apply enough emission controls to attain fully. This “under-control” would then bias both estimated control cost low; it would also bias estimated benefits low, as we would monetize the human health benefits of achieving a smaller increment of air quality change than necessary to reach attainment. We believe our ‘interim’ method reduces the bias in future-year estimates used in this analysis compared to our approach in the RIA for the proposed rule.

Due to the significance of this emissions inventory forecasting assumption, EPA consulted with the Advisory Council on Clean Air Compliance Analysis and the Air Quality Modeling Subcommittee (Council) of the Science Advisory Board (SAB) on August 31, 2006 by public teleconference. In the consultation, EPA requested advice as to proper characterization of the interim emissions forecasting approach and the uncertainties involved. The review of this methodological assumption was completed on an expedited basis by the Council. On September 15, 2006, the Council members issued a letter to the EPA Administrator Stephen L. Johnson reporting their findings. In this letter, the Council recommended an alternative forecasting methodology for the stationary non-EGU source categories as preferred to the method used in this RIA. The Council members suggested the alternative would capture “the underlying technological change that is likely driving the historical decline in emissions, i.e., the efficiency gains in production processes and improvements in air pollution control technologies that can be expected over time.” Specifically, the Council suggested using the National Emission Inventory in the 1990s to establish a declining emissions intensity as it relates to changes in the output by sector. As a default, the Council recommended assuming this historical rate of decline would continue to be constant in future years. In the letter to Administrator Johnson, the Council members did recognize that the time constraints involved with the PM NAAQS review and the limitations that might result in the EPA’s ability to accomplish their recommendations.

In response to the Council’s recommendations, the EPA did endeavor to conduct a limited analysis using the Council’s recommended approach for three important non-EGU stationary source sectors including Pulp and Paper Manufacturing, Petroleum Refining, and Chemicals and Allied Products for SO_2 emissions only. The court-ordered schedule for the PM NAAQS review did not allow for further investigation of this method for all non-EGU stationary source categories or relevant pollutants. We found that the Council’s suggested approach resulted in essentially a downward trend in future year SO_2 emissions for these source categories implying negative emissions growth in the future for these source categories. Using an approach similar to the Council’s suggested approach, future-year emissions would decline significantly from 2002 to 2020 for these industries. This result occurs because historical emissions reductions used in this analysis could not be directly attributed to Clean Air Act mandated controls and therefore the entire declining SO_2 emission trend for these three sectors was assumed to continue into the future. We recognize the limitations of this analysis since some historical emission reductions may have been due to Clean Air Act mandated controls (e.g., SIPs, NSPS) that are applied to individual facilities (rather than mandated controls that would be applicable to the entire sector), but given the limited time and quality of the control information in the emission inventory an accurate attribution of these historical emission reductions to the Clean Air Act was not possible. The EPA recognizes the need to find an improved growth forecasting methodology for the stationary non-EGU sectors and is committed to developing the necessary methods and models to achieve this goal in the near future. More information on this issue and copies of the background paper presented to the Council members are included in Appendix D of this document.

Changes to Assumptions for Key Sectors in Nonattainment Areas

In addition to the changed growth assumption, we made a variety of key improvements to our assumptions that we considered most relevant for PM nonattainment areas. One general aspect of these changes was to identify some facilities that were actually closed in 2001, but which were included in our 2001 modeling prior to the discovery of that issue. For all such facilities, we ensured that future-year emissions were identical to base-year emissions, so that the difference between a future baseline run and 2001 would be zero. This approach, which we refer to below as the "no impact approach," causes such sources to have minimal impact on the calculation of future-year nonattainment estimates. Since this calculation applies the difference between 2001 and the future baseline to the ambient data, a difference of zero minimizes the effect of such sources on the calculation.

The following list below provides details on updates made to the control part of our projections for stationary non-EGU sources:

- For the pulp and paper industry, we applied the "no impact approach" to several facilities that closed prior to 2001.
- For the pulp and paper industry, we also reflected plant closures for facilities that have closed since 2001.
- We added consent decrees reducing NOx, SO_2 and $PM_{2.5}$ emissions from the refineries listed in Table 2-7.
- We removed any VOC reductions from MACT programs that had implementation dates prior to 2001.
- We eliminated reductions from control programs which we assessed had reductions that would be accounted for using our growth assumption. Consequently, we did not assume any additional reductions from the NSPS or RICE programs.
- We added existing and planned automobile plant closures, some of which were announced in 2005.
- We removed industrial facilities in Lincoln County, Montana that had closed since 2001.
- We reviewed the NO_X SIP Call reductions for cement plants and made updates to these where needed.
- The CAIR on-road mobile emissions did not completely account for the effects of recent emissions standards that affect the PM emissions for 2007 and newer model year heavy duty diesel vehicles. As a result of this issue, CAIR PM emissions for 2010, 2015, and 2020 from heavy duty vehicles were slightly higher than OTAQ intended and did not

reflect the complete benefits of the emission standards described in the rule. This issue was corrected in this platform. The net impact on $PM_{2.5}$ emissions from mobile sources was a 11% reduction in on-road mobile $PM_{2.5}$ in 2020; this decrease is reflected in our analysis for the current RIA.

Table 2-8: Changes to refinery emissions based on consent decrees

			NOX			SO2			PM2.5		
State	County	Plant	2001	2015	% Diff	2001	2015	% Diff	2001	2015	% Diff
Arkansas	Union Co	LION OIL COMPANY	1,881	1,881	0%	972	850	-13%	268	268	0%
California	Contra Costa Co	CHEVRON PRODUCTS COMPANY	2,560	1,643	-36%	1,143	1,008	-12%	248	248	0%
California	Contra Costa Co	MARTINEZ REFINING COMPANY	3,262	3,262	0%	1,155	867	-25%	508	508	0%
California	Los Angeles Co	ARCO PRODUCTS CO	2,536	1,962	-23%	3,227	2,262	-30%	433	433	0%
California	Los Angeles Co	ULTRAMAR INC (NSR USE ONLY)	331	331	0%	248	239	-3%	153	153	0%
California	Los Angeles Co	CHEVRON PRODUCTS CO.	1,674	921	-45%	1,222	618	-49%	65	65	0%
California	Los Angeles Co	HUNTWAY REFINING CO (EIS USE	7	7	0%	0	0	-90%	0	0	0%
California	Los Angeles Co	MOBIL OIL CORP (EIS USE)	1,668	504	-70%	1,001	1,001	0%	211	211	0%
California	Solano Co	EXXONMOBIL REFINING AND SUPPLY	3,257	3,257	0%	5,830	3,767	-35%	168	168	0%
Colorado	Adams Co	CONOCO INC DENVER REFINERY	814	562	-31%	2,538	601	-76%	218	218	0%
Colorado	Adams Co	COLORADO REFINING CO TOTAL PETROLEUM	260	234	-10%	531	10	-98%	471	266	-43%
Delaware	New Castle Co	MOTIVA ENTERPRISES, LLC - DELAWARE CITY	5,301	3,617	-32%	38,183	9,755	-74%	280	158	-43%
Hawaii	Honolulu Co	CHEVRON- HAWAII REFINERY	2,221	2,018	-9%	4,369	1,829	-58%	376	376	0%
Illinois	Crawford Co	MARATHON ASHLAND PETROLEUM LLC	5,944	3,575	-40%	4,093	406	-90%	400	400	0%
Illinois	Madison Co	CLARK REFINING AND MARKETING INC	1,475	0	-100%	5,721	0	-100%	110	0	-100%
Illinois	Madison Co	EQUILON ENTERPRISES LLC	10,750	10,146	-6%	36,262	8,455	-77%	947	762	-19%
Illinois	Will Co	CITGO PETROLEUM CORP-LEMONT REFINERY	2,700	1,844	-32%	20,358	1,697	-92%	379	315	-17%
Illinois	Will Co	MOBIL OIL-JOLIET REFINING CORP.	3,195	1,664	-48%	25,203	14,694	-42%	267	148	-44%
Kansas	Mc Pherson Co	NATIONAL COOPERATIVE REFINERY ASSN	1,421	1,256	-12%	2,336	1,378	-41%	344	344	0%
Kentucky	Boyd Co	MARATHON ASHLAND PET LCC	4,279	2,834	-34%	6,868	775	-89%	261	261	0%
Louisiana	Calcasieu Par	CONOCO INC/LAKE CHARLES REFINERY	1,487	985	-34%	1,719	1,148	-33%	1,176	1,176	0%
Louisiana	Calcasieu Par	CITGO PETROLEUM CORP/LAKE CHARLES MFG CM	8,164	5,715	-30%	8,083	345	-96%	663	663	0%
Louisiana	East Baton Rouge Par	EXXONMOBIL REF & SUPPLY CO/B R REFINERY	3,291	2,107	-36%	3,578	679	-81%	1,057	1,057	0%
Louisiana	Plaquemines Par	TOSCO REFINING CO/ALLIANCE REFINERY	4,582	4,582	0%	5,046	3,021	-40%	1,421	1,421	0%
Louisiana	St Bernard Par	MOBIL OIL CORP/CHALMETTE REFINERY	2,174	1,304	-40%	462	462	0%	494	494	0%
Louisiana	St Charles Par	ORION REFINING CORP	1,104	1,104	0%	606	545	-10%	42	42	0%
Louisiana	St John The Baptist	MARATHON ASHLAND PETROLEUM LLC/GARYVILLE	2,399	1,470	-39%	317	136	-57%	238	238	0%
Louisiana	St Landry Par	VALERO REFINING CO/KROTZ SPRINGS REFINER	491	422	-14%	634	350	-45%	140	140	0%
Michigan	Wayne Co	MARATHON ASHLAND PETROLEUM LLC	2,349	2,139	-9%	1,514	459	-70%	156	156	0%
Minnesota	Dakota Co	Koch Petroleum Group LP - Pine Bend	3,783	2,286	-40%	2,585	786	-70%	272	229	-16%
Minnesota	Washington Co	Marathon Ashland Petroleum LLC	844	509	-40%	1,476	492	-67%	292	292	0%
Mississippi	Jackson Co	CHEVRON USA	4,675	3,174	-32%	5,965	4,375	-27%	0	0	
Mississippi	Warren Co	ERGON REFINING INC	46	28	-39%	9	9	0%	0	0	0%
Montana	Cascade Co	MONTANA REFINING	80	48	-41%	779	116	-85%	16	16	0%
Montana	Yellowstone Co	CONOCO	683	434	-37%	1,233	1,016	-18%	138	138	0%
Montana	Yellowstone Co	CENEX	897	596	-34%	3,270	2,175	-33%	129	65	-49%
Montana	Yellowstone Co	EXXON CO USA	715	467	-35%	2,941	1,614	-45%	270	270	0%
New Jersey	Gloucester Co	Valero Refining Co.- N.J.	1,338	736	-45%	5,037	50	-99%	150	15	-90%
New Mexico	Eddy Co	ARTESIA REFINERY	370	221	-40%	1,816	83	-95%	243	43	-82%
Ohio	Lucas Co	SUN COMPANY, INC.	2,685	1,380	-49%	6,016	1,415	-76%	254	79	-69%
Ohio	Lucas Co	BP OIL COMPANY, TOLEDO REFINERY	1,880	1,591	-15%	1,326	762	-43%	260	260	0%

Ohio	Stark Co	MARATHON ASHLAND PETROLEUM LLC, CANTON R	862	737	-14%	798	332	-58%	36	36	0%
Oklahoma	Carter Co	TPI PETROLEUM, INC.	523	523	0%	506	73	-86%	451	115	-74%
Oklahoma	Kay Co	CONOCO INC.	3,060	2,024	-34%	2,937	1,082	-63%	155	155	0%
Oklahoma	Tulsa Co	SUN COMPANY INC.	594	357	-40%	2,875	369	-87%	51	51	0%
Pennsylvania	Delaware Co	BAYWAY REF CO/MARCUS HOOK REF	2,044	1,947	-5%	1,686	143	-92%	150	72	-52%
Pennsylvania	Delaware Co	SUNOCO INC (R&M)/MARCUS HOOK REFINERY	1,593	993	-38%	4,769	2,950	-38%	117	60	-49%
Pennsylvania	Delaware Co	FPL ENERGY MH50 LP/MARCUS HOOK	19	11	-40%	0	0	0%	0	0	0%
Pennsylvania	Philadelphia Co	SUN REFINING (FORMERLY CHEVRON)	3,023	1,674	-45%	5,124	487	-90%	419	419	0%
Pennsylvania	Philadelphia Co	SUN REFINING & MARKETING CO.	1	1	0%	1	0	-90%	0	0	
Texas	Galveston Co	BP AMOCO TEXAS CITY BUSINESS UNIT	7,439	4,448	-40%	7,673	774	-90%	607	315	-48%
Texas	Galveston Co	MARATHON ASHLAND PETROLEUM LLC	848	493	-42%	1,773	35	-98%	251	51	-80%
Texas	Galveston Co	VALERO REFINING CO - TEXAS	1,956	1,690	-14%	1,077	236	-78%	343	88	-74%
Texas	Harris Co	EXXONMOBIL REFINING & SUPPLY CO	7,548	5,097	-32%	1,073	295	-73%	500	409	-18%
Texas	Harris Co	SHELL OIL CO	8,136	8,136	0%	11,902	2,160	-82%	401	401	0%
Texas	Hutchinson Co	PHILLIPS 66CO	2,712	2,712	0%	10,615	789	-93%	0	0	
Texas	Jefferson Co	MOBIL OIL CORPORATION	6,827	4,126	-40%	14,012	384	-97%	136	108	-21%
Texas	Live Oak Co	DIAMOND SHAMROCK REFINING CO LP	535	535	0%	609	564	-7%	89	89	0%
Texas	Nueces Co	CITGO REFINING & CHEMICALS CO	1,787	1,083	-39%	2,029	712	-65%	250	250	0%
Texas	Nueces Co	COASTAL REFINING AND MARKETING INC	1,786	1,670	-7%	3,597	1,808	-50%	340	270	-21%
Texas	Nueces Co	VALERO REFINING CO--TEXAS	1,509	1,275	-16%	186	147	-21%	245	84	-66%
Texas	Nueces Co	KOCH PETROLEUM GROUP LP	697	551	-21%	182	20	-89%	201	34	-83%
Texas	Nueces Co	KOCH PETROLEUM GROUP LP	2,071	2,063	0%	153	152	-1%	64	63	-2%
Texas	Nueces Co	CITGO REFINING & CHEMICALS CO LP	317	191	-40%	170	143	-16%	32	32	0%
Utah	Davis Co	SALT LAKE REFINERY	582	416	-29%	795	289	-64%	106	90	-14%
Utah	Salt Lake Co	SALT LAKE CITY REFINERY	558	441	-21%	1,162	682	-41%	40	40	0%
Virginia	York Co	BP AMOCO PETROLEUM PRODUCTS - YORKTOWN	3,393	3,281	-3%	3,960	1,534	-61%	412	412	0%
Washington	Skagit Co	PUGET SOUND REFINING COMPANY	922	922	0%	2,687	1,177	-56%	102	53	-48%
Washington	Whatcom Co	TOSCO REFINING COMPANY	726	726	0%	2,346	235	-90%	91	91	0%
Washington	Whatcom Co	ARCO CHERRY POINT REFINERY	2,739	2,169	-21%	1,816	929	-49%	100	100	0%

Other ancillary data changes. We determined that the organic carbon fraction in the speciation profile code "NCOAL" used for CAIR is not representative of most coal combustion occurring in the U.S. This profile has an organic carbon fraction of about 20%, which includes an adjustment factor of 1.2 to account for other atoms, like oxygen, that are attached to the carbon. For this work, we have reverted back to the profile code "22001" for coal combustion, which has an organic carbon fraction of 1.07% (again including the 1.2 factor adjustment). This is the same profile that EPA used for previous rulemaking efforts including the Heavy Duty Diesel Rule and Nonroad Rule, which were done (and publicly reviewed) prior to the introduction of the NCOAL profile. The impact of this change is significant in that it reduces the amount and severity of unrealistic organic carbon hotspots.

We also revised several key monthly temporal profile datasets, which we use to compute month-specific emissions from the annual inventory emissions. These revisions included:

- Updating a nondairy agricultural NH_3 monthly temporal profile, based on latest inverse modeling by EPA's Office of Research and Development (EPA ORD). This change improved the nitrate prediction performance by CMAQ.

- Revising a dairy cow monthly profile. This was a minor change.

- Updated residential wood combustion (RWC) monthly temporal profiles to include the latest data from the RPOs, 2002 NEI, and States. This change significantly improves the distribution of RWC emissions to reflect a more realistic, climate-specific distribution.

In addition, we have updated the $PM_{2.5}$ speciation factors for future-year gas and diesel speciation. We now use a different profile in the 2001 base and the future baseline runs that account for changes in the percentage of $PM_{2.5}$ emissions coming from brake and tire wear rather than exhaust. As emissions decrease in the future, a smaller proportion of emissions in the future are from exhaust, which has a different $PM_{2.5}$ species signature than brake and tire wear. This approach was used in the modeling for the Nonroad Rule and Heavy Duty Diesel Engine Rule, but was inadvertently left out of the CAIR modeling work. The impacts of this change are minimal.

Significant Processing Changes. Lastly, we included two significant software updates in this work. First, a new version of the SMOKE model is employed in our data processing. This version is largely the same as the version used for CAIR, with the exception of an updated plumerise algorithm, which changes the vertical distribution of emissions from large point sources. The new approach tends to have more emissions at the surface than the old approach, particularly during afternoon hours. Second, we used the Biogenic Emission Inventory System version 3.13 (BEIS3.13) instead of BEIS version 3.12, which was used for the CAIR modeling. While these are notable changes to the processing approach, the resulting impacts of both of these changes on the RIA results are minimal.

EGU Sector

EPA uses the Integrated Planning Model (IPM) to examine a broad variety of issues facing the electric power sector. IPM considers all aspects of wholesale generation resources, power system reliability, environmental compliance, fuel usage, transmission capability, capacity requirements, and other fundamental issues in developing forward forecasts for plant dispatch, power prices, and capacity and transmission expansion. IPM is unique in its ability to provide an assessment that integrates power, environmental and fuel markets. Structurally, IPM is a dynamic linear optimization model which enables the projection of the behavior of the power system over a specified future period. The optimization logic determines the least-cost means of meeting electric generation and capacity requirements while complying with specified constraints including air pollution regulations, transmission bottlenecks, fuel market restrictions and plant-specific operational constraints.

IPM is designed to accurately represent and forecast power sector dispatch, utilization, capital investments, and fuel forecasts, while also being able to forecast emissions from power sector sources. IPM produces unit specific emissions of SO_2, NO_x, Hg, and CO_2 for every power producing unit in the country. This data is then fed into air quality modeling and serves as the basis for the assessment of the environmental impacts of emissions from EGUs.

Since the time CAIR was finalized in March of 2005, EPA has updated the modeling done with IPM to better reflect the requirements under CAIR and also to incorporate more recent data. For example, a Final Rule to include Delaware and New Jersey in the annual CAIR requirements for SO_2 and NO_x was finalized in March, 2006. Modeling done for the Final CAIR (March, 2005) included these two States for the ozone-season NO_x requirements only.

Another important update to IPM is based upon more recent data regarding pollution controls, New Source Review (NSR) settlements, and consent decrees. EPA's last update to IPM occurred in early 2004, and since that time new pollution control equipment has either been installed or is under construction on various power facilities. In addition, there have been a number of NSR settlements and consent decrees requiring surrender of Title IV Acid Rain Program SO_2 allowances and/or installation of pollution controls on certain electricity generating facilities. EPA has documented these updates and will include this information in the next version of IPM (v3.0), to be completed in the fall of 2006. However, in light of the air quality issues in certain parts of the country**,** and aware that some of these new updates may have a significant positive impact on air emissions in these areas, EPA concluded that a small subset of these updates should be included in updated power sector modeling. The updates focused on areas of particular air quality concern: Atlanta, Georgia, Detroit, Michigan, Louisville, Kentucky, St. Louis, Missouri, and Stuebenville, Ohio. EPA identified units in these areas that were projected to lack advanced pollution controls for SO_2 removal in 2020 based upon EPA's most recent IPM results from the fall of 2005, and applied pollution controls for SO_2, NO_x, and particulates to these units if new information was available indicating that those controls either exist on the units, are under construction, or will be installed based upon a recent consent decree or settlement. Table 2-8 summarizes the units and controls that were updated in IPM.

Table 2-8: Summary of Unit Updates Applied to IPM

Unit #	*State*	*County*	*Plant Name*	*NA Area*	*Controls Added*	*Year of Control Addition*	*PM Controls Added*
1	Georgia	Bowen	Bowen	Atlanta	Wet Scrubber	2010	---
3	Michigan	Monroe	Monroe	Detroit	Wet Scrubber	2007	---
4	Michigan	Monroe	Monroe	Detroit	Wet Scrubber	2007	---
1	Illinois	Randolph	Baldwin Energy Complex	St. Louis	Scrubber	2013	Baghouse
3	Illinois	Randolph	Baldwin Energy Complex	St. Louis	Scrubber	2013	Baghouse
6	Indiana	Jefferson	Clifty Creek	Louisville	Wet Scrubber	2010	
1	Ohio	Jefferson	W.H. Sammis[a]	Stuebenville	SNCR	2007	Baghouse
2	Ohio	Jefferson	W.H. Sammis[a]	Stuebenville	---	2007	Baghouse
3	Ohio	Jefferson	W.H. Sammis[a]	Stuebenville	SNCR	2007	Baghouse
4	Ohio	Jefferson	W.H. Sammis[a]	Stuebenville	SNCR	2007	Baghouse

[a] W.H. Sammis agreement calls for a plant-wide 50% SO_2 reduction requirement or 1.1 lbs mm/Btu in 2008.

The updated power sector emissions from revised modeling using IPM, which incorporate the changes previously discussed, were used in the analysis of both the 1997 PM NAAQS (15 μ/m^3 annual and 65 μ/m^3 daily) and the proposed revised standards (15 μ/m^3 annual and 35 μ/m^3 daily). For the other alternative standard (14 μ/m^3 annual, 35 μ/m^3 daily), additional changes were made to the power sector modeling and those changes are discussed in a subsequent chapter.

Another notable change to power sector assumptions is the siting of new power plants. In the past, EPA has assumed that all counties would be eligible for the siting of new power capacity, regardless of attainment status. EPA has revised this methodology for purposes of this illustrative analysis and no longer sites new capacity in future (2015) nonattainment counties, based on EPA's most recent baseline air quality modeling. This includes twenty counties, including eleven counties in California, and one or two each in Alabama, Georgia, Illinois, Indiana, Michigan, Montana, Ohio, and Pennsylvania.

2.4 Projected Air Quality and Nonattainment in 2015 and 2020

As a first step in both defining the future year $PM_{2.5}$ air quality problem and developing illustrative control scenarios to simulate attainment, this analysis used the CMAQ air quality model to project 2015 and 2020 annual and 98th percentile daily $PM_{2.5}$ levels. This modeling provided a base case on which we developed the illustrative control scenarios found in Chapter 3 of this RIA. The sections below provide this projected air quality data in map and tabular form and then provides the key insights into the base case air quality modeling. Readers interested in documentation concerning both the base-case emissions estimates and CMAQ air quality modeling used to develop these estimates should consult Chapter 3.

2.4.1 Results

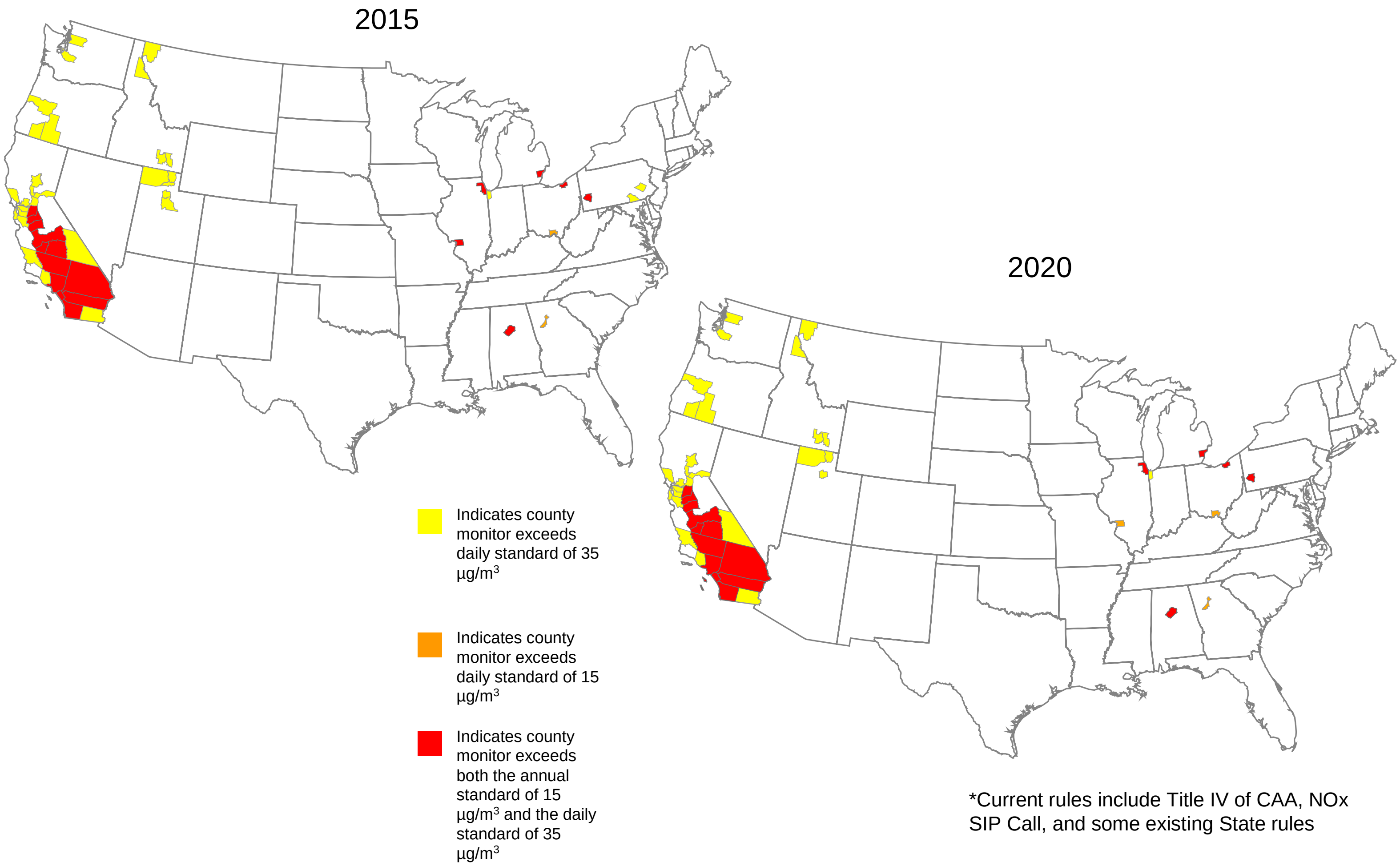
Figure 2-7 below illustrates the projected regulatory base case non-attainment with the revised standard of 15/35. The map on the left shows projected non-attainment in 2015. The map on the right shows projected non-attainment in 2020. Figure 2-8 illustrates the air quality increment by which counties are projected to violate the revised daily standard of 35 µg/m^3. Table 2-9 below summarizes the number of counties projected to not attain the standard in 2015 and 2020.

Counties Projected to Exceed Revised Standards in 2015 and 2020

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

Figure 2-7. Counties projected to Violate the Revised PM2.5 Standards of 15/35 in 2015 and 2020

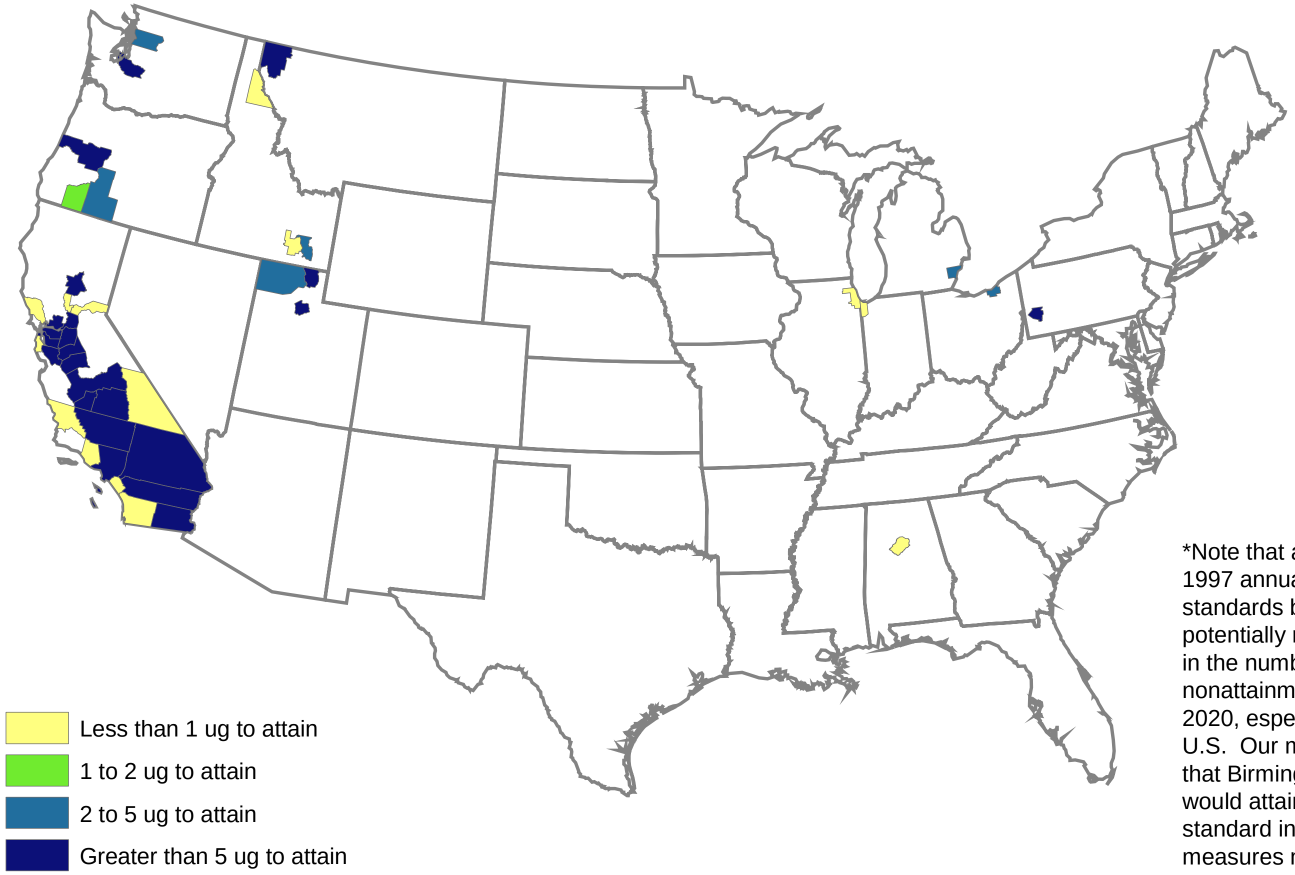
With CAIR/CAMR/CAVR and Some Current Rules* Absent Additional Local Controls



*Current rules include Title IV of CAA, NOx SIP Call, and some existing State rules

Figure 2-8. Projected Reduction in Daily Design Value Needed to Attain the Revised Daily Standard of 35 µg/m^3 in 2020

*Incremental to baseline with CAIR/CAMR/CAVR and Mobile Source Rules without additional local controls for attainment of the current standards**



*Note that attainment with the 1997 annual and daily standards by 2020 would potentially result in reductions in the number of nonattainment counties in 2020, especially in the Eastern U.S. Our modeling suggests that Birmingham and Chicago would attain the revised daily standard in 2020 with measures needed to attain the 1997 standards.

2.4.2 Major Insights

A few key observations may be gleaned from the baseline air quality modeling:

- In total, EPA projects that in 2015 52 counties will not attain some combination of the current annual standard of 15 µg/m^3 and the revised daily standard of 35 µg/m^3.
- More western than eastern counties are projected to not attain the revised daily standard.
- Compared to the western US outside of California, more eastern counties are projected to violate both the annual standard of 15 µg/$m^3$and revised daily standard of 35 µg/m^3.
- Western counties located outside of California are projected to not attain the revised daily standard of 35 µg/m^3, but to attain the current annual standard of 15 µg/m^3.
- Most counties in southern California are projected to not attain either the revised daily standard 35 µg/m^3or the current annual standard of 15µg/m^3.
- Utah County, located south of Salt Lake City, and York County, located to the west of Philadelphia, are projected to attain the revised standard in 2020, but not 2015.

2.5 References

Frank, N.H., Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities, *J. Air & Waste Manage. Assoc.* **2006**, *56,* 500-511.