TABLE IV–1.—STATE SO_2 EMISSIONS BY SECTOR IN THE 2010 BASE CASE [1]—Continued

ST	EGU v21	EGU v216	Non-EGU	On-road	Non-road	Area	Total
KS	71,500	63,500	16,000	300	800	3,500	84,100
KY	393,300	363,100	42,900	500	1,800	58,000	466,400
LA	96,300	112,500	193,600	400	21,100	94,000	421,700
ME	4,700	3,200	22,200	200	200	10,800	36,600
MD	261,400	232,200	22,500	600	8,100	900	264,300
MA	17,700	15,600	15,300	600	1,200	61,300	94,000
MI	375,800	387,600	135,000	1,000	1,300	32,700	557,600
MN	94,200	91,600	41,200	500	1,100	5,700	140,000
MS	84,600	73,500	77,500	400	2,000	82,700	236,100
MO	261,000	293,100	128,600	700	900	31,900	455,200
MT	17,700	17,900	34,700	100	300	1,400	54,400
NE	97,200	97,600	7,300	200	600	10,100	115,800
NV	56,700	16,400	3,500	200	400	3,900	24,300
NH	7,300	7,300	7,900	100	200	90,800	106,300
NJ	85,300	41,300	70,800	700	53,500	42,600	208,900
NM	48,300	48,600	115,200	300	200	9,400	173,700
NY	211,400	214,100	168,600	1,300	2,200	122,100	508,200
NC	221,500	219,400	95,400	1,000	1,200	33,800	350,800
ND	172,200	160,900	56,100	100	400	64,100	281,600
OH	979,300	1,258,700	337,600	1,200	5,700	63,300	1,666,40
OK	133,000	133,000	41,200	500	600	5,500	180;800
OR	15,200	15,200	6,600	400	800	20,900	43,800
PA	670,200	853,400	141,000	1,100	3,300	80,900	1,079,80
RI	0	0	2,400	100	2,900	4,100	9,500
SC	191,500	199,700	63,900	500	1,200	15,600	280,900
SD	42,100	36,300	1,400	100	200	23,800	61,800
TN	317,300	306,100	134,300	700	2,800	47,800	491,700
TX	539,900	487,700	318,600	2,300	33,400	9,600	851,700
UT	31,200	31,500	30,300	300	400	13,100	75,600
VT	0	0	2,000	100	100	13,000	15,100
VA	180,600	187,800	112,700	900	4,600	9,500	315,400
WA	6,000	6,000	51,600	600	9,500	3,700	71,400
WV	456,800	550,600	62,200	200	33,600	11,300	658,000
WI	217,200	214,100	88,500	600	800	45,900	349,800
WY	47,100	47,300	59,700	100	200	17,300	124,600
	9,435,400	9,856,900	3,799,200	29,800	236,400	1,367,600	15,290,0

[1] All values rounded to nearest 100 tons. EGU v216 emissions are latest version and are included in totals. EGU v21 emissions were used for the zero-out analysis.

TABLE IV–2.—STATE NO_X EMISSIONS BY SECTOR IN THE 2010 BASE CASE [1]

ST	EGU v21	EGU v216	Non-EGU	On-road	Non-road	Area	Total
AL	129,500	134,100	83,400	110,200	55,800	69,400	453,000
AZ	88,200	84,600	118,200	91,300	43,600	78,100	415,700
AR	52,600	52,500	23,500	64,900	35,400	44,800	221,100
CA	18,200	17,700	137,300	401,900	276,100	129,300	962,300
CO	87,000	82,700	44,900	80,600	57,000	59,900	325,100
CT	6,700	5,200	11,300	48,500	17,300	9,300	91,600
DE	11,500	10,300	8,500	17,400	16,800	6,900	59,900
DC	100	0	800	4,800	5,400	1,900	13,000
FL	162,900	161,800	59,000	293,900	147,900	53,200	716,000
GA	152,500	150,600	71,400	189,200	66,400	74,700	552,300
ID	1,400	1,200	6,600	32,700	17,300	29,400	87,200
IL	194,200	171,400	134,900	177,700	150,200	115,800	750,100
IN	223,300	239,700	45,400	142,900	90,400	37,900	556,300
IA	95,400	86,100	26,500	61,600	57,600	31,100	262,900
KS	101,400	100,900	108,800	59,100	79,500	74,300	422,600
KY	186,300	195,900	34,800	95,700	73,100	76,900	476,400
LA	64,700	49,800	297,100	89,300	205,000	103,500	744,700
ME	6,000	2,100	15,600	30,600	8,800	4,900	62,000
MD	60,500	60,600	19,100	73,100	38,900	15,900	207,700
MA	27,800	10,400	18,200	74,400	70,000	24,900	197,800
MI	126,200	125,400	161,000	171,400	63,200	115,600	636,500
MN	109,700	104,500	83,800	103,400	64,800	24,800	381,500
MS	49,700	43,200	74,400	68,800	44,800	56,700	287,800
MO	144,700	137,000	29,700	117,800	64,200	14,800	363,600
MT	38,500	38,500	20,800	24,800	34,000	18,400	136,400
NE	58,100	57,800	14,500	37,700	57,400	15,400	182,800
NV	44,800	37,400	6,000	36,300	25,400	8,500	113,500

TABLE IV–2.—STATE NO_X EMISSIONS BY SECTOR IN THE 2010 BASE CASE [1]—Continued

ST	EGU v21	EGU v216	Non-EGU	On-road	Non-road	Area	Total
NH	3,000	3,600	4,200	25,700	6,200	13,900	53,700
NJ	40,000	29,300	51,000	93,100	86,400	79,800	339,600
NM	77,300	76,400	68,700	54,500	10,700	32,400	242,800
NY	58,700	68,400	36,700	181,500	90,900	88,100	465,600
NC	64,700	62,100	63,300	150,000	60,100	37,000	372,400
ND	81,100	77,900	7,200	16,400	41,800	21,200	164,600
OH	249,100	266,800	77,500	201,300	116,900	82,200	744,700
OK	97,700	82,100	121,000	86,800	40,000	33,200	363,100
OR	18,000	13,300	16,800	67,400	52,600	39,900	190,000
PA	212,100	209,800	173,000	200,600	80,600	114,300	778,300
RI	1,300	1,400	900	12,300	5,600	2,800	23,000
SC	67,500	64,700	46,000	94,200	29,900	26,100	260,900
SD	13,800	11,700	4,700	20,200	24,400	7,900	69,000
TN	106,700	102,800	78,000	132,900	138,900	52,300	505,000
TX	246,200	200,900	523,800	399,600	432,100	43,100	1,599,50
UT	68,400	69,400	31,600	49,000	31,500	23,500	205,100
VT	0	0	800	16,000	3,900	11,500	32,100
VA	55,800	55,500	66,500	147,000	76,600	45,700	391,300
WA	26,600	28,400	47,000	114,600	78,800	23,000	291,800
WV	142,500	155,200	50,100	40,400	57,000	21,300	324,000
WI	116,200	111,500	54,300	109,600	51,000	58,700	385,100
WY	90,300	90,500	49,500	18,600	22,900	71,700	253,200
	4,079,200	3,943,400	3,228,200	4,931,900	3,405,000	2,225,900	17,734,4

[1] All values rounded to nearest 100 tons. EGU v216 emissions are latest version and are included in totals. EGU v21 emissions were used for the zero-out analysis.

b. Development of Emissions Inventories for On-road Vehicles

The 2001 base year inventory for the on-Road vehicle sector was developed by applying State and pollutant specific adjustment ratios to each grid cell's emissions as found in the existing 1996 model-ready file for on-road sources. The adjustment ratios were created by dividing State-level emissions for each pollutant as estimated for the 2001 NEI using the MOBILE6 model by the State-level emissions for 1996 as estimated using the same MOBILE6 model.

The 1996 model-ready file, along with consistent files for 2007 and 2020 emissions, had been developed for previous EPA rulemakings using a version of the MOBILE5b model which had been adjusted to simulate the MOBILE6 model that was under development at that time. The 1996 and 2007 emissions files had been developed for the HDDE rule (*http://www.epa.gov/otaq/models/hd2007/r00020.pdf*) and the 2020 emissions file had been developed for the LNDE rule (*http://www.epa.gov/nonroad/454r03009.pdf*). Note that the 2020 on-road vehicle emissions file developed for the LNDE rule includes the reductions expected from implementation of the HDDE rule.

Application of the MOBILE6-based adjustment ratios to the 1996 MOBILE5b-based emission file allowed the resulting 2001 model-ready file to remain consistent in methodology with the existing 2007 and 2020 files. The 2010 and 2015 base case emissions files used for this proposal were then developed as straight-line interpolations between those 2007 and 2020 files, and they are therefore also consistent with the 2001 file.

c. Development of Emissions Inventories for Non-Road Engines

For the non-road sector, the 2001 model-ready emissions file was developed in a manner similar to that described above for the on-road vehicle sector. State-level 2001 NEI emissions developed from the NONROAD2002 model were divided by a consistent set of emissions for 1996, also developed using the NONROAD2002 model, to produce a set of adjustment ratios for each State and pollutant. These adjustment ratios were applied to the existing 1996 model-ready emissions for each grid cell to produce a 2001 model-ready file that remains consistent with the 1996 file and the existing future projections that were based on that 1996 file.

For the future scenarios, the 2010 and 2020 emissions files developed for EPA's analysis of the preliminary controls of the LNDE rule were modified to reflect that rule as finally proposed (68 FR 28327, May 23, 2003) and to incorporate the effects of the Large Spark Ignition and Recreational Vehicle rules. These modifications were done using adjustment ratios developed from national-level estimates of the benefits of these two rules. A 2015 emissions file for this sector was then developed as a straight-line interpolation between the modified 2010 and 2020 files.

d. Development of Emissions Inventories for Other Sectors

The NEI estimates for 2001 were not available at the time modeling was begun for the remaining two man-made emission sectors: non-EGU point sources and area sources. For these two sectors, linear interpolations were performed between gridded 1996 emissions and gridded projected 2010 base case emissions to produce gridded 2001 emissions files. The gridded emissions input files for 1996 and 2010 were available from previous EPA analyses. The interpolations were done separately for each of the two sectors, for each grid cell, and for each pollutant. The 2010 and 2015 emissions files for these sectors that were used as part of this interpolation to 2001 were themselves developed as straight-line interpolations between the 2007 and 2020 inventories described above for the on-road vehicle sector. The interpolated 2010 and 2015 emissions were adjusted to reflect the SO_2, PM_{10}, and $PM_{2.5}$ co-control benefits of the proposed Industrial Boiler and Process Heater MACT (68 FR 1660, January 13, 2003). The 2007 and 2020 projection inventories had been developed by applying State- and 2-digit SIC-specific economic growth ratios to the 1996 NEI, followed by application of any emissions control regulations.

5. Preparation of Emissions for Air Quality Modeling

The annual and summer day emissions inventory files were processed through the Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System version 1.4 to produce 36–km gridded input files for annual $PM_{2.5}$ air quality modeling and 12–km input files for episodic ozone air quality modeling. In addition to the U.S. man-made emission sources described above, hourly biogenic emissions were estimated for individual modeling days using the BEIS model version 3.09 (*ftp.epa.gov/amd/asmd/beis3v09/*). Emissions inventories for Canada and for U.S. offshore oil platforms were merged in using SMOKE to provide a more complete modeling data set. The single set of biogenic, Canadian, and offshore U.S. emissions was used in all scenarios modeled. That is, the emissions for these sources were not varied from run to run. Additional information on the development of the emissions data sets for modeling is provided in the AQMTSD.

D. Ozone Air Quality Modeling

1. Ozone Modeling Platform

The CAM_X was used to assess 8-hour ozone concentrations as part of this rulemaking. The CAM_X is a publicly available Eulerian model that accounts for the processes that are involved in the production, transport, and destruction of ozone over a specified three-dimensional domain and time period. Version 3.10 of the CAM_X model was employed for this analyses. More information on the CAM_X model can be found in the model user's guide.[57] The model simulations were performed for a domain covering the Eastern U.S. and adjacent portions of Canada.

Three episodes during the summer of 1995 were used for modeling ozone and precursor pollutants: June 12–24, July 5–15, and August 10–21. The start of each episode was chosen to correspond to a day with no ozone exceedances (an exceedance is an 8-hour daily maximum ozone concentration of 85 ppb or more). The first three days of each episode are considered ramp-up days and were discarded from analysis to minimize effects of the clean initial concentrations used at the start of each episode. In total, thirty episode days were used for analyzing interstate transport. As described in the AQMTSD, these episodes contain meteorological conditions that reflect various ozone transport wind patterns across the East. In general, ambient ozone concentrations during these episodes span the range of 2000–2002 8-hour ozone design values at monitoring sites in the East.

In order to solve for the change in pollutant concentrations over time and space, the CAM_X model requires certain meteorological inputs for the episodes being modeled, including: winds, temperature, water vapor mixing ratio, atmospheric air pressure, cloud cover, rainfall, and vertical diffusion coefficient. Most of the gridded meteorological data for the three historical 1995 episodes were developed by the New York Department of Environment and Conservation using the Regional Atmospheric Modeling System (RAMS), version 3b. A model performance evaluation[58] was completed for a portion of the 1995 meteorological modeling (July 12–15). Observed data not used in the assimilation procedure were compared against modeled data at the surface and aloft. This evaluation concluded there were no widespread biases in the RAMS meteorological data. The remaining meteorological inputs (cloud fractions and rainfall rates) were developed based on observed data.

2. Ozone Model Performance Evaluation

The CAM_X model was run with Base Year emissions in order to evaluate the performance of the modeling platform for replicating observed concentrations. This evaluation was comprised principally of statistical assessments of paired model/observed data. The results indicate that, on average, the predicted patterns and day-to-day variations in regional ozone levels are similar to what was observed with measured data. When all hourly observed ozone values (greater than 60 ppb) are compared to their model counterparts for the 30 days modeled (paired in time and space), the mean normalized bias is −1.1 percent and the mean normalized gross error is 20.5 percent. As described in the AQMTSD, the performance for individual episodes indicates variations in the degree of model performance with a tendency for underprediction during the June and July episodes and overprediction during the August episode.

At present, there are no generally accepted statistical criteria by which one can judge the adequacy of model performance for regional scale ozone model applications. However, as documented in the AQMTSD, the base year modeling for today's rule represents an improvement in terms of statistical model performance when compared to prior regional modeling analyses (*e.g.*, model performance analyses for OTAG, the Tier-2/Low Sulfur Rule, and the Heavy Duty Engine Rule).

3. Projection of Future 8-Hour Ozone Nonattainment

Ozone modeling was performed for 2001 emissions and for the 2010 and 2015 Base Cases as part of the approach for forecasting which counties are expected to be nonattainment in these 2 future years. In general, the approach involves using the model in a relative sense to estimate the change in ozone between 2001 and each future base case. Concentrations of ozone in 2010 were estimated by applying the relative change in model predicted ozone from 2001 to 2010 with present-day 8-hour ozone design values (2000–2002). The procedures for calculating future case ozone design values are consistent with EPA's draft modeling guidance[59] for 8-hour ozone attainment demonstrations, "Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS." The draft guidance specifies the use of the higher of the design values from (a) the period that straddles the emissions inventory Base Year or (b) the design value period which was used to designate the area under the ozone NAAQS. In this case, 2000–2002 is the design value period which straddles the 2001 Base Year inventory and is also the latest period which is available for determining designation compliance with the NAAQS. Therefore, 2000–2002 was the only period used as the basis for projections to the future years of 2010 and 2015.

The procedures in the guidance for projecting future 8-hour ozone nonattainment are as follows:

Step 1: Hourly model predictions are processed to determine daily maximum 8-hour concentrations for each episode day modeled. A relative reduction factor (RRF) is then determined for each monitoring site. First, the multi-day mean (excluding ramp-up days) of the 8-hour daily maximum predictions in the nine grid cells that include or surround the site is calculated using only those

[57] Environ, 2002: User's Guide to the Comprehensive Air Quality Model with Extensions (CAM_X), Novato, CA.

[58] Hogrefe, C., S.T. Rao, P. Kasibhatla, G. Kallos, C. Tremback, W. Hao, D. Olerud, A. Xiu, J. McHenry, K. Alapaty, 2001. "Evaluating the performance of regional-scale photochemical modeling systems: Part-I meteorological predictions." *Atmospheric Environment*, vol. 35, No. 34, 4159–4174.

[59] U.S. EPA, 1999: *Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS*, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

predictions greater than or equal to 70 ppb, as recommended in the guidance. This calculation is performed for the base year 2001 scenario and the future-year scenario. The RRF for a site is the ratio of the mean prediction in the future-year scenario (*e.g.*, 2010) to the mean prediction in the 2001 base year scenario. The RRFs were calculated on a site-by-site basis.

Step 2: The RRF for each site is then multiplied by the 2000–2002 ambient design value for that site, yielding an estimate of the future design value at that particular monitoring location.

Step 3: For counties with only one monitoring site, the value at that site was selected as the value for that county. For counties with more than one monitor, the highest value in the county was selected as the value for that county. Counties with projected 8-hour ozone design values of 85 ppb or more are projected to be nonattainment.

As an example, consider Clay County, Alabama which has one ozone monitor. The 2000–2002 8-hour ambient ozone design value is 82 ppb. In the 2001 base year simulation, 24 of the 30 episode modeling days have CAMx values of 70 ppb or more in one of the nine grid cells that include or surround the monitor location. The average of these predicted ozone values is 88.62 ppb. In 2010, the average of the predicted values for these same grid cells was 70.32 ppb. Therefore, the RRF for this location is 0.79, and the projected 2010 design value is 82 multiplied by 0.79 equals 65.07 ppb. All projected future case design values are truncated to the nearest ppb (*e.g.*, 65.07 becomes 65). Since there are no other monitoring locations in Clay County, Alabama, the projected 2010 8-hour design value for this county is 65 ppb.

The RRF approach described above was applied for the 2010 and 2015 Base Case scenarios. The resulting 2010 and 2015 Base Case design values are provided in the AQMTSD. Of the 287 counties that were nonattainment based on 2000–2002 design values, 47 are forecast to be nonattainment in 2010 and 34 in 2015. None of the counties that were measuring attainment in the period 2000–2002 are forecast to become nonattainment in the future. Those counties projected to be nonattainment for the 2010 and 2015 Base Cases are listed in Table IV–3.

TABLE IV–3.—COUNTIES PROJECTED TO BE NONATTAINMENT FOR THE 8-HOUR OZONE NAAQS IN THE 2010 AND 2015 BASE CASES

State	2010 Base case projected nonattainment counties	2015 Base case porojected nonattainment counties
AR	Crittenden	Crittenden.
CT	Fairfield, Middlesex, New Haven	Fairfield, Middlesex, New Haven.
DC	Washington, DC	Washington, DC.
DE	New Castle	None.
GA	Fulton	None.
IL	None	Cook.
IN	Lake	Lake.
MD	Anne Arundel, Baltimore, Cecil, Harford, Kent, Prince Georges.	Anne Arundel, Cecil, Harford.
MI	None	Macomb.
NJ	Bergen, Camden, Cumberland, Gloucester, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean.	Bergen, Camden, Gloucester, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean.
NY	Erie, Putnam, Richmond, Suffolk, Westchester	Erie, Richmond, Suffolk, Westchester.
NC	Mecklenburg	None.
OH	Geauga, Summit	Geauga.
PA	Allegheny, Bucks, Delaware, Montgomery, Philadelphia	Bucks, Montgomery, Philadelphia.
RI	Kent	Kent.
TX	Denton, Harris, Tarrant	Harris.
VA	Arlington, Fairfax	Arlington, Fairfax.
WI	Kenosha, Racine, Sheboygan	Kenosha, Sheboygan.

The counties projected to be nonattainment for the 2010 Base Case are the nonattainment receptors used for assessing the contribution of emissions in upwind States to downwind nonattainment as part of today's proposal. It should be noted that the approach used to identify these nonattainment receptors differed from that used in the NO_X SIP Call where we aggregated on a State-by-State basis all grid cells which were both (a) associated with counties that violated the 8-hour NAAQS (based on 1994–1996 data), and (b) had future base case predictions of 85 ppb or more. For this proposal, we have treated each individual county projected to be nonattainment in the future as a downwind nonattainment receptor.

E. The $PM_{2.5}$ Air Quality Modeling

1. The $PM_{2.5}$ Modeling Platform

The REMSAD model version 7 was used as the tool for simulating base year and future concentrations of $PM_{2.5}$ in support of today's proposed rule. The REMSAD is a publicly available model. An overview of the scientific aspects of this model is provided below. More detailed information can be found in the REMSAD User's Guide.[60] The basis for REMSAD is the atmospheric diffusion equation (also called the species continuity or advection/diffusion equation). This equation represents a mass balance in which all of the relevant emissions, transport, diffusion, chemical reactions, and removal processes are expressed in mathematical terms.

The REMSAD simulates both gas phase and aerosol chemistry. The gas phase chemistry uses a reduced-form version of Carbon Bond (CB4) chemical mechanism termed "micro-CB4" (mCB4). Formation of secondary PM species, such as sulfate[61] and nitrate, is simulated through chemical reactions within the model. Aerosol sulfate is formed in both the gas phase and the aqueous phase. The REMSAD also accounts for the production of secondary organic aerosols through atmospheric chemistry processes. Direct PM emissions in REMSAD are treated as inert species which are advected and

[60] ICF Kaiser, 2002: *User's Guide to the Regional Modeling System for Aerosols and Deposition (REMSAD) Version 7*, San Rafael, CA.

[61] Ammonium sulfates are referred to as "sulfate" in sections IV and V of today's proposed rule.

deposited without any chemical interaction with other species.

The REMSAD was run using a latitude/longitude horizontal grid structure in which the horizontal grids are generally divided into areas of equal latitude and longitude. The grid cell size was approximately 36 km by 36 km. The REMSAD was run with 12 vertical layers extending up to 16,000 meters, with a first layer thickness of approximately 38 meters. The REMSAD modeling domain used for this analysis covers the entire continental United States.

The REMSAD requires input of winds, temperatures, surface pressure, specific humidity, vertical diffusion coefficients, and rainfall rates. The meteorological input files were developed from a 1996 annual MM5 model run that was developed for previous projects. The MM5 is a numerical meteorological model that solves the full set of physical and thermodynamic equations which govern atmospheric motions. The MM5 was run in a nested-grid mode with 2 levels of resolution: 108 km, and 36km with 23 vertical layers extending from the surface to the 100 mb pressure level.[62] All of the $PM_{2.5}$ model simulations were performed for a full year using the 1996 meteorological inputs.

2. The $PM_{2.5}$ Model Performance Evaluation

An annual simulation of REMSAD was performed for 1996 using the meteorological data and emissions data for that year. The predictions from the 1996 Base Year modeling were used to evaluate model performance for predicting concentrations of $PM_{2.5}$ and its related speciated components (*e.g.*, sulfate, nitrate, elemental carbon, organic carbon). The evaluation was comprised principally of statistical assessments of model versus observed pairs.

The evaluation used data from the IMPROVE,[63] CASTNet[64] dry deposition, and NADP[65] monitoring networks. The IMPROVE and NADP networks were in full operation during 1996. The CASTNet dry deposition network was partially shutdown during the first half of the year. There were 65 CASTNet sites with at least one season of complete data. There were 16 sites which had complete annual data. The largest available ambient data base for 1996 comes from the IMPROVE network. The IMPROVE network is a cooperative visibility monitoring effort between EPA, Federal land management agencies, and State air agencies. Data is collected at Class I areas across the United States mostly at national parks, national wilderness areas, and other protected pristine areas. There were approximately 60 IMPROVE sites that had complete annual $PM_{2.5}$ mass and/or $PM_{2.5}$ species data for 1996. Forty-two sites were in the West[66] and 18 sites were in the East. The following is a brief summary of the model performance for $PM_{2.5}$ and deposition. Additional details on model performance are provided in the AQMTSD.

Considering the ratio of the annual mean predictions to the annual mean observations (*e.g.*, predicted divided by observed) at the IMPROVE monitoring sites REMSAD underpredicted fine particulate mass ($PM_{2.5}$), by 18 percent. Specifically, $PM_{2.5}$ in the East was underpredicted by 2 percent, while $PM_{2.5}$ in the West was underpredicted by 33 percent. Sulfate in the East is slightly underpredicted and nitrate and largely crustal material are overestimated. Elemental carbon is neither overpredicted nor underpredicted in the East. Organic aerosols are slightly overpredicted in the East. All $PM_{2.5}$ component species were underpredicted in the West.

The comparisons to the CASTNet data show generally good model performance for sulfate. Comparison of total nitrate indicate an overestimate, possibly due to overpredictions of nitric acid in the model.

Performance at the NADP sites for wet deposition of ammonium, sulfate, and nitrate was reasonably good. However, the nitrate and sulfate wet deposition were each underestimated compared to the corresponding observed values.

Given the state of the science relative to PM modeling, it is inappropriate to judge PM model performance using criteria derived for other pollutants, like ozone. The overall model performance results may be limited by our current knowledge of PM science and chemistry, by the emissions inventories for direct PM and secondary PM precursor pollutants, by the relatively sparse ambient data available for comparisons to model output, and by uncertainties in monitoring techniques. The model performance for sulfate in the East is quite reasonable, which is key since sulfate compounds comprise a large portion of $PM_{2.5}$ in the East.

Negative effects of relatively poor model performance for some of the smaller (*i.e.*, lower concentration) components of $PM_{2.5}$, such as crustal mass, are mitigated to some extent by the way we use the modeling results in projecting future year nonattainment and downwind contributions. As described in more detail below, each measured component of $PM_{2.5}$ is adjusted upward or downward based on the percent change in that component, as determined by the ratio of future year to base year model predictions. Thus, we are using the model predictions in a relative way, rather than relying on the absolute model predictions for the future year scenarios. By using the modeling in this way, we are reducing the risk that large overprediction or underprediction will unduly affect our projection of future year concentrations. For example, REMSAD may overpredict the crustal component at a particular location by a factor of 2, but since measured crustal concentrations are generally a small fraction of ambient $PM_{2.5}$, the future crustal concentration will remain as a small fraction of $PM_{2.5}$.

A number of factors need to be considered when interpreting the results of this performance analysis. First, simulating the formation and fate of particles, especially secondary organic aerosols and nitrates is part of an evolving science. In this regard, the science in air quality models is continually being reviewed and updated as new research results become available. Also, there are a number of issues associated with the emissions and meteorological inputs, as well as ambient air quality measurements and how these should be paired to model predictions that are currently under investigation by EPA and others. The process of building consensus within the scientific community on ways for doing PM model performance evaluations has not yet progressed to the point of having a defined set of common approaches or criteria for judging model performance. Unlike ozone, there is a limited data base of past performance statistics against which to measure the performance of regional/national PM modeling. Thus, the approach used for this analysis may be modified or expanded in future evaluation analyses.

[62] Olerud, D., K. Alapaty, and N. Wheeler, 2000: *Meteorological Modeling of 1996 for the United States with MM5*. MCNC-Environmental Programs, Research Triangle Park, NC.

[63] IMPROVE, 2000. *Spatial and Seasonal Patterns and Temporal Variability of Haze and its Constituents in the United States: Report III*. Cooperative Institute for Research in the Atmosphere, ISSN: 0737–5352–47.

[64] U.S. EPA, *Clean Air Status and Trends Network (CASTNet), 2001 Annual Report*.

[65] NADP, 2002: *National Acid Deposition Program 2002 Annual Summary*.

[66] The dividing line between the West and East was defined as the 100th meridian (*e.g.*, monitoring sites to the east of this meridian are included in aggregate performance statistics for the East).

3. Projection of Future $PM_{2.5}$ Nonattainment

As with ozone, the approach for identifying areas expected to be nonattainment for $PM_{2.5}$ in the future involves using the model predictions in a relative way to forecast current $PM_{2.5}$ design values to 2010 and 2015. The modeling portion of this approach includes annual simulations for 2001 emissions and for the 2010 and 2015 Base Case emissions scenarios. As described below, the predictions from these runs were used to calculate RRFs which were then applied to current $PM_{2.5}$ design values. The approach we followed is consistent with the procedures in the draft $PM_{2.5}$ air quality modeling guidance,[67] "Guidance for Demonstrating Attainment of Air Quality Goals for $PM_{2.5}$ and Regional Haze." It should be noted that the approach for $PM_{2.5}$ differs from the approach recommended for projecting future year 8-hour ozone design values in terms of the base period for design values. The approach for ozone uses the higher of the ambient design values for two 3-year periods, as described above. In contrast, the $PM_{2.5}$ guidance recommends selecting the highest design value from among the three periods that straddle the base emissions year (*i.e.*, 2001). The three periods that straddle this year are 1999–2001, 2000–2002, and 2001–2003. The data from the first two design value periods are readily available, but the data from the 2001–2003 period could not be used since the 2003 data were not yet available. Thus, we have relied on the data for the two periods 1999–2001 and 2000–2002. The design values from the period 2000–2002, which is the most recent period with available data, were used to identify which monitors are currently measuring nonattainment (*i.e.*, annual average $PM_{2.5}$ of 15.05 $\mu g/m^3$ or more). To be consistent with procedures in the modeling guideline, we selected the higher of the 1999–2001 or 2000–2002 design value from each nonattainment monitor for use in projecting future design values. The recommendation in the guidance for selecting the highest values from among 3 periods is applicable for nonattainment counties, but not necessarily for attainment counties. Thus, for monitors that are measuring attainment (*i.e.*, $PM_{2.5}$ less than 15.05 $\mu g/m^3$) using the most recent 3 years of data, we used the 2000–2002 design values as the starting point for projecting future year design values. Note that none of the counties that are attainment for the period 2000–2002 are forecast to become nonattainment in 2010 or 2015.

The modeling guidance recommends that model predictions be used in a relative sense to estimate changes expected to occur in each major $PM_{2.5}$ species. These species are sulfate, nitrate, organic carbon, elemental carbon, crustal and un-attributed mass. Un-attributed mass is defined as the difference between FRM $PM_{2.5}$ and the sum of the other five components. The procedure for calculating future year $PM_{2.5}$ design values is called the Speciated Modeled Attainment Test (SMAT). The following is a brief summary of those steps. Additional details are provided in the AQMTSD.

Step 1: Calculate quarterly mean concentrations (averaged over 3 years) for each of the six major components of $PM_{2.5}$. This is done by multiplying the monitored quarterly mean concentration of FRM-derived $PM_{2.5}$ by the monitored fractional composition of $PM_{2.5}$ species for each quarter in 3 consecutive years (*e.g.*, 20 percent sulfate multiplied by 15 $\mu g/m^3$ $PM_{2.5}$ equals 3 $\mu g/m^3$ sulfate).

Step 2: For each quarter, calculate the ratio of future (*e.g.*, 2010) to current (*i.e.*, 2001) predictions for each component specie. The result is a component-specific RRF (*e.g.*, assume that 2001 predicted sulfate for a particular location is 10 $\mu g/m^3$ and the 2010 Base concentration is 8 $\mu g/m^3$, then RRF for sulfate is 0.8).

Step 3: For each quarter and each component specie, multiply the current quarterly mean component concentration (Step 1) by the component-specific RRF obtained in Step 2. This produces an estimated future quarterly mean concentration for each component (*e.g.*, 3 $\mu g/m^3$ sulfate multiplied by 0.8 equals future sulfate of 2.4 $\mu g/m^3$).

Step 4: Average the four quarterly mean future concentrations to get an estimated future annual mean concentration for each component specie. Sum the annual mean concentrations of the 6 components to obtain an estimated future annual average concentration for $PM_{2.5}$.

We are using the FRM data for projecting future design values since these data will be used for nonattainment designations. In order to apply SMAT to the FRM data, information on $PM_{2.5}$ speciation is needed for the location of each FRM monitoring site. Only a small number of the FRM sites have measured species information. Therefore, spatial interpolation techniques were applied to the speciated component averages from the IMPROVE and Speciation Trends Network (STN) data to estimate concentrations of species mass at all FRM $PM_{2.5}$ monitoring sites. Details on the procedures and assumptions used in mapping the IMPROVE and STN data to the locations of the FRM sites are described in the AQMTSD.

The preceding procedures for determining future year $PM_{2.5}$ concentrations were applied for each FRM site. For counties with only one FRM site, the forecast design value for that site was used to determine whether or not the county will be nonattainment in the future. For counties with multiple monitoring sites, the site with the highest future concentration was selected for that county. Those counties with future year design values of 15.05 $\mu g/m^3$ or more are predicted to be nonattainment. The result is that 61 counties in the East are forecast to be nonattainment for the 2010 Base Case. Of these, 41 are forecast to remain nonattainment for the 2015 Base Case. The $PM_{2.5}$ nonattainment counties for the 2010 and 2015 Base Cases are listed in Table IV–4. These counties were used as receptors for quantifying the impacts of the SO_2 and NO_X emissions reductions in today's proposal, as presented in section IX.

TABLE IV–4. COUNTIES PROJECTED TO BE NONATTAINMENT FOR THE ANNUAL AVERAGE $PM_{2.5}$ NAAQS FOR THE 2010 AND 2015 BASE CASES

State	2010 Base case projected nonattainment counties	2015 Base case projected nonattainment counties
AL	DeKalb, Jefferson, Montgomery, Russell, Talladaga	Jefferson, Montgomery, Russell, Talladaga.
CT	New Haven	New Haven.
DC	Washington, DC	None.
DE	New Castle	None.

[67] U.S. EPA, 2000: *Draft Guidance for Demonstrating Attainment of Air Quality Goals for $PM_{2.5}$ and Regional Haze;* Draft 1.1, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

TABLE IV–4. COUNTIES PROJECTED TO BE NONATTAINMENT FOR THE ANNUAL AVERAGE $PM_{2.5}$ NAAQS FOR THE 2010 AND 2015 BASE CASES—Continued

State	2010 Base case projected nonattainment counties	2015 Base case projected nonattainment counties
GA	Clarke, Clayton, Cobb, DeKalb, Floyd, Fulton, Hall, Muscogee, Paulding, Richmond, Wilkinson.	Clarke, Clayton, Cobb, DeKalb, Floyd, Fulton, Hall, Muscogee, Richmond, Wilkinson.
IL	Cook, Madison, St. Clair, Will	Cook, Madison, St. Clair.
IN	Clark, Marion	Clark, Marion.
KY	Fayette, Jefferson	Jefferson.
MD	Baltimore City	Baltimore City.
MI	Wayne	Wayne.
MO	St. Louis	None.
NY	New York (Manhattan)	New York (Manhattan).
NC	Catawba, Davidson, Mecklenburg	None.
OH	Butler, Cuyahoga, Franklin, Hamilton, Jefferson, Lawrence, Mahoning, Scioto, Stark, Summit, Trumbull.	Butler, Cuyahoga, Franklin, Hamilton, Jefferson, Scioto, Stark, Summit.
PA	Allegheny, Bucks, Lancaster, York	Allegheny, York.
SC	Greenville	None.
TN	Davidson, Hamilton, Knox, Roane, Sullivan	Hamilton, Knox.
WV	Brooke, Cabell, Hancock, Kanawha, Marshal, Wood	Brooke, Cabell, Hancock, Kanawha, Wood.

As noted above in section IV.C.4, the 2010 Base Case used for the zero-out $PM_{2.5}$ modeling included EGU emissions from an earlier simulation of the Integrated Planning Model. Of the 61 2010 Base Case nonattainment counties listed in Table IV–4, 4 counties (*i.e.*, Catawba Co., NC, Trumbull Co., OH, Greenville Co., SC, and Marshall Co., WV) were projected to be in attainment in the 2010 Base Case used for the zero-out modeling. Thus, 57 nonattainment counties (*i.e.*, the 61 counties in Table IV–4 less these 4 counties) were used as downwind receptors in the air quality modeling assessment of interstate $PM_{2.5}$ contributions described in section V.C.3.

F. Analysis of Locally-Applied Control Measures for Reducing $PM_{2.5}$

We conducted two air quality modeling analyses to assess the probability that attainment of the PM standard could be reached with local measures only. The results of these analyses, discussed in detail in the AQMTSD, support the need for today's rulemaking requiring reductions of transport pollutants. Both analysis were conducted by:

- Identifying a list of local control measures that could be applied in addition to those measures already in place or required to be in place in the near future;
- Determining the emissions inventory categories that would be affected by those measures, and the estimated percentage reduction;
- Applying those percentage reductions to sources within a selected geographic area; and
- Conducting regional large-scale air quality modeling using REMSAD to determine the ambient impacts those measures would have, and the degree to which those measures would reduce the expected number of nonattainment areas.

1. Control Measures and Percentage Reductions

For our analysis of $PM_{2.5}$ attainment prospects, we developed a list of emissions reductions measures as a surrogate for measures that State, local and Tribal air quality agencies might include in their $PM_{2.5}$ implementation plans. The list includes measures that such agencies might be able to implement to reach attainment in 2009 or as soon thereafter as possible. The measures address a broad range of man-made point, area, and mobile sources. In general, the measures represent what we consider to be a highly ambitious but achievable level of control.[68] We identified measures for direct $PM_{2.5}$ and also for the following $PM_{2.5}$ precursors: SO_2, NO_X, and VOC.[69] We did not attempt to address ammonia emissions, in part due to relatively low emissions of ammonia in urban areas and the likelihood of fewer controllable sources within the urban areas targeted for the analysis.

The percentage reductions were developed in two ways. First, we developed percentage reduction estimates for specific technologies when available. The available estimates were based on both the percentage control that might be achieved for sources applying that technology, and the percentage of the inventory the measures might be applicable to. For example, if a given technology would reduce a source's emissions by 90 percent where it was installed, but would be reasonable to install for only 30 percent of sources in the category, that technology would be assigned a percentage reduction of 90 times 30, or 27 percent.

Second, there were some groups of control measures where data and resources were not available to develop technology-specific estimates in this manner. For these, we felt it preferable to make broad judgments on the level of control that might be achieved rather than to leave these control measures out of the analysis entirely. For example, the analysis reflects a reduction of 3 percent from on-road mobile source emissions relative to a 2010 and 2015 baseline. We judged this 3 percent estimate to represent a reasonable upper bound on the degree to which transportation control measures and other measures for reducing mobile source emissions could reduce the overall inventory of mobile source emissions in a given area.

Additionally, we believe that it may be possible for point source owners to improve the performance of emissions control devices such as baghouses and electrostatic precipitators, and in some cases to upgrade to a more effective control device. In our current emissions inventories, we have incomplete data on control equipment currently in use. As a result, data are not available to calculate for each source the degree to which the control effectiveness could be improved. Nonetheless, we believed it important to include reasonable assumptions concerning controls for this category for direct $PM_{2.5}$. For this analysis, we assumed across the board that all point sources of PM could reduce emissions by 25 percent.

[68] Our assumptions regarding the measures for this analysis are not intended as a statement regarding the measures that represent RACT or RACM for $PM_{2.5}$ nonattainment areas.

[69] Some VOCs are precursors to the secondary organic aerosol component of $PM_{2.5}$.

Table IV–5 shows the control measures selected for the analysis, the pollutants reduced and the percentage reduction estimates.

2. Two Scenarios Analyzed for the Geographic Area Covered by Control Measures

We developed two scenarios for identifying the geographic area to which the control measures were applied. These two scenarios were intended to address two separate issues related to the effects of urban-based control measures.

The first scenario was intended to illustrate the effect of the selected local control measures within the geographic area to which controls were applied. For this, we applied the control measures and associated emissions reductions to the inventories for three cities—Birmingham, Chicago, and Philadelphia. We selected these three urban areas because each area was predicted to exceed the $PM_{2.5}$ standard in 2010, albeit to varying degrees. Additionally, the three urban areas were selected because they are widely separated. Accordingly, we were able to conduct a single air quality analysis with less concerns for overlapping impacts due to transport than if less separated cities were selected.

The control measures were applied to the projected 2010 baseline emission inventories for all counties within those Primary Metropolitan Statistical Areas (PMSAs).[70] Thus, for Chicago, measures were applied to the 10 counties in Illinois, but were not applied in northwest Indiana or Wisconsin. For Philadelphia, measures were applied to the New Jersey and Pennsylvania counties within the Philadelphia urban area. For Birmingham, measures were applied to four Alabama counties.

The second scenario was intended to address the cumulative impact of local control measures applied within nonattainment areas. Recognizing that $PM_{2.5}$ nonattainment areas may be near enough to each other to have transport effects between them, we applied the control measures identified in Table IV–5, with some modifications discussed below, to all 290 counties of the metropolitan areas we projected to contain any nonattainment county in 2010 in the baseline scenario. Specifically, the control measures were applied to all counties in Consolidated Metropolitan Statistical Areas (CMSAs) for which any county in the CMSA contained a nonattainment monitor.

3. Results of the Two Scenarios

Table IV–6 shows the results of applying the control measures in each of the three urban areas addressed in the first scenario. The emissions reductions were estimated to achieve ambient $PM_{2.5}$ reductions of about 0.5 $\mu g/m^3$ to about 0.9 $\mu g/m^3$, less than needed to bring any of the cities into attainment in 2010.

The SO_2 reductions in Birmingham were large—80 percent—because of the assumption that scrubbers would be installed for two large-emitting power plants within the Birmingham-area counties. Reductions of other pollutants in Birmingham, and of all pollutants in the two other cities, were 33 percent or lower. We note that despite the large reduction assumed for SO_2 emissions in the Birmingham area, ambient sulfate in Birmingham declined only 7 percent, indicating that the large majority of sulfate in Birmingham is attributable to SO_2 sources outside the metropolitan area.

TABLE IV–5.—CONTROL MEASURES, POLLUTANTS, AND PERCENTAGE REDUCTIONS FOR THE LOCAL MEASURES ANALYSIS

Source Description	Control Measure	SO_2	NO_X			$PM_{2.5}$			Tol+Xyl (VOC)		
		Eff	Eff	App	Red	Eff	App	Red	Eff	App	% Red
Utility boilers	FGD scrubber for some or all unscrubbed units.	(1)	.....	.....	.....	.....	.....	.....	.....	.....	.....
Coal-fired industrial boilers > 250 mmBtu/hr.	Coal switching	50	.....	.....	.....	.....	.....	.....	.....	.....	.....
Petroleum fluid catalytic cracking units.	Wet gas scrubber	50	.....	.....	.....	.....	.....	.....	.....	.....	.....
Refinery process heaters—oil-fired.	Switch to natural gas	50	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sulfuric acid plants	Meet NSPS level	42–96	.....	.....	.....	.....	.....	.....	.....	.....	.....
Coal-fired industrial boilers	SNCR	.....	50	20	10	.....	.....	.....	.....	.....	.....
Gas-fired industrial boilers (large & medium).	SNCR	.....	45	20	9	.....	.....	.....	.....	.....	.....
Gas-fired industrial boilers (small).	Low NO_X burner	.....	50	20	10	.....	.....	.....	.....	.....	.....
Gas-fired IC Engines (reciprocating).	NSCR	.....	94	10	9.4	.....	.....	.....	.....	.....	.....
Gas-fired turbine & cogeneration.	SCR	.....	90	10	9	.....	.....	.....	.....	.....	.....
Asphalt Concrete, Lime Manufacture.	Low No_X burner	.....	27	50	14	.....	.....	.....	.....	.....	.....
Cement Manufacturing	Tire derived fuel & mid-kiln firing.	.....	34	50	18	.....	.....	.....	.....	.....	.....
Petroleum Refinery Gas-fired Process Heaters.	Ultra-low No_X burner & SNCR.	.....	93	50	46.5	.....	.....	.....	.....	.....	.....
All direct $PM_{2.5}$ points sources.	Improve existing controls (baghouses, ESPs).	.....	.....	.....	.....	.....	.....	25	.....	.....	.....
Wood fireplaces[2]	Natural gas inserts	.....	.....	.....	.....	80	30	24	.....	.....	.....
	Replace with certified non-catalytic woodstove.	.....	.....	.....	.....	71	30	21.4	.....	.....	.....

[70] For the three-city study, we chose the PMSA counties rather than the larger list of counties in the consolidated metropolitan statistical area (CMSA). Both the PMSA and the CMSA classifications for metrololitan areas are created by the Office of Management and Budget (OMB). For this study, we used the classifications of counties in place as of spring 2003, rather than the revised classifications released by OMB on June 6, 2003.

TABLE IV–5.—CONTROL MEASURES, POLLUTANTS, AND PERCENTAGE REDUCTIONS FOR THE LOCAL MEASURES ANALYSIS—Continued

Source Description	Control Measure	SO_2	NO_X			$PM_{2.5}$			Tol+Xyl (VOC)		
		Eff	Eff	App	Red	Eff	App	Red	Eff	App	% Red
HDDV including buses	Engine Modifications, Diesel oxidation catalyst.	.....	40	5	2	.....	.....	.....	.....	.....	.....
	Particulate filter	.....	.....	.....	.....	90	30	27	.....	.....	.....
	Idling reduction	.....	.....	.....	1.7	.....	.....	1.7	.....	.....	1.7
Off-highway diesel construction and mining equipment.	Engine modifcations, diesel oxidation catalyst.	.....	40	73	29	.....	.....	.....	.....	.....	.....
	particulate filter	.....	.....	.....	.....	25	73	18	.....	.....	.....
Diesel Marine Vessels	SCR	.....	75	5	4	.....	.....	.....	.....	.....	.....
	Particulate filter	.....	.....	.....	.....	90	30	27	.....	.....	.....
Diesel locomotives	SCR	.....	72	5	4	.....	.....	.....	.....	.....	.....
	Electrification of yard	2.5	2.5	6	0.2	2.5	6	0.2	2.5	6	0.2
Unpaved roads	Gravel covering	.....	.....	.....	.....	60	30	18	.....	.....	.....
Construction road	Watering	.....	.....	.....	.....	.....	50	30	15		
Open burning	Ban	.....	100	75	75	100	75	75	100	75	75
Agricultural tilling	Soil conservation measures, unspecified.	.....	.....	.....	.....	20	30	6	.....	.....	.....
LDGV and LDGT1	Combination of unspecified measures to reduce highway vehicle miles and emissions.	.....	.....	.....	3	.....	.....	3	.....	.....	3

[1] For the three-city study, we assumed controls to an emission rate of 0.15 lb/mmBtu on all currently unscrubbed coal-fired utility boilers within the three metropolitan areas. For the second scenario, we applied a 50 percent reduction to all unscrubbed utility units within the 290 counties, as a surrogate for a strategy that applied FGD scrubbers to enough units to achieve a 50 percent reduction overall.

[2] For the 1996 inventory, woodstoves and fireplaces are combined into one SCC category. We assumed for the purpose of this analysis, that woodstoves and fireplaces each comprise half of the total wood burned for the category overall. Thus, the total percentage reduction is (24+21.4)/2 = 22.7 percent.

TABLE IV–6.—MODELED $PM_{2.5}$ REDUCTIONS FROM APPLICATION OF HYPOTHETICAL LOCAL CONTROLS IN 3 URBAN AREAS

Metro area	2010 base $PM_{2.5}$ ($\mu g/m^3$)	$PM_{2.5}$ reduction ($\mu g/m^3$)	Final $PM_{2.5}$ ($\mu g/m^3$)	Attainment achieved?
Birmingham, AL	20.07	−0.84	19.23	No.
Chicago, IL	18.01	−0.94	17.07	No.
Philadelphia, PA	15.6	−0.52	15.08	No.

Table IV–7 shows the results for the second scenario which, again, applied the same list of controls to 290 counties, resulting in local and transport reductions. These results show that some of the 2010 nonattainment areas would be projected to attain, but many are not. Accordingly, we concluded that for a sizable number of $PM_{2.5}$ nonattainment areas it will be difficult if not impossible to reach attainment unless transport is reduced to a much greater degree than by the simultaneous adoption of controls within only the nonattainment areas.

TABLE IV–7.—MODELED $PM_{2.5}$ REDUCTIONS FROM APPLICATION OF HYPOTHETICAL LOCAL CONTROLS IN ALL AREAS PREDICTED TO EXCEED THE NAAQS IN 2010

	Baseline	With local controls
Part A—Full Modeling Results Considering All Pollutants and Species		
Number of nonattainment counties	61	26
Average Reduction in $PM_{2.5}$ Design Value ($\mu g/m^3$)	Not Applicable	1.26
Part B—Results Not Counting Reductions in Sulfate Component of $PM_{2.5}$		
Number of nonattainment counties	61	48
Average Reduction in $PM_{2.5}$ Design Value ($\mu g/m_3$)	Not Applicable	0.37

We were interested in what part of the $PM_{2.5}$ improvement seen in this modeling run was attributable to SO_2 reductions both locally and upwind. Part B of Table IV–7 shows a re-analysis of the modeling results in which the observed sulfate reductions were not considered in calculating the $PM_{2.5}$ effects of the control package. If, as we

expect, the observation from the earlier described modeling of Birmingham and two other cities that local SO_2 reductions have relatively small local effects on sulfate applies more generally, then the difference between parts A and B of Table IV–7 would generally represent the effect of upwind reductions in SO_2 from power plants and other sources in other urban areas.

The results of the two scenarios show that much of the difference between the baseline case and the local control case is due to the sulfate component.

4. Additional Observations on the Results of the Local Measures Analyses

The application of control measures for the local measures analyses (with the exception of sulfur dioxide for Birmingham as noted previously) results in somewhat modest percentage and overall tons/year reductions. This is because a substantial part of local emissions is attributable to mobile sources, small business, and household activities for which practical, large-reduction, and quick-acting emissions reductions measures could not be identified at this time. A list of the control measures and their reduction potential is contained in the AQMTSD.

Preliminary analysis indicates that the reductions in SO_2 and NO_X required by today's proposed rule, if achieved through controls on EGUs, will have a lower cost per ton than most of the measures applied in the local measures study.

The EPA recognizes that the above analysis of the possible results of local control efforts is uncertain. It is not feasible at this time to identify with certainty the levels of emissions reductions from sources of regional transport and reductions from local measures that will lead to attainment of the PM standards. Much technical work remains as States develop their SIPs, including improvements in local emissions inventories, local area and subregional air quality analyses, and impact analysis of the effects and costs of local controls. At the same time, EPA believes that all of the available analyses of the effects of local measures support the reductions in transported pollutants that are addressed by today's proposal. Taken as a whole, the studies described above strongly support the need for the substantial reductions in transported pollutants that EPA is proposing.

At the same time, EPA believes that nothing in the local measures analysis should be interpreted as discouraging the development of urban-based control measures. Clearly, for many areas, attaining the $PM_{2.5}$ standard will require measures to address both local and regional transport. We encourage the development of early reduction measures, and specifically we note that the CAA requires States to analyze the control measures necessary to attain the standard as soon as possible.

We also note that the baseline emissions inventory used for this analysis has some known gaps. For example, direct $PM_{2.5}$ and VOXC commercial cooking (*e.g.*, charbroiling) are not included because no robust estimates were available for the 1996 base year used for this analysis. Also, excess $PM_{2.5}$ due to deterioration of engines in service, and emissions from open burning of refuse, may not be well represented. The effect of these omissions on our estimates of the number of areas reaching attainment is uncertain, but we do not believe the omissions affect our preliminary conclusions that transport controls are less expensive on a per ton basis, and are beneficial for attainment.

V. Air Quality Aspects of Significant Contribution for 8-Hour Ozone and Annual Average $PM_{2.5}$ Before Considering Cost

A. Introduction

In this section, we present the analyses of ambient data and modeling which support the findings in today's proposal on the air quality aspects of significant contribution (before considering cost) for 8-hour ozone and annual average $PM_{2.5}$. The analyses for ozone are presented first, followed by the analyses for $PM_{2.5}$. For both pollutants, we summarize information from non-EPA studies then present the procedures and findings from EPA's air quality modeling analyses of interstate transport for ozone and $PM_{2.5}$.

B. Significant Contribution to 8-Hour Ozone Before Considering Cost

1. Findings From Non-EPA Analyses That Support the Need for Reductions in Interstate Ozone Transport

As discussed in section II, it is a long-held scientific view that ground-level ozone is a regional, and not merely a local, air quality problem. Ozone and its precursors are often transported long distances across State boundaries exacerbating the downwind ozone problem. This transport of ozone can make it difficult—or impossible—for some States to meet their attainment deadlines solely by regulating sources within their own boundaries.

The EPA participated with States in the Eastern U.S. as well as industry representatives and environmental groups in the Ozone Transport Assessment Group (OTAG), which documented that long-distance transport of NO_X (a primary ozone precursor) across much of the OTAG study area contributed to high levels of ozone. For background on OTAG and the results from the study, see the following Web site: *http://www.epa.gov/ttn/naaqs/ozone/rto/otag/index.html.*

The air quality and modeling analyses by OTAG yielded the following major findings and technical conclusions relevant to today's proposed rulemaking:

- Air quality data indicate that ozone is pervasive, that ozone is transported, and that ozone aloft is carried over and transported from 1 day to the next.
- Regional NO_X reductions are effective in producing ozone benefits; the more NO_X reduced, the greater the benefit.
- Ozone benefits are greatest where emissions reductions are made; benefits decrease with distance.
- Elevated and low-level NO_X reductions are both effective.
- Volatile organic compounds (VOC) controls are effective in reducing ozone locally and are most advantageous to urban nonattainment areas. The OTAG report also recognized that VOC emissions reductions do not play much of a role in long-range transport, and concluded that VOC reductions are effective in reducing ozone locally and are most advantageous to urban nonattainment areas.

These OTAG findings provide technical evidence that transport within portions of the OTAG region results in large contributions from upwind States to ozone in downwind areas, and that a regional approach to reduce NO_X emissions is an effective means of addressing interstate ozone transport.

2. Air Quality Modeling of Interstate Ozone Contributions

This section documents the procedures used by EPA to quantify the impact of emissions in specific upwind States on air quality concentrations in projected downwind nonattainment areas for 8-hour ozone. These procedures are the first of the two-step approach for determining significant contribution, as described in section III, above.

The analytic approach for modeling the contribution of upwind States to ozone in downwind nonattainment areas is described in subsection (a), the methodology for analyzing the modeling results is presented in subsection (b), and the findings as to whether individual States make a significant contribution (before considering cost) to 8-hour ozone nonattainment is provided in subsection (c).

The air quality modeling for the interstate ozone contribution analysis was performed for those counties predicted to be nonattainment for 8-hour ozone in the 2010 Base Case, as described above in section IV.D. The procedures used by EPA to determine the air quality component of whether emissions in specific upwind States make a significant contribution (before considering cost) to projected downwind nonattainment for 8-hour ozone are the same as those used by EPA for the State-by-State determination in the NO_X SIP Call.

a. Analytical Techniques for Modeling Interstate Contributions to 8-Hour Ozone Nonattainment

The modeling approach used by EPA to quantify the impact of emissions in specific upwind States on projected downwind nonattainment areas for 8-hour ozone includes two different techniques, zero-out and source apportionment. The outputs of the two modeling techniques were used to calculate "metrics" or measures of contribution. The metrics were evaluated in terms of three key contribution factors to determine which States make a significant contribution (before considering cost) to downwind ozone nonattainment. Details of the modeling techniques and metrics are described in this section.

The zero-out and source apportionment modeling techniques provide different technical approaches to quantifying the downwind impact of emissions in upwind States. The zero-out modeling analysis provides an estimate of downwind impacts by comparing the model predictions from a base case run to the predictions from a run in which the base case man-made emissions are removed from a specific State. Zero-out modeling was performed by removing all man-made emissions of NO_X and VOC in the State.

In contrast to the zero-out approach, the source apportionment modeling quantifies downwind impacts by tracking the impacts of ozone formed from emissions in an upwind source area. For this analysis, the source apportionment technique was implemented to provide the contributions from all man-made sources of NO_X and VOC in each State. Additional information on the source apportionment technique can be found in the CAM_X User's Guide.[71] There is currently no technical evidence showing that one technique is clearly superior to the other for evaluating contributions to ozone from various emission sources; therefore, both approaches were given equal consideration in this analysis.

The EPA performed State-by-State zero-out modeling and source apportionment modeling for 31 States in the East. These States are as follows: Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin. In both types of modeling, emissions from the District of Columbia were combined with those from Maryland. For the source apportionment modeling, North Dakota and South Dakota were aggregated into a single source region. Because large portions of the six States along the western border of the modeling domain (*i.e.*, Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas) are outside the domain, EPA has deferred analyzing the contributions to downwind ozone nonattainment for these States.

The EPA selected several metrics to quantify the projected downwind contributions from emissions in upwind States. The metrics were designed to provide information on three fundamental factors for evaluating whether emissions in an upwind State make large and/or frequent contributions to downwind nonattainment. These factors are:

- The magnitude of the contribution,
- The frequency of the contribution, and
- The relative amount of the contribution.

The magnitude of contribution factor refers to the actual amount of ozone contributed by emissions in the upwind State to nonattainment in the downwind area. The frequency of the contribution refers to how often contributions above certain thresholds occur. The relative amount of the contribution is used to compare the total ozone contributed by the upwind State to the total amount of nonattainment ozone in the downwind area. The factors are the basis for several metrics that can be used to assess a particular impact. The metrics used in this analysis are the same as those used in the NO_X SIP Call. These metrics are described below for the zero-out modeling and for the source apportionment modeling. Table V–1 lists the metrics for each factor. Additional details with examples of the procedures for calculating the metrics are provided in the AQMTSD. We solicit comment on other metrics including whether it would be appropriate to develop a metric based on annualized costs for each State per ambient impact on each downwind nonattainment receptor.

TABLE V–1.—OZONE CONTRIBUTION FACTORS AND METRICS

Factor	Zero-out	Source apportionment
Magnitude of contribution	Maximum contribution	Maximum contribution; and Highest daily average contribution (ppb and percent).
Frequency of contribution	Number and percent of exceedances with contributions in various concentration ranges.	Number and percent of exceedances with contributions in various concentration ranges.
Relative amount of contribution	Total contribution relative to the total exceedance ozone in the downwind area and. Population-weighted total contribution relative to the total population-weighted exceedance ozone in the downwind area.	Total average contribution to exceedance hours in the downwind area.

[71] Environ, 2002: User's Guide to the Comprehensive Air Quality Model with Extensions (CAM_X), Novato, CA.

The values for each metric were calculated using only those periods during which model-predicted 8–hour average ozone concentration were of 85 ppb or more in at least one of the model grid cells that are associated with the receptor county. That is, we only analyzed interstate ozone contributions for the nonattainment receptor counties when the model predicted an exceedance in the 2010 Base Case. The procedures for assigning model grid cells to each nonattainment county are described in the AQMTSD.

As in the NO_X SIP Call, the ozone contribution metrics are calculated and evaluated for each upwind State to each downwind nonattainment receptor. These source-receptor pairs are referred to as "linkages."

b. Zero-Out Metrics

A central component of several of the metrics is the number of predicted exceedances in the 2010 Base Case for each nonattainment receptor. The number of exceedances in a particular nonattainment receptor is determined by the total number of daily predicted peak 8-hour concentrations of 85 ppb or more across all the episode days for the model grid cells assigned to the receptor.

The Maximum Contribution Metric for a particular upwind State to an individual downwind nonattainment receptor linkage is determined by first calculating the concentration differences between the 2010 Base Case and the zero-out simulation for that upwind State. This calculation is performed for all 2010 Base Case exceedances predicted for the downwind receptor. The largest difference (*i.e.*, contribution) for the linkage across all of the exceedances at the downwind receptor is the maximum contribution.

The Frequency of Contribution Metric for a particular linkage is determined by first sorting the contributions by concentration range (*e.g.*, 2 to 5 ppb, 5 to 10 ppb, etc.). The number of impacts in each range is used to assess the frequency of contribution.

Determining the Total Ozone Contribution Relative to the Base Case Exceedance Metric for a particular linkage involves first calculating the total ozone of 85 ppb or more in the 2010 Base Case and in the upwind State's zero-out run. The calculation is performed by summing the amount of ozone above the NAAQS for each predicted exceedance at the downwind receptor area. Finally, the amount of ozone above the NAAQS from the zero-out run is divided by the amount of ozone above the NAAQS from the 2010 Base simulation to form this metric.

The Population-Weighted Relative Contribution Metric is similar to the total ozone contribution metric described in the preceding paragraph, except that during the calculation the amount of ozone above the NAAQS in both the base case and the zero-out simulation is weighted by (*i.e.*, multiplied by) the 2000 population in the receptor county.

c. Source Apportionment Metrics

Despite the fundamental differences between the zero-out and source apportionment techniques, the definitions of the source apportionment contribution metrics are generally similar to the zero-out metrics. One exception is that all periods during the day with predicted 8-hour averages of 85 ppb or more are included in the calculation of source apportionment metrics, as opposed to just the daily peak 8-hour predicted values which are used for the zero-out metrics. Additional information on differences between the zero-out and source apportionment metrics calculations can be found in the AQMTSD.

The outputs from the source apportionment modeling provide estimates of the contribution to each predicted exceedance for each linkage. For a given upwind State to downwind nonattainment receptor linkage, the Maximum Contribution Metric is the highest contribution from among the contributions to all exceedances at the downwind receptor. The Frequency of Contribution Metric for the source apportionment technique is determined in a similar way to which this metric is calculated for the zero-out modeling.

The Highest Daily Average Contribution Metric is determined for each day with predicted exceedances at the downwind receptor. The metric is calculated by first summing the contributions for that linkage over all exceedances on a particular day, then dividing by the number of exceedances on that day to produce a daily average contribution to nonattainment. The daily average contribution values across all days with exceedances are examined to identify the highest value which is then selected for use in the determination of significance (before considering cost). We also express this metric as a percent by dividing the highest daily average contribution by the corresponding ozone exceedance concentration on the same day.

The Percent of Total Nonattainment Metric is determined for each of the three episodes individually as well as for all 30 days (*i.e.*, all three episodes) combined. This metric is calculated by first summing the contributions to all exceedances for a particular linkage to produce an estimate of the total contribution. Second, the total contribution is divided by the total ozone for periods above the NAAQS.

d. Evaluation of Upwind State Contributions to Downwind 8-Hour Ozone Nonattainment

The EPA compiled the 8-hour metrics by downwind area in order to evaluate the contributions to downwind nonattainment. The contribution data were reviewed to determine how large of a contribution a particular upwind State makes to nonattainment in each downwind area in terms of both the magnitude of the contribution, and the relative amount of the total contribution. The data were also examined to determine how frequently the contributions occur.

The first step in evaluating this information was to screen out linkages for which the contributions were very low. This initial screening was based on: (1) A maximum contribution of less than 2 ppb from either of the two modeling techniques and/or, (2) a percent of total nonattainment of less than 1 percent. Any upwind State that did not pass both of these screening criteria for a particular downwind area was considered not to make a significant contribution to that downwind area.

The finding of meeting the air quality component of significance (*i.e.*, before considering cost) for linkages that passed the initial screening criteria was based on EPA's technical assessment of the values for the three factors. Each upwind State that had large and/or frequent contributions to the downwind area, based on these factors, is considered as contributing significantly (before considering cost) to nonattainment in the downwind area. For each upwind State, the modeling disclosed a linkage in which all three factors—high magnitude of contribution, high frequency of contribution, high relative percentage of nonattainment—are met. In addition, each upwind State contributed to nonattainment problems in at least two downwind States (except for Louisiana and Arkansas which contributed to nonattainment in only Texas).[72] There have to be at least two different factors that indicate large and/or frequent contributions in order for the linkage to be significant (before considering cost).

[72] In some cases, we determined the contribution of some States to downwind problems as significant (before considering cost) because it passed two, but not all three, factors.

In this regard, the finding of a significant contribution (before considering cost) for an individual linkage was not based on any single factor. For most of the individual linkages, the factors yield a consistent result (*i.e.*, either large and frequent contributions and high relative contributions or small and infrequent contributions and low relative contributions). In some linkages, however, not all of the factors are consistent. The EPA believes that each of the factors provides an independent, legitimate measure of contribution.

The EPA applied the evaluation methodology described above to each upwind-downwind linkage to determine which States contribute significantly (before considering cost) to nonattainment in the 47 specific downwind counties. The analysis of the metrics for each linkage is presented in the AQMTSD. Of the 31 States included in the assessment of interstate ozone contributions, 25 States were found to have emissions which make a significant contribution (before considering cost) to downwind 8-hour ozone nonattainment. These States are listed in Tables V–2 and V–3. The linkages which EPA found to be significant (before considering cost) are listed in Tables V–2 (by upwind State) and V–3 (by downwind nonattainment county) for the 8-hour NAAQS. Of the 31 States included in the assessment of interstate ozone transport, the following six States are found to not make a significant contribution to downwind nonattainment: Florida, Maine, Minnesota, New Hampshire, Rhode Island, and Vermont.

TABLE V–2.—PROJECTED DOWNWIND COUNTIES TO WHICH SOURCES IN UPWIND STATES CONTRIBUTE SIGNIFICANTLY (BEFORE CONSIDERING COST) FOR THE 8-HOUR NAAQS.

Upwind state	Downwind 2010 nonattainment counties
AL	Crittenden AR, Fulton GA, Harris TX.
AR	Harris TX, Tarrant TX.
CT	Kent RI, Suffolk NY.
DE	Bucks PA, Camden NJ, Cumberland NJ, Delaware PA, Gloucester NJ, Hunterdon NJ, Mercer NJ, Middlesex NJ, Monmouth NJ, Montgomery PA, Morris NJ, Ocean NJ, Philadelphia PA, Richmond NY, Suffolk NY.
GA	Crittenden AR, Mecklenburg NC.
IA	Kenosha WI, Lake IN, Racine WI.
IL	Allegheny PA, Crittenden AR, Erie NY, Geauga OH, Kenosha WI, Lake IN, Racine WI, Sheboygan WI, Summit OH.
IN	Allegheny PA, Crittenden AR, Geauga OH, Kenosha WI, Racine WI, Sheboygan WI, Summit OH.
KY	Allegheny PA, Crittenden AR, Fulton GA, Geauga OH.
LA	Harris TX, Tarrant TX.
MA	Kent RI, Middlesex CT.
MD	Arlington VA, Bergen NJ, Bucks PA, Camden NJ, Cumberland NJ, Delaware PA, Erie NY, Fairfax VA, Fairfield CT, Gloucester NJ, Hudson NJ, Hunterdon NJ, Mecklenburg NC, Mercer NJ, Middlesex CT, Middlesex NJ, Monmouth NJ, Montgomery PA, Morris NJ, New Haven CT, Newcastle DE, Ocean NJ, Philadelphia PA, Putnam NY, Richmond NY, Suffolk NY, Summit OH, Washington DC, Westchester NY.
MI	Allegheny PA, Anne Arundel MD, Baltimore MD, Bergen NJ, Bucks PA, Camden NJ, Cecil MD, Cumberland NJ, Delaware PA, Erie NY, Geauga OH, Gloucester NJ, Harford MD, Hudson NJ, Hunterdon NJ, Kenosha WI, Kent MD, Lake IN, Mercer NJ, Middlesex NJ, Monmouth NJ, Montgomery PA, Morris NJ, Newcastle DE, Ocean NJ, Philadelphia PA, Prince Georges MD, Racine WI, Richmond NY, Suffolk NY, Summit OH.
MO	Crittenden AR, Geauga OH, Kenosha WI, Lake IN, Racine WI, Sheboygan WI.
MS	Crittenden AR, Harris TX.
NC	Anne Arundel MD, Baltimore MD, Camden NJ, Cecil MD, Cumberland NJ, Fulton GA, Gloucester NJ, Harford MD, Kent MD, Newcastle DE, Ocean NJ, Philadelphia PA, Suffolk NY.
NJ	Bucks PA, Delaware PA, Erie NY, Fairfax VA, Fairfield CT, Kent RI, Middlesex CT, Montgomery PA, New Haven CT, Philadelphia PA, Putnam NY, Richmond NY, Suffolk NY, Westchester NY.
NY	Fairfield CT, Hudson NJ, Kent RI, Mercer NJ, Middlesex CT, Middlesex NJ, Monmouth NJ, Morris NJ, New Haven CT.
OH	Allegheny PA, Anne Arundel MD, Arlington VA, Baltimore MD, Bergen NJ, Bucks PA, Camden NJ, Cecil MD, Cumberland NJ, Delaware PA, Fairfax VA, Fairfield CT, Gloucester NJ, Harford MD, Hudson NJ, Hunterdon NJ, Kenosha WI, Kent MD, Kent RI, Lake IN, Mercer NJ, Middlesex CT, Middlesex NJ, Monmouth NJ, Montgomery PA, Morris NJ, New Haven CT, Newcastle DE, Ocean NJ, Philadelphia PA, Prince Georges MD, Racine WI, Richmond NY, Suffolk NY, Washington DC, Westchester NY.
PA	Anne Arundel MD, Arlington VA, Baltimore MD, Bergen NJ, Camden NJ, Cecil MD, Cumberland NJ, Erie NY, Fairfax VA, Fairfield CT, Gloucester NJ, Harford MD, Hudson NJ, Hunterdon NJ, Kenosha WI, Kent MD, Kent RI, Lake IN, Mecklenburg NC, Mercer NJ, Middlesex CT, Middlesex NJ, Monmouth NJ, Morris NJ, New Haven CT, Newcastle DE, Ocean NJ, Prince Georges MD, Putnam NY, Racine WI, Richmond NY, Suffolk NY, Summit OH, Washington DC, Westchester NY.
SC	Fulton GA, Mecklenburg NC.
TN	Crittenden AR, Fulton GA, Lake IN, Mecklenburg NC, Tarrant TX.
VA	Anne Arundel MD, Baltimore MD, Bergen NJ, Bucks PA, Camden NJ, Cecil MD, Cumberland NJ, Delaware PA, Erie NY, Fairfield CT, Gloucester NJ, Harford MD, Hudson NJ, Hunterdon NJ, Kent MD, Kent RI, Lake IN, Mecklenburg NC, Mercer NJ, Middlesex CT, Middlesex NJ, Monmouth NJ, Montgomery PA, Morris NJ, New Haven CT, Newcastle DE, Ocean NJ, Philadelphia PA, Prince Georges MD, Putnam NY, Richmond NY, Suffolk NY, Summit OH, Washington DC, Westchester NY.
WI	Erie NY, Lake IN.
WV	Allegheny PA, Anne Arundel MD, Baltimore MD, Bucks PA, Camden NJ, Cecil MD, Cumberland NJ, Delaware PA, Fairfax VA, Fairfield CT, Fulton GA, Gloucester NJ, Harford MD, Hunterdon NJ, Kent MD, Mercer NJ, Middlesex NJ, Monmouth NJ, Montgomery PA, Morris NJ, New Haven CT, Newcastle DE, Ocean NJ, Philadelphia PA, Prince Georges MD, Suffolk NY, Summit OH, Washington DC, Westchester NY.

TABLE V–3.—UPWIND STATES THAT CONTAIN EMISSIONS SOURCES THAT CONTRIBUTE SIGNIFICANTLY (BEFORE CONSIDERING COST) TO PROJECTED 8-HOUR NONATTAINMENT IN DOWNWIND STATES.

Downwind nonattainment counties	Upwind States
Crittenden AR	AL GA IL IN KY MO MS TN
Fairfield CT	MD NJ NY OH PA VA WV
Middlesex CT	MA MD NJ NY OH PA VA
New Haven CT	MD NJ NY OH PA VA WV
Washington DC	MD OH PA VA WV
Newcastle DE	MD MI NC OH PA VA WV
Fulton GA	AL KY NC SC TN WV
Lake IN	IA IL MI MO OH PA TN VA WI
Anne Arundel MD	MI NC OH PA VA WV
Baltimore MD	MI NC OH PA VA WV
Cecil MD	MI NC OH PA VA
Harford MD	MI NC OH PA VA WV
Kent MD	MI NC OH PA VA WV
Prince Georges MD	MI OH PA VA WV
Mecklenburg NC	GA MD SC TN VA
Bergen NJ	MD MI OH PA VA
Camden NJ	DE MD MI NC OH PA VA WV
Cumberland NJ	DE MD MI NC OH PA VA WV
Gloucester NJ	DE MD MI NC OH PA VA WV
Hudson NJ	MD MI NY OH PA VA
Hunterdon NJ	DE MD MI OH PA VA WV
Mercer NJ	DE MD MI NY OH PA VA WV
Middlesex NJ	DE MD MI NY OH PA VA WV
Monmouth NJ	DE MD MI NY OH PA VA WV
Morris NJ	DE MD MI NY OH PA VA WV
Ocean NJ	DE MD MI NC OH PA VA WV
Erie NY	IL MD MI NJ PA VA WI
Putnam NY	MD NJ PA VA
Richmond NY	DE MD MI NJ OH PA VA
Suffolk NY	CT DE MD MI NC NJ OH PA VA WV
Westchester NY	MD NJ OH PA VA WV
Geauga OH	IL IN KY MI MO
Summit OH	IL IN MD MI PA VA WV
Allegheny PA	IL IN KY MI OH WV
Bucks PA	DE MD MI NJ OH VA WV
Delaware PA	DE MD MI NJ OH VA WV
Montgomery PA	DE MD MI NJ OH VA WV
Philadelphia PA	DE MD MI NC NJ OH VA WV
Kent RI	CT MA NJ NY OH PA VA
Denton TX	None of the upwind States examined in this analysis were found to make a significant contribution (before considering cost) to this nonattainment receptor.
Harris TX	AL AR LA MS
Tarrant TX	AR LA TN
Arlington VA	MD OH PA
Fairfax VA	MD NJ OH PA WV
Kenosha WI	IA IL IN MI MO OH PA
Racine WI	IA IL IN MI MO OH PA
Sheboygan WI	IL IN MO

C. Significant Contribution for Annual Average $PM_{2.5}$ Before Considering Cost

1. Analyses of Air Quality Data That Support the Need To Reduce Interstate Transport of $PM_{2.5}$

a. Spatial Gradients of Pollutant Concentrations

Daily maps of $PM_{2.5}$ mass concentrations from EPA's national monitoring network show large areas of elevated $PM_{2.5}$ occurring over monitoring locations in urban areas as well as rural areas. The fact that many of the rural monitors are not located near emissions sources, or at least not near large emission sources, and yet the rural concentrations are elevated like the neighboring urban concentrations, provides evidence that $PM_{2.5}$ is being transported to the rural areas.

When the daily maps of $PM_{2.5}$ mass concentrations are viewed in sequence, they show the large areas of elevated $PM_{2.5}$ moving from one area to another, suggesting that $PM_{2.5}$ is being transported not just from urban areas to neighboring rural areas, but also from one State to another and from one part of the country to another. The smoke from wildfires in southeastern Ontario reaching all of the New England States in July of 2002 is but one well-publicized example of transported $PM_{2.5}$.

It may be suggested that it is not $PM_{2.5}$ that is being transported; rather, it is meteorological conditions conducive to $PM_{2.5}$ formation that are being transported. However, the fact that the monitors located far from emission sources often report elevated $PM_{2.5}$ just after the upwind monitors record high levels and just before the downwind monitors record high levels indicates strongly that it is $PM_{2.5}$ that is being transported.

Episodes of movement of elevated $PM_{2.5}$ have been seen in almost every

direction in the Eastern United States, including in the west to east direction along the lower Great Lakes, in the south to north direction along the East Coast, in the south to north direction across the Midwestern States, in the north to south direction across the Midwestern States, and in the north to south direction along the East Coast. More information on episodes of movement of $PM_{2.5}$ is contained in the Air Quality Data Analysis Technical Support Document.

Satellite data from Moderate Resolution Imaging Spectroradiometer (MODIS) sensors, designed to retrieve aerosol properties over both land and ocean, are strongly correlated with the ground-based monitors that measure $PM_{2.5}$ concentrations below. The MODIS data provide a visual corroboration for the above described regional transport. Three examples follow:[73]

Midwest-Northeast Haze Event: June 20–28, 2002

During late June 2002, the Central and Eastern United States experienced a haze event from a combination of man-made air pollutants combined with some smoke. The MODIS images document the buildup of aerosols in the Midwest from June 20–22, then the transport of aerosols across the Northeast from June 23–26. Images from June 27 and 28 show the beginning of smoke transported from fires in Canada into the Northern Midwest. This series from June 20–26 qualitatively documents a haze transport event from the Midwest into the Northeast. The imagery also documents the geographical scale of the smoke transport on June 27–28.

Northeast Fire Event: July 4–9, 2002

In early July 2002, the MODIS imagery captured two events: an episodic widespread haze event in the East, Southeast, and Midwest; and an event directly related to major forest fires in Canada. On July 4 and 5, MODIS images show urban haze in the East, Southeast, and Midwest. This haze event persists in the Southeast and southern Midwest throughout the remaining days, July 7–9. At the same time, MODIS images for July 6 through July 8 document how the Northeast and mid-Atlantic become dominated by smoke transported into the region from Canada fires. On July 9, MODIS images show the smoke and the southern haze has moved towards the east while dissipating over the Atlantic. This series from July 6–8 qualitatively documents the smoke transport event from major fires in Canada. The imagery also documents the widespread geographical scale of haze, particularly from July 4–8, as well as the movement of the haze (along with smoke) across large distances.

Midwest-Southeast Haze Event: September 8–14, 2002

This imagery during September 2002 reveals the formation of a large-scale haze event over the lower Ohio River Valley that eventually transports over large portions of Southcentral and Southeastern United States. The MODIS images document the buildup of aerosols in the Midwest over September 8 and 9. Influenced by a strong low-pressure system off the mid-Atlantic seaboard on September 10, the haze plume divides, with the majority traveling south and west toward Texas and a small remnant moving northeast. On September 11 and 12, the Midwest plume, combined with additional pollutants from Texas and the Southeast, is transported to the East. September 13 has another low pressure system, forcing collection of pollutants in Texas and Louisiana, which are obscured by cloud cover on September 14. This series reveals the geographic extent and the complexities that are possible with the transfer of pollutants. More information on the use of satellite data to observe the movement of $PM_{2.5}$ is contained in the Air Quality Data Analysis Technical Support Document.

b. Urban vs. Rural Concentrations

Differences between concentrations at urban areas and nearby rural locations help indicate the general magnitudes of regional and local contributions to $PM_{2.5}$ and $PM_{2.5}$ species.[74] The differences indicate that in the Eastern United States, the regional contributions to the annual average concentrations at urban locations is 50 to 80 percent which, in terms of mass, is generally between 10 and 13 $\mu g/m^3$. For many rural areas, average $PM_{2.5}$ concentrations exceed 10 $\mu g/m^3$ and are often not much below the annual $PM_{2.5}$ NAAQS of 15 $\mu g/m^3$. These results are consistent with those found in the NARSTO Fine Particle Assessment.[75] More information on comparisons of urban and rural concentrations of $PM_{2.5}$ is contained in the Air Quality Data Analysis Technical Support Document.

For the most part, sulfate is regionwide, as indicated by the rural sulfate concentrations being 80 to 90 percent of the urban sulfate concentrations. Total carbon is less of a regional phenomenon than sulfate, as evidenced by the rural total carbon concentrations being about 50 percent of the urban total carbon concentrations. Last, nitrate has a regional component; however, the local component can be as large as 2.0 $\mu g/m^3$.

c. Inter-Site Correlation of $PM_{2.5}$ Mass and Component Species

Correlation analysis provides further evidence for the transport of $PM_{2.5}$ and its constituents. Analysis of the time series history of $PM_{2.5}$ among different monitoring locations indicates a strong tendency for $PM_{2.5}$ concentrations to rise and fall in unison. Correlations of $PM_{2.5}$ daily concentrations among stations separated by over 300 to 500 kilometers frequently have correlation coefficients that exceed 0.7. The correlation coefficient is a measure of the degree of linear association between two variables, and the square of the correlation coefficient, denoted R^2, measures how much of the total variability in the data is explained by a simple linear model. For example, in the preceding case, approximately 50 percent, $(0.7)^2$, of the variability in $PM_{2.5}$ concentrations at one site frequently can be explained by $PM_{2.5}$ concentrations at a site over 300 kilometers away. These high correlations occur both in warm and cool seasons suggesting that large scale transport phenomenon in conjunction with large and small scale meteorological conditions play a major role in particle concentration changes over large geographic areas.

Correlation of major $PM_{2.5}$ constituents among monitoring stations show differing patterns as distance separating monitors increases. For sulfate, the correlation among daily average concentrations remains strong (above 0.7) at distances exceeding 300 kilometers. Correlation of nitrates among monitoring stations tends to be lower than for sulfate and also varies somewhat among seasons. Warm season correlations, when nitrates are lowest, tend to be relatively low (about 0.4) for stations separated by 300 kilometers or more. Cool season correlations for nitrates are larger than warm season correlations and range from about 0.5 to above 0.6 for stations near urban areas and separated by 300 kilometers or more. Correlation coefficients for organic carbon typically range from about 0.4 to above 0.6 for separation

[73] Battelle, *Satellite Data for Air Quality Analysis.* July 2003.

[74] Rao, Tesh, *Chemical Speciation of* $PM_{2.5}$ *in Urban and Rural Areas,* Published in the Proceedings of the Air and Waste Management Symposium on Air Quality Measurement Methods and Technology—2002, November 2002.

[75] North American Research Strategy for Tropospheric Ozone and Particulate Matter, *Particulate Matter Science for Policy Makers—A NARSTO Assessment.* February 2003.

distances above 300 kilometers but appear to decrease more rapidly during the summer season compared with the other three seasons. For elemental carbon and crustal material, correlation with distance drops very rapidly to values below 0.2 or 0.3 for separation distances above 50 to 100 kilometers.

The formation rate and relative stability for the major $PM_{2.5}$ species help explain the observed correlation patterns. For sulfate, conversion of SO_2 to sulfate occurs slowly over relatively large distances downwind of major emission sources of SO_2. Slow conversion of SO_2 to sulfate over large travel distances promotes greater spatial homogeneity and thus large correlation among distant monitoring stations. For nitrates, evidence suggests that higher inter-station correlations in winter are associated with increased stability of nitrate (longer travel distances) when conditions are cool compared with warm seasons when nitrates are much less stable. The formation of secondary organic carbon from natural sources helps maintain a relatively homogeneous regional component (higher correlation) that is offset somewhat by higher organic carbon in urban areas associated with local carbon sources. For elemental carbon and crustal material, almost all of the contributions come from nearby sources and hence the relatively low correlation among stations that are separated by even small distances. More information on inter-site correlation of $PM_{2.5}$ and species is contained in the Air Quality Data Analysis Technical Support Document.

d. Ambient Source Apportionment Studies

Generally, sources emitting particulate matter, or precursors that later form particulate matter, emit multiple species of particulate matter simultaneously. Often, the proportions of the species are sufficiently different from one source type to another that it is possible to determine how much each source type contributes to the $PM_{2.5}$ mass observed at a monitoring location. This technique is called source apportionment or receptor modeling.

A review of nearly 20 recently published articles using source apportionment modeling at over 35 locations in the Eastern United States was conducted to understand commonalities and differences in source apportionment results.[76] A large sulfate dominated source was identified as the largest or one of the largest source types in nearly every study. Some studies labeled this source coal combustion, while others labeled it secondary sulfate and did not attribute it to an emission source. For many of the locations, over 50 percent of the $PM_{2.5}$ mass is apportioned to this source type during some seasons. Summer is typically the season with the largest contributions. Most of the studies, by using back trajectory analysis, indicated that the probable location of the sulfate/coal combustion sources is in the Midwest. Also, studies with multiple years of data tended to identify a winter and summer signature of the sulfate source type, with more mass being apportioned to the summer version. Reasons cited in these studies for the two signatures included different types of coal being burned during the summer versus the winter or different atmospheric chemistry leading to different proportions of species at the monitoring location by season.

A nitrate-dominated source type was identified at approximately half the sites and contributes to between 10 and 30 percent of the annual $PM_{2.5}$ mass. The source has seasonal variation with maxima in the cold seasons. The back trajectories sometimes point to areas with high ammonia emissions. However, the interpretation of this nitrate-dominated source type is not consistent from study to study. Some authors associate this source type with NO_X point sources and motor vehicles from major cities that are sufficiently far from the receptor for the NO_X to oxidize and react with ammonia. Other authors associate this source type with mobile emissions from nearby highways. One author does not interpret the source type since he believes it is artificially created by the meteorological conditions and atmospheric chemistry required for formation of ammonium nitrate.

Another major source type identified at nearly all the sites is one dominated by secondary organic matter. Some studies labeled this source motor vehicles, while other studies labeled it secondary organic matter and did not attribute it to an emission source. For several sites, this source type contributes more than 20 percent of the annual $PM_{2.5}$ mass. Only a few studies separated the source type into the combustion of gasoline and diesel fuel, and this separation was generally accomplished by using the four organic carbon fractions and the three elemental carbon fractions available from the IMPROVE network. In Washington, DC, over 85 percent of the mobile source type contribution is associated with gasoline vehicles and less than 15 percent with diesel. This contrasts with Atlanta, where only 33 to 55 percent (depending on the study) of the mobile source type contribution is associated with gasoline vehicles.

Wood smoke and forest fires were identified as a significant source type at several sites. The magnitude of their contributions varies from site to site. For a rural site in Vermont, the magnitude of the contribution of this source type is approximately 1 $\mu g/m^3$, which is approximately 15 percent of the total $PM_{2.5}$ mass. For Atlanta, the magnitude of contribution ranged from 0.5 to 2.0 $\mu g/m^3$ depending on the study, which is approximately 3 to 11 percent of the total $PM_{2.5}$ mass.

A crustal source category is identified for all sites and usually comprises 1 to 3 percent of the total $PM_{2.5}$ mass.

In addition to reviewing the source apportionment results in the published literature, EPA conducted receptor modeling using the data from the EPA speciation network to identify and quantify major contributors to $PM_{2.5}$ in eight urban areas: Houston, Birmingham, Charlotte, St. Louis, Indianapolis, Washington, DC, Milwaukee, and New York City.[77] The "8 city report" contains 2 general types of findings that provide evidence to support that interstate transport of fine particles occurs. First, the source apportionment analyses at the eight cities provides evidence of the types of sources that are most likely the major contributors to fine particle mass in each city. Second, linking wind trajectories with the source apportionment analyses provides evidence of the most likely locations of the source types that are the major contributors to fine particle mass in each city.

The source apportionment results identify the largest source type at each site to be coal combustion. The source type contains a large amount of sulfate and is a major source of selenium, a trace particle normally associated with the combustion of coal. The mass apportioned to this source type ranged from a low of 1 to 3 $\mu g/m^3$ in the lowest season to more than 10 $\mu g/m^3$ in the high seasons at 5 of the sites. The source type accounted for 30 to 50 percent of the overall mass, consistent with the proportions found in the published literature. The consistency in the relative and absolute magnitude in the contributions from the coal combustion source type in these eight cities, combined with the fact that the distance of major coal combustion sources from each city varies widely, indicates that it

[76] Battelle, *Compilation of Existing Studies of Source Apportionment for* $PM_{2.5}$. August 2003.

[77] Battelle, *Eight Site Source Apportionment of* $PM_{2.5}$ *Specification Trends Data*. September 2003.

is most likely a regional source rather than a local source.

The second and third largest source types are an ammonium nitrate source type and mobile sources. As the name implies, the ammonium nitrate source type contains a large amount of both ammonium and nitrate. Association of actual emission sources with this source type is less definitive, as was the case in the published literature. It is most likely that the source type originates from both coal combustion and mobile emissions. The mass apportioned to this source type ranged from 1 to 5 $\mu g/m^3$, which is 8 to 30 percent of the overall mass. This source type was identified in each city except Houston.

The absolute and relative magnitude of contribution from this source type showed much more variation than the coal combustion source type. It was highest in the Midwest in the winter, contributing between 7 and 10 $\mu g/m^3$, where the temperatures are cooler and there are more ammonia emissions. The summertime contributions of this source type are generally low, near 1 $\mu g/m^3$.

The mobile source type contains a large amount of organic carbon, some elemental carbon, very little sulfate and some metals (particularly barium from brake pads). The mass apportioned to this source type ranged from a low of 2.5 $\mu g/m^3$ at Milwaukee to a high of 6.5 $\mu g/m^3$ at Birmingham. This source type has the least seasonal variability of the largest source types. Contributions for the highest season, which varies from site to site but is generally fall or summer, are only 1.5 or 2 times higher than the contributions for the lowest season. As a percentage of mass, the mobile source type accounts for 15 to 40 percent of the total mass. It is assumed that most of the mass apportioned to the mobile source type is associated with local sources.

Linking the wind trajectories with the source apportionment results allows us to develop source regions (*i.e.*, geographic regions with a high probability of being the origin of the mass associated with a source profile). These source regions provide evidence that at least some of the particles associated with the source profiles are likely transported over long distances. For example, the highest probability source region for the coal combustion source profile for Birmingham includes parts of the following States: Missouri, Illinois, Indiana, Ohio, Kentucky, Virginia, North Carolina, South Carolina, Alabama, and Mississippi. Table V–4 lists the States included in the highest probability source regions for each of the three largest source profiles at each of the 8 sites.

The EPA compared the source regions for the coal combustion source (the largest source in each city) with the results from the zero-out modeling (described below) at the six cities in the 8 City Source Apportionment Study that were projected to violate the $PM_{2.5}$ standard in 2010. To perform these comparisons, for each city, the States in the highest probability source regions were compared to the States with a maximum contribution of 0.10 $\mu g/m^3$ or greater at the monitor in that city. These comparisons were generally good. At the Bronx site for instance, 8 of the 9 States with a maximum contribution of 0.10 $\mu g/m^3$ or greater were included in the highest probability source region for the coal combustion source. In 5 of the 6 cities for which the comparison was performed, at least two thirds of the States with a maximum contribution of 0.10 $\mu g/m^3$ were also in the highest probability source region for the coal combustion source. In the 6th city, St. Louis, 7 of the 13 States with a maximum contribution of 0.10 $\mu g/m^3$ were the highest probability source region for the coal combustion source. In summary, the general agreement between these two independent methods (source apportionment linked with wind trajectories and zero-out modeling) produce similar results in determining what States impact downwind receptors.

Sulfate is generally formed in the atmosphere from SO_2 (which is why the source is often referred to as secondary sulfate). Since the major sources of SO_2 emissions are utility plants, which are fairly well inventoried, the sulfate source locations have been compared to the utility plant SO_2 emissions as a check on the source identifications. Similarly, much of the nitrate is formed from NO_X reactions in the atmosphere with utility plants being a major source of NO_X. Hence, the nitrate source locations have also been compared with utility plant NO_X emissions inventories (although we do not expect the correlation to be as good because (a) nitrate is semi-volatile, (b) there are other significant sources of NO_X, and (c) the nitrate formation is also dependent on NH_3 emissions).

The comparisons of the sulfate source regions with the utility SO_2 emissions were good for some of the sites. At the Bronx site for instance, the back trajectories do yield the expected source region associations with large utility emissions of SO_2, namely the Ohio River Valley and the borders of Ohio, West Virginia, and Pennsylvania.

Comparisons of the contour maps of the various non-marine nitrate sources show a common pattern, namely Midwest farming regions. Illinois, in particular, stands out. It has both NO_X utility emissions and the farming regions for sources of ammonia.

More information on ambient source apportionment studies is contained in the Air Quality Data Analysis Technical Support Document.

TABLE V–4.—EIGHT CITY SOURCE APPORTIONMENT STUDY STATES IN HIGHEST PROBABILITY REGIONS FOR LARGEST SOURCES

Eight city source apportionment study states in highest probability regions for largest sources			
City	Coal combustion source	Mobile sources	Ammonium nitrate source
Bronx	NY, PA, MD, VA, NC, WV, OH, KY, IN, MI, IL, WI.	VT, MA, NY, NJ, PA, MD, VA, OH, IN, IL, WI, MN.	NY, NJ, DE, MD, VA, NC, PA, OH, IL, WI, MN.
Washington, DC	NY, PA, VA, NC, SC, GA, OH, KY, TN, IN, IL, AR.	MD, DE, VA, NC, SC, WV, OH, KY, TN.	NY, PA, MD, DE, KY, TN, IL.
Charlotte	NY, CT, NJ, PA, MD, VA, NC, SC, GA, FL, WV, OH, KY, MI, IN, AL, MS.	NC, SC, GA, TN AR	PA, MD, VA, NC, SC, GA, FL, KY, TN, AR, MO, KS.
Birmingham	VA, NC< SC, GA, FL, OH, KY, TN, AL, IN, IL, MO.	NC, SC, GA, AL, MS, AR	IN, KY, TN, IL, MS, MN, IA, AR, LA, NE, OK, TX.
Milwaukee	OH, MI, IN, KY, TN, AL, MS, IL, WI, IA, MO, AR, LA, SD, NE, KS, OK.	AL, WI, TN, MS, MN, MO	MI, OH, IN, WI, IL, MN, IA, MO, AR, ND, KS, OK.

TABLE V–4.—EIGHT CITY SOURCE APPORTIONMENT STUDY STATES IN HIGHEST PROBABILITY REGIONS FOR LARGEST SOURCES—Continued

Eight city source apportionment study states in highest probability regions for largest sources			
City	Coal combustion source	Mobile sources	Ammonium nitrate source
Indianapolis	NC, KY, TN, AL, FL, IN, IL, IA, MO, AR, LA, TX, NE, KS.	OH, KY, TN, NC, GA, IN, MI, WI, AR, LA.	MI, OH, IN, WI, IL, MN, IA, MO, AR, ND, KS, OK.
St. Louis	WV, MI, KY, TN, IL, MO, AR, LA, TX.	MO, LA, NE, KS	OH, IN, KY, TN, IL, IA, KS.
Houston [1]	SC, GA, FL, AL, MS, LA, TX, IN ..	KY, TN, AL, MS, IN, IL, AR, LA, TX.	

[1] No ammonium nitrate source was identified in Houston.

2. Non-EPA Air Quality Modeling Analyses Relevant to $PM_{2.5}$ Transport and Mitigation Strategies

Air quality modeling was performed as part of the Southern Appalachian Mountains Initiative (SAMI) to support an assessment of the impacts of aerosols, ozone, and acid deposition in Class I areas within an eight-State portion of the Southeast.[78] The results of the SAMI modeling[79] provide the following technical information on transport relevant to today's proposal:

- Emissions reductions strategies produce the largest changes in fine particle mass on days with the highest mass.
- Most of the reductions in fine particle mass are due to reductions in sulfate particles.
- Particle mass in Class I areas of the SAMI region are influenced most by SO_2 emissions within the State and within adjacent States.
- SO_2 emissions in other regions outside SAMI also contribute to particle mass at Class I areas in the SAMI States.
- Specifically, in a 2010 baseline scenario, SO_2 emissions reductions in States outside the SAMI region accounted for approximately 20 percent to as much as 60 percent of the modeled sulfate reduction in the 10 Class 1 areas in the SAMI region.
- The relative sensitivity of nitrate fine particle mass at the SAMI Class I areas to changes in NO_X emissions from SAMI States and from other regions is similar to the above findings for sulfate fine particle mass.
- For SAMI to accomplish its mission, emissions reductions are essential both inside and outside the SAMI region.
- Formation of nitrate particles is currently limited in the rural southeastern U.S. by the availability of ammonia. As sulfate particles are reduced, more ammonia will be available to react with nitric acid vapor and form nitrate particles.

The findings of the air quality modeling performed by SAMI are very consistent and supportive of EPA's zero-out modeling, as described below. The findings indicate that interstate transport results in non-trivial contributions to $PM_{2.5}$ in downwind locations. High concentrations of $PM_{2.5}$ at sensitive downwind receptors are not only influenced by emissions within that State, but are also heavily influenced by emissions in adjacent States as well as emissions from States in other regions. The SAMI results support a regional control approach involving SO_2 emissions reductions in order to sufficiently reduce $PM_{2.5}$ to meet environmental objectives. The SAMI also found that SO_2 emissions reductions can lead to an increase in particle nitrate (*i.e.*, nitrate replacement). As described in section II.B.3, any such increases could be mitigated through reductions in emissions of NO_X.

3. Air Quality Modeling of Interstate $PM_{2.5}$ Contributions

This section documents the procedures used by EPA to quantify the impact of emissions in specific upwind States on projected downwind nonattainment for annual average $PM_{2.5}$. These procedures are part of the two-step approach for determining significant contribution, as described in section III, above.

The analytic approach for modeling the contribution of upwind States to $PM_{2.5}$ in downwind nonattainment areas and the methodology for analyzing the modeling results are described in subsection (a) and the findings as to whether individual States meet the air quality prong of the significant contribution test is provided in subsection (b). The air quality modeling for the interstate $PM_{2.5}$ contribution analysis was performed for those counties predicted to be nonattainment for annual average $PM_{2.5}$ in the 2010 Base Case, as described above in section IV.E.

a. Analytical Techniques for Modeling Interstate Contributions to Annual Average $PM_{2.5}$ Nonattainment

The EPA performed State-by-State zero-out modeling to quantify the contribution from emissions in each State to future $PM_{2.5}$ nonattainment in other States and to determine whether that contribution meets the air quality prong (*i.e.*, before considering cost) of the "contribute significantly" test. As part of the zero-out modeling technique we removed the 2010 Base Case man-made emissions of SO_2 and NO_X for 41 States on a State-by-State basis in different model runs. The States EPA analyzed using zero-out modeling are: Alabama, Arkansas, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Mexico, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, Wisconsin, and Wyoming. Emissions from the District of Columbia were combined with those from Maryland.

The contribution from each State to $PM_{2.5}$ at nonattainment receptors in other States was determined in the following manner:

Step 1: The $PM_{2.5}$ species predictions from the zero-out run were applied using the SMAT to calculate $PM_{2.5}$ at the 57 2010 Base Case nonattainment receptor counties. These receptors are identified in section IV.E.3, above.

Step 2: For each of the 57 receptors, we calculated the difference in $PM_{2.5}$ between the 2010 Base Case and the zero-out run. This difference is the

[78] The eight States of the Southern Appalachians covered by SAMI are: Alabama, Georgia, Kentucky, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia.

[79] Southern Appalachian Mountains Initiative Final Report, August 2002.

contribution from the particular State to the downwind nonattainment receptor.

As described above in section V.B.2., EPA used three fundamental factors for evaluating the contribution of upwind States to downwind 8-hour ozone nonattainment, *i.e.*, the magnitude, frequency, and relative amount of contribution. One of these factors, the frequency of contribution, is not relevant for an annual average NAAQS and thus, frequency was not considered in the evaluation of interstate contributions to nonattainment of the $PM_{2.5}$ NAAQS.

The EPA considered a number of metrics to quantify the magnitude and relative amount of the $PM_{2.5}$ contributions. All of the metrics are described in the AQMTSD. As discussed in section III, above, EPA is proposing to use the maximum downwind contribution metric as the means for evaluating the significance (before considering cost) of interstate $PM_{2.5}$ transport. We solicit comment on other metrics including population-weighted metrics and whether it would be appropriate to develop a metric based on annualized costs for each State per ambient impact on each downwind nonattainment receptor.

The procedures for calculating the maximum contribution metric are as follows:

Step 1: Determine the contribution from each upwind State to $PM_{2.5}$ at each downwind receptor;

Step 2: The highest contribution from among those determined in Step 1 is the maximum downwind contribution.

b. Evaluation of Upwind State Contributions to Downwind $PM_{2.5}$ Nonattainment

The EPA is proposing to use a criterion of 0.15 $\mu g/m^3$ for determining whether emissions in a State make a significant contribution (before considering cost) to $PM_{2.5}$ nonattainment in another State. The rationale for choosing this criterion is described in section III, above. The maximum downwind contribution from each upwind State to a downwind nonattainment county is provided in Table V–5. Of the States analyzed for this proposal, 28 States and the District of Columbia contribute 0.15 $\mu g/m^3$ or more to nonattainment in other States and therefore are found to make a significant contribution (before considering cost) to $PM_{2.5}$. Although we are proposing to use 0.15 $\mu g/m^3$ as the air quality criterion, we have also analyzed the impacts of using 0.10 $\mu g/m^3$. Based on our current modeling, two additional States, Oklahoma and North Dakota, would be included if we were to adopt 0.10 $\mu g/m^3$ as the air quality criterion. The contributions to $PM_{2.5}$ from each of the 41 upwind States to each of the downwind nonattainment counties are provided in the AQMTSD. Table V–6 provides a count of the number of downwind counties that received contributions of 0.15 $\mu g/m^3$ or more from each upwind State. This table also provides the number of downwind counties that received contributions of 0.10 $\mu g/m^3$ or more from each upwind State.

TABLE V–5.—MAXIMUM DOWNWIND $PM_{2.5}$ CONTRIBUTION ($\mu g/m^3$) FOR EACH OF 41 UPWIND STATES

Upwind state	Maximum downwind contribution	Downwind nonattainment county of maximum contribution
Alabama	1.17	Floyd, GA.
Arkansas	0.29	St. Clair, IL.
Connecticut	0.07	New York, NY.
Colorado	0.04	Madison, IL.
Delaware	0.17	Berks, PA.
Florida	0.52	Russell, AL.
Georgia	1.52	Russell, AL.
Illinois	1.50	St. Louis, MO.
Indiana	1.06	Hamilton, OH.
Iowa	0.43	Madison, IL.
Kansas	0.15	Madison, IL.
Kentucky	1.10	Clark, IN.
Louisiana	0.25	Jefferson, AL.
Maryland/District of Columbia	0.85	York, PA.
Maine	0.03	New Haven, CT.
Massachusetts	0.21	New Haven, CT.
Michigan	0.88	Cuyahoga, OH.
Minnesota	0.39	Cook, IL.
Mississippi	0.30	Jefferson, AL.
Missouri	0.89	Madison, IL.
Montana	0.03	Cook, IL.
Nebraska	0.08	Madison, IL.
New Hampshire	0.06	New Haven, CT.
New Jersey	0.45	New York, NY.
New Mexico	0.03	Knox, TN.
New York	0.85	New Haven, CT.
North Carolina	0.41	Sullivan, TN.
North Dakota	0.12	Cook, IL.
Ohio	1.90	Hancock, WV.
Oklahoma	0.14	Madison, IL.
Pennsylvania	1.17	New Castle, DE.
Rhode Island	0.01	New Haven, CT.
South Carolina	0.72	Richmond, GA.
South Dakota	0.04	Madison, IL.
Tennessee	0.57	Floyd, GA.
Texas	0.37	St. Clair, IL.
Vermont	0.06	New Haven, CT.
Virginia	0.67	Washington, DC.
West Virginia	0.89	Allegheny, PA.

TABLE V–5.—MAXIMUM DOWNWIND $PM_{2.5}$ CONTRIBUTION ($\mu g/m^3$) FOR EACH OF 41 UPWIND STATES—Continued

Upwind state	Maximum downwind contribution	Downwind nonattainment county of maximum contribution
Wisconsin	1.00	Cook, IL.
Wyoming	0.05	Madison, IL.

TABLE V–6.—NUMBER OF DOWNWIND $PM_{2.5}$ NONATTAINMENT COUNTIES THAT RECEIVE CONTRIBUTIONS 0.15 $\mu g/m^3$ OR MORE AND 0.10 $\mu g/m^3$ OR MORE FROM EACH UPWIND STATE

Upwind state	Number of downwind nonattainment counties with contributions of 0.10 $\mu g/m^3$ or more	Number of downwind nonattainment counties with contributions of 0.15 $\mu g/m^3$ or more
Alabama	43	32
Arkansas	27	4
Delaware	4	1
Florida	23	19
Georgia	38	27
Illinois	53	53
Indiana	54	53
Iowa	30	13
Kansas	4	2
Kentucky	52	50
Louisiana	33	25
Maryland/District of Columbia	9	7
Massachusetts	2	1
Michigan	55	39
Minnesota	18	8
Mississippi	28	18
Missouri	47	31
New Jersey	8	7
New York	16	12
North Carolina	35	28
North Dakota	4	0
Ohio	47	47
Oklahoma	3	0
Pennsylvania	52	46
South Carolina	23	19
Tennessee	50	43
Texas	48	36
Virginia	35	17
West Virginia	46	32
Wisconsin	48	29

VI. Emissions Control Requirements

This section describes the proposed criteria EPA used to establish these new SO_2 and NO_X control requirements, for the States with emissions sources contributing to nonattainment as described in section V. This section also explains how information on EGUs was used in proposing emissions control requirements for SO_2 and NO_X to address interstate pollution transport, and what source categories were also considered by the Agency. This includes consideration of the technologies available for reducing SO_2 and NO_X emissions and the methods that we used to evaluate the cost effectiveness of these emissions reductions. This section also discusses interactions of today's proposed action with the existing Acid Rain Program under title IV of the CAA. This section discusses the emission source categories that EPA considered for today's action, and explains that we assumed control on EGUs in developing this proposal. This section also describes the methodology used for developing State budgets from the proposed control requirements, with a step in the methodology based on regionwide targets. Further, this section presents the proposed State budgets for NO_X and SO_2 for EGUs. (More details regarding requirements related to budget demonstrations can be found in section VII.) This section also discusses baseline inventories.

A. Source Categories Used for Budget Determinations

Today's action proposes requirements based on emissions reductions for EGUs. The EPA is examining potential pollution control approaches and the cost effectiveness of emissions reductions for other source categories. Today, EPA solicits comments on those other source categories, but is not proposing action on them.

1. Electric Generation Units

In developing today's proposal, we investigated various source categories to see which may be candidates for additional controls. Our attention focused on emission reductions from EGUs for several reasons. Electric Generating Units are the most

significant source of SO_2 emissions and a very substantial source of NO_X in the affected region. For example, EGU emissions are projected to represent approximately one-quarter (23 percent) of the total NO_X emissions in 2010 and over two-thirds (67 percent) of the total SO_2 emissions in 2010 in the 28-State plus DC region that is being controlled for both SO_2 and NO_X after application of current CAA controls. Furthermore, control technologies available for reducing NO_X and SO_2 from EGUs are considered highly cost effective and able to achieve significant emissions reductions.

The methodology for setting SO_2 and NO_X budgets described below under sections VI.B, VI.C, and VI.D applies to EGUs only. Electric Generating Units are defined as fossil-fuel fired boilers and turbines serving an electric generator with a nameplate capacity of greater than 25 megawatts (MW) producing electricity for sale. Fossil fuel is defined as natural gas, petroleum, coal, or any form of solid, liquid, or gaseous fuel derived from such material. The term "fossil fuel-fired" with regard to a unit means combusting fossil fuel, alone or in combination with any amount of other fuel or material. These definitions are the same as those used under the title IV Acid Rain program.

2. Treatment of Cogenerators

The EPA is proposing that the determination of whether a boiler or turbine that is used for cogeneration should be considered an EGU is dependent upon the amount of electricity that the unit sells.[80]

We propose to treat a cogeneration unit as an EGU in this proposed rule if it serves a generator with a nameplate capacity of greater than 25 MW and supplies more than one-third of its potential electric output capacity and sells more than 25 MW electrical output to any utility power distribution system for sale in any of the years 1999 through 2002. If one-third or less of the potential electric output capacity or 25 MW or less is sold during all of those years, the cogeneration unit would be classified as a non-EGU. The definition of potential electrical output capacity proposed for this rule is the definition under part 72, appendix D of the Acid Rain regulations.

The definition of a cogeneration facility under the title IV Acid Rain program and the NO_X SIP Call was based on the Federal Energy Regulatory Commission Qualifying Facility definition. We propose to use this same definition with one change. We propose to apply the efficiency standards under title 18, section 292.205 to coal, oil, and gas-fired units instead of applying the efficiency standards only to oil and gas-fired units. The EPA believes this change would be more consistent with its fuel-neutral approach throughout this proposed rule. In addition, not applying an efficiency standard to coal-fired units would be counter productive to EPA's efforts to reduce SO_2 and NO_X emissions under this proposed rule because of the relatively high SO_2 and NO_X emissions from coal-fired units.

We solicit comment on use of this definition of cogeneration facility for purposes of developing emission budgets.

3. Non-EGU Boilers and Turbines

For several reasons, the approach we are proposing today would not require or assume additional emissions reductions from non-EGU boilers and turbines. First, compared to the information we have about emissions from EGUs and the costs of controlling those emissions, we have relatively little information about non-EGU boilers and turbines.[81] In particular, we have limited information both about SO_2 controls and the integration of NO_X and SO_2 controls. As a result, we are not able to determine that further emissions reductions from these sources would be highly cost effective. Second, based on the information we do have, projected emissions of NO_X and SO_2 from these sources in 2010 are much lower than those projected from EGUs. However, we invite information and comment on these source categories. In particular, we request comments on sources of emissions and cost information.

We recognize, for example, that some industrial boiler owners may prefer the certainty and flexibility of being included in a regional trading program, rather than facing the uncertainty of the SIP development process. In addition, many non-EGU boilers and turbines already are regulated under the NO_X SIP Call and thus are part of a NO_X trading program with EGUs. It is EPA's intent that, for EGUs, compliance with the more stringent annual NO_X reduction requirement in today's proposed rule will be able to serve as compliance with the seasonal NO_X SIP Call limits. Therefore since EGUs will no longer be participating in the seasonal NO_X SIP Call Trading Program, the cost of compliance for non-EGUs will likely increase.

4. Other Non-EGUs

We also evaluated the available information on SO_2 and NO_X emissions and control measures for source categories other than EGUs and large industrial boilers and turbines, in order to identify highly cost effective emission reductions. Our approach to considering these source categories is discussed in a technical support document available in the docket, entitled "Identification and Discussion of Sources of Regional Point Source NO_X and SO_2 Emissions Other Than EGUs (January 2004)". Based on this evaluation, we are not proposing to consider reductions from any of these source categories because we are unable to identify specific quantities of SO_2 or NO_X emissions reductions that would be highly cost effective. However, we invite information and comment on these sources categories. In particular, we request comment on sources of emissions and cost information.

The EPA did not identify highly cost-effective controls on mobile or area sources that would achieve broad-scale regional emissions reductions relative to baseline conditions and fit well with the regulatory authority available under section 110(a)(2)(D). We observe that Federal requirements for new on-road and off-road engines and motor vehicles will substantially reduce emissions as the inventory of vehicles and engines turns over.

B. Overview of Control Requirements and EGU Budgets

This section explains how EPA developed State emissions reduction requirements for NO_X and SO_2 emissions that will lead to reductions of emissions associated with the interstate transport of fine particles and ozone. We seek to implement the section 110(a)(2)(D) requirement that upwind States act as "good neighbors" by eliminating the amount of their emissions that contribute significantly to the downwind nonattainment areas. The proposed requirements would apply to 29 Eastern States (and DC) that significantly contribute to fine particle and/or ozone nonattainment.

We propose to establish these emissions reduction requirements, for both SO_2 and NO_X purposes, based on

[80] The NO_X SIP Call, as finalized in 1998, moved beyond the "utility unit" definition in the Acid Rain Program and treated as "ECUs" all fossil- fuel-fired units serving generators with a nameplate capacity exceeding 25 MW and producing any electricity for sale. This EGU definition, as applied to cogeneration units, was remanded to EPA as a result of litigation. Subsequently, EPA proposed to retain the approach in the 1998 rule, but in response to comments EPA received on that proposal, EPA is preparing to finalize a response to the court remand in which EPA will change the definition of EGU originally finalized in the NO_X SIP Call to be very similar to the existing title IV definition.

[81] *See* "Identification and Discussion of Sources of Regional Point Source NO^X and SO_2 Emissions Other Than EGUs (January 2004)".

assuming the application of highly cost-effective controls to large EGUs. The approach of identifying highly cost-effective controls was the basis for developing the emissions budgets in the NO_X SIP Call, and is the basis for developing the emissions budgets in today's action. Today's proposal bases its reduction and control requirements solely on controls for EGUs.

The States have full flexibility in choosing the sources that must reduce emissions. If the States choose to require EGUs to reduce their emissions, then the States must impose a cap on EGU emissions, which would, in effect, be an emissions budget. If a State chooses to control EGUs and elects to allow them to participate in the interstate cap and trade program, the State must follow EPA rules for allocating allowances to the individual EGUs. If a State wants to control EGUs but does not want to allow EGUs to participate in the interstate cap and trade program, the State has flexibility in allocating, but it must cap EGUs. The State must also assure that EGUs meet title IV requirements.

In 2010, the proposed requirements would effectively establish emissions caps for SO_2 and NO_X of 3.9 million tons and 1.6 million tons, respectively. The budgets would be lowered in 2015 to provide SO_2 and NO_X emissions caps of 2.7 million tons and 1.3 million tons, respectively, in the proposed control region. An SO_2 emissions cap of 2.7 million tons in 28 States will lead to nationwide emissions of approximately 3.5 million tons when the cap is fully implemented. This is significantly lower than the 8.95 million tons of SO_2 emissions allowed from EGUs under the current title IV Acid Rain SO_2 Trading Program. EPA expects that States will elect to join a regional cap and trade program for these pollutants that the Agency will administer similar to the NO_X SIP Call. This is discussed in section VIII of this proposal.

If the States choose to control other sources, then they must employ methods to assure that those other sources implement controls that will yield the appropriate amount of reductions. This is discussed further in section VII, below.

The EPA believes that it will take substantial time (more than 3 years from completion of SIPs) to install all of the equipment necessary to meet the proposed control requirements. Thus, EPA is proposing that the required reductions be made in two phases, with annual emissions caps for NO_X and SO_2 taking effect in 2010 and 2015.

Today's approach is similar to that of the NO_X SIP Call. In that case, EPA required States that controlled emissions from large boilers (either EGUs or non-EGUs) to cap emissions from those source categories. In addition, EPA allowed States to meet part of their emissions budget requirements by participating in an interstate emissions cap and trade program. The cap and trade program in effect meant that the total amount of NO_X emissions from EGUs and non-EGU boilers and turbines was limited on a regionwide basis, rather than on a State-specific basis. For other source categories, EPA did not require the State to cap emissions, as long as it demonstrated that it had enforceable measures that achieved the necessary emission reductions. We are proposing to take a similar approach in today's rulemaking.

For convenience, we use specific terminology to refer to certain concepts. "State budget" refers to the statewide emissions that may be used as an accounting technique to determine the amount of emissions reductions that controls may yield. It does not imply that there is a legally enforceable statewide cap on emissions from all SO_2 or NO_X sources. "Regionwide budget" refers to the amount of emissions, computed on a regionwide basis, which may be used to determine State-by-State requirements. It does not imply that there is a legally enforceable regionwide cap on emissions from all SO_2 or NO_X sources. "State EGU budget" refers to the legally enforceable cap on EGUs a State would apply should it decide to control EGUs.

C. Regional Control Requirements and Budgets Based on a Showing of Significant Contribution

In determining States' emissions reduction requirements, EPA considered both the level and timing of the emissions budgets for the electric power industry at a regional level and State level. The EPA wants to assist the States to attain the NAAQS for $PM_{2.5}$ and 8-hour ozone in a way that is timely, practical, and cost effective.

For purposes of the $PM_{2.5}$ and 8-hour ozone transport requirements, CAA section 110(a)(2)(D) requires that States submit SIPs than prohibit emissions in the amount that contributes significantly to nonattainment downwind. Our interpretation of the "contribute significantly" determination includes an air quality component and a cost-effectiveness component. The air quality component is discussed in sections IV, V, and IX. As to the cost-effectiveness component, in the NO_X SIP Call, we applied this component by employing "highly cost-effective" controls as the benchmark. We adopt that benchmark for today's proposal.

In determining the States' obligations under this rule, EPA considers a variety of factors. These include:

- The availability of information,
- The identification of source categories emitting relatively large amounts of the relevant emissions,
- The performance and applicability of control measures,
- The cost effectiveness of control measures, and
- Engineering and financial factors that affect the availability of control measures.

We have relatively complete information with respect to these factors for the electric power industry. We do not have information to this degree of completeness for other sources.

The electric power industry emits relatively large amounts of the relevant emissions. This factor is particularly important in a case such as this when the Federal government is proposing a multistate regional approach to reducing transported pollution.

We request comment on how to determine what constitutes "a relatively large amount" of the relevant emissions. One approach would be to consider the percent contribution the source category makes to the total inventory (*e.g.*, 1 to 10 percent). Another approach, which some have suggested, would be to consider the contribution of a source category to the total NAAQS exceedance level. For example, this approach might consider a source category's contribution to ambient concentrations above the attainment level in all nonattainment areas in affected downwind States for $PM_{2.5}$. We request comment on both of these approaches as well as what the appropriate percent contribution under each approach might be.

Under the cost effectiveness component, we also take into account available information about the applicability, performance, and reliability of different types of pollution control technologies for different types of sources. Based on engineering judgement, we consider how many sources in a particular source category can install control technology, and whether such technology is compatible with the typical configuration of sources in that category. As was done in the NO_X SIP Call, and as proposed in today's rule we also evaluate the downwind impacts of the level of control that is identified as highly cost effective. The fact that a particular control level has a substantial downwind impact affirms the selection of that level as "highly cost effective."

However, as noted above, we are requesting comment on an approach that would incorporate the effect on downwind States as part of the cost effectiveness component of significant contribution.

There are other practical considerations that we may also consider. For example, if we are aware that emissions from a particular source category will be controlled under an upcoming regulation (a MACT standard, for example), we would also take that fact into account.

We considered several additional factors, including the engineering factors concerning construction and installation of the controls when evaluating the time period needed to implement the controls. This analysis also involves consideration of the time period needed by sources to obtain the financing needed for the controls. Engineering and financial factors are discussed in this section.

The EPA's approach to controls factored in the air quality improvements that could occur. Air quality modeling that is covered in section IX indicates that today's proposed transport reductions will bring many fine particle nonattainment areas and some ozone nonattainment areas into attainment by 2010 or 2015, and improve air quality in many downwind $PM_{2.5}$ and ozone nonattainment areas. The modeling also shows more reductions will be needed for some areas to attain. We are striving in this proposal to set up a reasonable balance of regional and local controls to provide a cost effective and equitable governmental approach to attainment with the NAAQS for fine particles and ozone.

1. Performance and Applicability of Pollution Control Technologies for EGUs

In developing today's proposal, EPA focused on the utility industry as a potential source of highly cost effective reductions of both SO_2 and NO_X emissions. We began by reviewing the reliability, capability and applicability of today's SO_2 and NO_X pollution controls for this industry.

Both wet and dry flue gas desulfurization (FGD) technologies for SO_2 control, and the selective catalytic reduction (SCR) technology for NO_X control on coal-fired boilers, are fully demonstrated and available pollution control technologies. The design and performance levels for these technologies were based on proven industry experience.[82]

[82] References for this dicussion are provided in the docket for today's rulemaking.

For SO_2 control, EPA has considered two wet FGD technologies, consisting of the limestone forced oxidation system (LSFO) with dibasic acid injection and the magnesium enhanced lime (MEL) system. In addition, a dry FGD technology, lime spray dryer (LSD) system, has also been considered. Of these, the LSFO system is generally used for installations firing high-sulfur (2 percent and higher) coals, LSD for low-sulfur (less than 2 percent) coals, and MEL for both low- and high-sulfur coals, depending on the overall economics of each application.

In EPA's analyses, the SO_2 reduction capabilities considered are 95 percent for the LSFO system, 96 percent for the MEL system, and 90 percent for the LSD system. A significant amount of industry information is available on the use of these technologies. One reference shows over 30 years of operating experience in U.S. electrical utility plants. The three FGD systems considered by EPA have been used in the majority of these plants. A significant number of the wet FGD systems, especially those installed in the last 10 years, have design SO_2 removal efficiencies ranging from 95 to 99 percent. Also, there are several LSD installations designed for 90 percent or higher SO_2 removal, supporting the performance levels selected by EPA.

The EPA has also identified several other references that support its FGD technology selections. These references report long-term operating experience with wet FGD systems, with and without dibasic acids, at SO_2 removal rates of 95 to 99 percent. We also performed a study that lists in a greater detail the criteria and the references for selection of all three FGD technologies considered.

The NO_X reduction capability considered by EPA for the SCR technology is 90 percent, with the minimum NO_X emission rate limited to 0.05 lb/mmBtu. Because of this 0.05 lb/mmBtu limit, the actual NO_X reduction requirement for SCR systems on the boilers with existing or future combustion controls is expected to be less than 90 percent. For example, the baseline NO_X emissions on a large number of boilers with existing combustion controls are below 0.3 lb/mmBtu, requiring SCRs with NO_X removal rates of approximately 83 percent or lower.

The first SCR application in the U.S. on a coal-fired boiler started operating in 1993. At the end of 2002, the number of operating SCR installations on U.S. boilers stood at 56. Another 85 SCR units are scheduled to go into operation in 2003. The design NO_X reduction efficiencies of these SCR systems vary, but many of them are designed for 90 percent reduction. Operating data available from many plants indicate that the 90 percent NO_X removal rate has been met or exceeded at these plants.

There is more long-term experience with coal-fired SCR applications in Europe and Japan. This experience includes high- and medium-sulfur coal applications and is directly applicable to the U.S. installations. The overall SCR experience both in the U.S. and abroad, therefore, supports the criteria EPA has used for this technology.

SCRs and scrubbers have been used in combination on most new coal-fired powered plants built in the U.S. since the early 1990s. The combination has also been retrofit on a number of existing coal-fired units.

2. Evaluation of Cost Effectiveness

With effective, well-established controls available for both SO_2 and NO_X emissions from EGUs, EPA must determine what is the appropriate level of costs for these controls. In the NO_X SIP Call rule, EPA defined the cost component of the "contribute significantly" test in terms of a level of cost effectiveness, that is, dollars spent per ton of emissions reductions. Specifically, in the NO_X SIP Call, EPA defined the cost component in terms of "highly cost-effective" controls, a definition upheld by the D.C. Circuit in the Michigan case. Today, EPA proposes to use this approach.

We want to provide an emissions reductions program for SO_2 and NO_X that complements State efforts to attain the $PM_{2.5}$ and ozone standards in the most cost-effective, equitable and practical manner possible. The objective of the analysis is to select from the spectrum of possible pollution controls the least expensive approaches available at the time the controls are selected.

To ensure that EPA's overarching goal of achieving the NAAQS in the most cost effective, equitable and practical manner possible is met by Federal and State actions, the Agency has decided to pursue emissions reductions that it considers are highly cost effective now before State plans for nonattainment are due. Proposing highly cost-effective controls also provides greater certainty that transport controls are not being overemphasized relative to local controls.

For today's proposal, EPA independently evaluated the cost effectiveness of strategies to reduce SO_2 and NO_X to address $PM_{2.5}$ and ozone nonattainment. The results of EPA's analysis are summarized below. (All costs in this summary are rounded to

the nearest hundred dollars, and are presented in 1999$.) It should be noted that the results of these analyses for SO_2 controls are not relevant to NO_X controls, and vice versa. Each pollutant has a different history of cost of controls, which makes cross-pollutant comparison inappropriate.

We note that comparisons of the cost per ton of pollutant reduced from various control measures should be viewed carefully. Cost per ton of pollutant reduction is a convenient way to measure cost effectiveness, but it does not take into account the fact that any given ton of pollutant reduction may have different impacts on ambient concentration and human exposure, depending on factors such as the relative locations of the emissions sources and receptor areas. Thus, for example, an alternative approach might adopt the effect of emission reductions on ambient concentrations in downwind nonattainment areas as the measure of effectiveness of further control. The EPA solicits comment on whether to take such considerations into account and what, if any, scientifically defensible methods may be available to do so.

a. Cost Effectiveness of SO_2 Emission Reductions

The EPA developed criteria for highly cost-effective amounts through: (1) Comparison to the average cost effectiveness of other regulatory actions and (2) comparison to the marginal cost effectiveness of other regulatory actions. These ranges indicate cost-effective controls. EPA believes that controls with costs towards the low end of the range may be considered to be highly cost effective because they are self-evidently more cost effective than most other controls in the range. Moreover, this level of cost is consistent with SO_2 and NO_X emissions reductions that yield substantial ambient benefits in downwind nonattainment areas, as discussed in section IX. For these reasons, EPA proposes today the costs identified below as highly cost-effective levels, and the associated set of SO_2 and NO_X emissions reductions and emissions budgets, as the basis for the SIP requirements.

Table VI–1 provides the average and marginal costs of annual SO_2 reductions under EPA proposed controls for 2010 and 2015. Also, EPA considered the sensitivity of the marginal cost results to assumptions of higher electric growth and future natural gas prices than it used in its base case. These assumptions in the sensitivity analysis were based on the Energy Information Agency's *Annual Energy Outlook for 2003*.

Table VI–2 provides the average cost per ton of recent EPA, State, and local Best Available Control Technology (BACT) permitting decisions for SO_2. These decisions reflect the application of BACT for SO_2 to new sources and major modifications at existing sources. These decisions, which include consideration of average and incremental cost effectiveness, reflect the application of best available controls in attainment and unclassified areas. These decisions do not reflect the application of lowest achievable emission rate, which is required in nonattainment areas and which does not directly consider cost in any form. The BACT decisions are relevant for present purposes because they comprise cost effective controls that have been demonstrated.

Table VI–3 provides the marginal cost per ton of recent State decisions for annual SO_2 controls where marginal cost information was available. These include the WRAP Regional SO_2 Trading Program and statewide rules that have required significant reductions of SO_2 in North Carolina and Wisconsin.

The results of the sensitivity analysis of the marginal cost in Table VI–1 when compared to Table VI–3 results further supports that the SO_2 controls are highly cost effective.

Additionally, the Agency further considered the cost effectiveness of alternative stringency levels for this regulatory proposal (examining changes in the marginal cost curve at varying levels of emissions reductions). Figure VI–1 shows that the "knee" in the marginal cost effectiveness curve—the point where the cost of control is increasing at a higher rate than the amount of SO_2 removal for EGUs—appears to start above $1,200 per ton. The selected approach was well below the point at which there would be significant diminishing returns on the dollars spent for pollution control. The EPA used the Technology Retrofitting Updating Model (TRUM), a spreadsheet model based on the Integrated Planning Model (IPM), for this analysis. Details of this analysis can be found in "An Analysis of the Marginal Cost of SO_2 and NO_X Reductions" (January 2004) in the docket for today's rulemaking.

TABLE VI–1.—PREDICTED COSTS PER TON OF SO_2 CONTROLLED UNDER PROPOSED CONTROL STRATEGY (1999$)/TON [1]

	2010	2015
Average Cost	$700	$800
Marginal Cost ...	700	1,000
Sensitivity Analysis: Marginal Cost, Assuming High Electric Demand and Natural Gas Price	900	1,100

[1] EPA IPM modeling; available in the docket.

TABLE VI–2.—AVERAGE COSTS PER TON OF ANNUAL SO_2 CONTROLS

SO_2 control action	Average cost (1999$)/ton
Best Available Control Technology (BACT) determinations.	$500–$2,100 [1]

[1] These numbers reflect a range of cost effectiveness data entered into EPA's RACT/BACT/LAER Clearinghouse (RBLC) for add-on SO_2 controls.

TABLE VI–3.—MARGINAL COSTS PER TON OF ANNUAL SO_2 CONTROL ACTIONS

SO_2 control action	Marginal cost (1999$)/ton
Wisconsin Multi-pollutant rule.	$1,400 [1]
North Carolina Multi-pollutant rule.	$800 [2]
WRAP Regional SO_2 Trading Program.	$1,100–$2,200 [3]

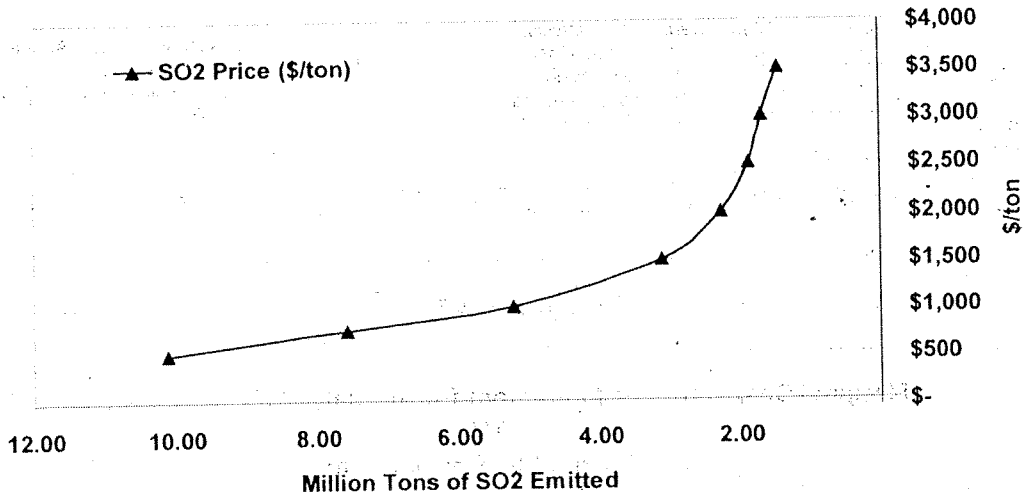
[1] EPA's IPM Base Case run, available in the docket.

[2] EPA's IPM Base Case run, available in the docket.

[3] "An Assessment of Critical Mass for the Regional SO_2 Trading Program," Prepared for Western Regional Air Partnership Market Trading Forum by ICF Consulting Group, September 27, 2002, available in the docket and at *http://www.wrapair.org/forums/mtf/critical_mass.html*. This analysis looked at the implications of one or more States choosing to opt-out of the WRAP regional SO_2 trading program.

Figure VI-1

Marginal Cost Curve of Abatement for SO2 Emissions in 2015
(NOx cap at 2.3 million tons)



b. Cost Effectiveness of NO_X Emission Reductions

In developing the NO_X SIP Call, EPA determined that an average cost effectiveness of $2,500/ton (in 1999$, from original $2,000/ton in 1990$), or less, was highly cost effective for NO_X reductions during the ozone season. This was based on review of other relevant actions EPA and others had recently taken. An updated summary of average costs of NO_X control actions is in Table VI–4. Each of the programs in Table VI–4 cover annual NO_X reductions, which makes comparison of these estimates to ozone season reductions a conservative comparison, as was done in the NO_X SIP Call. The table's results are very similar to what EPA found in 1998 and reaffirm the Agency's earlier determination of what a highly cost-effective reduction of NO_X emissions is.

Table VI–5 provides the results of EPA's analysis of the cost effectiveness of the proposed NO_X control requirements for States contributing to downwind ozone nonattainment. The average costs are well below $2,500/ton. The marginal costs in 2010 are much lower than the benchmark, but in 2015 are above it by a modest amount. Notably, if the controls during the ozone season are then used for the remaining months of the year, their costs are very low. Table VI–6 provides these results. These reductions are among the lowest cost EPA has ever observed in NO_X control actions and are obviously highly cost effective.

Table VI–7 shows the average and marginal costs of year-round controls for EPA's proposed approach. When these costs are compared to the costs in Table VI–8, it is clear that in the States that control NO_X for $PM_{2.5}$ only, the controls are highly cost effective.

The Agency further considered the cost effectiveness of alternative stringency levels for this regulatory proposal (examining changes in the marginal cost curve at varying levels of emission reductions). Figure VI–2 shows that the knee in the marginal cost effectiveness curve for NO_X appears to start above $2,000 per ton. The selected approach was well below the point at which there would be significant diminishing returns on the dollars spent for pollution control.

TABLE VI–4.—AVERAGE COST PER TON OF EXISTING AND PROPOSED ANNUAL NO_X RULES

NO_X rule [1]	Average cost (1999$)
Tier 2 Vehicle Gasoline Sulfur [2].	$1,300–$2,300
2004 Highway HD Diesel [2]	$200–$400
Off-highway Diesel Engine [2]	$400–$700
Tier 1 Vehicle Standards [2]	$2,100–$2,800
National Low Emission Vehicle [2].	$1,900
Marine SI Engines [2]	$1,200–$1,800
2007 Highway HD Diesel Stds [2].	$1,600–$2,100
On-board Diagnostics [2]	$2,300
Marine CI Engines [2]	Up to $200
Revision of NSPS for New EGUs.	$2,100

[1] Costs for rules affecting mobile sources presented here include a VOC component.

[2] Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements; Final Rule (66 FR 5102; January 18, 2001). The values shown for 2007 Highway HD Diesel Stds are discounted costs.

TABLE VI–5.—PREDICTED COSTS PER TON OF OZONE SEASON-ONLY NO_X CONTROLLED UNDER PROPOSED CONTROL STRATEGY (1999$)/TON [1]

	2010	2015
Average Cost	$1,000	$1,500
Marginal Cost	2,200	2,600

[1] EPA IPM modeling; available in the docket.

TABLE VI–6.—PREDICTED COSTS PER TON OF WINTER SEASON NO_X CONTROLLED UNDER PROPOSED CONTROL STRATEGY (1999$)/TON [1]

	2010	2015
Average Cost	$700	$500

[1] EPA IPM modeling; available in the docket.

TABLE VI–7.—PREDICTED COSTS PER TON OF ANNUAL NO_X CONTROLLED UNDER PROPOSED CONTROL STRATEGY (1999$)/TON [1]

	2010	2015
Average Cost	$800	$700
Marginal Cost	1,300	1,500
Sensitivity Analysis: of Marginal Cost, Assuming High Electricity Demand and Natural Gas Price	1,300	1,600

TABLE VI–7.—PREDICTED COSTS PER TON OF ANNUAL NO_X CONTROLLED UNDER PROPOSED CONTROL STRATEGY (1999$)/TON [1]—Continued

	2010	2015
Sensitivity Analysis: of Marginal Cost, Assuming High Electricity Demand, Natural Gas Price and SCR Costs	2,200	2,000

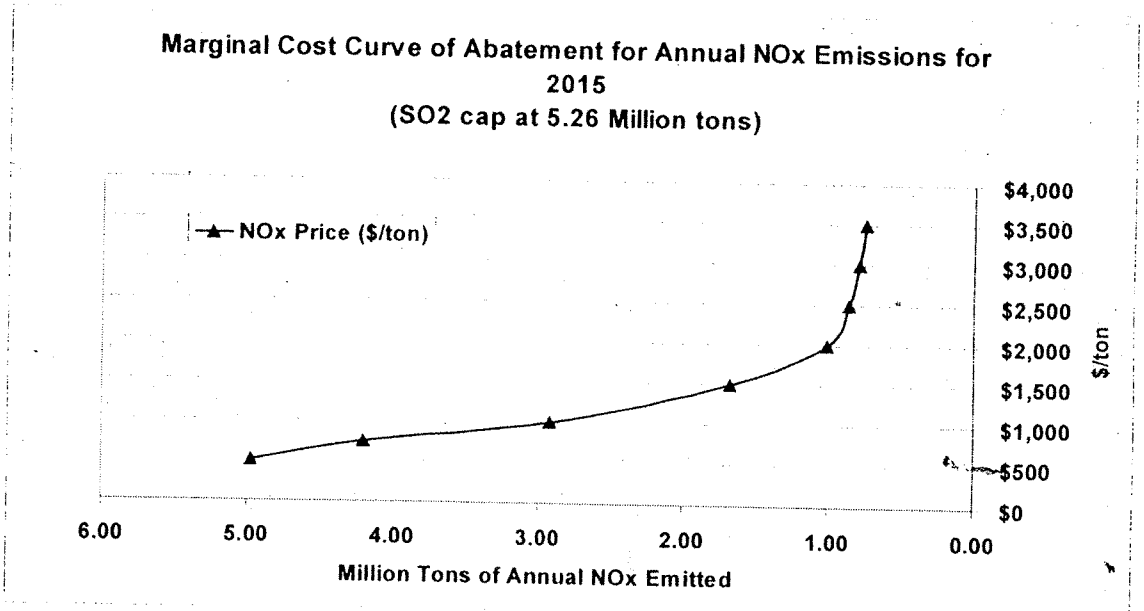
[1] EPA IPM modeling; available in the docket.

TABLE VI–8.—MARGINAL COST PER TON OF REDUCTION RECENT NO_X RULES

NO_X action	Marginal cost per ton (1999$)
Wisconsin Rules—Annual Controls.	$1,800 [1]
Texas Rules—Annual Controls.	$1,400–$3,000 [1]

[1] EPA's IPM Base Case run, available in the docket. NO_X control requirements in Texas vary regionally; the range of marginal costs here reflects the various requirements in the State.

Figure VI-2



c. EPA Cost Modeling Methodology

The EPA conducted analysis through the Integrated Planning Model (IPM) that indicates that its proposed SO_2 and NO_X control strategies are consistent with the level of controls proposed as highly cost effective. We use IPM to examine costs and, more broadly, analyze the projected impact of environmental policies on the electric power sector in the 48 contiguous States and the District of Columbia. The IPM is a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. It provides forecasts of least-cost capacity expansion, electricity dispatch, and emission control strategies for meeting energy demand and environmental, transmission, dispatch, and reliability constraints. We used IPM to evaluate the cost and emissions impacts of the policies to limit emissions of SO_2 and NO_X from the electric power sector that are proposed in today's rulemaking. The National Electric Energy Data System (NEEDS) contains the generation unit records used to construct model plants that represent existing and planned/committed units in EPA modeling applications of IPM. The NEEDS includes basic geographic, operating, air emissions, and other data on all the generation units that are represented by model plants in EPA's v. 2.1.6 update of IPM.

We used the IPM to conduct the cost effectiveness analysis for the emissions control program proposed in this action. The model was also used to derive the marginal cost of several State programs that EPA considers as part of its base case.

For the purpose of preliminarily evaluating today's proposal, EPA modeled a strategy that assumes SO_2 controls in the 48 contiguous States in a manner that largely leads to a cap on Eastern States without leakage of emissions to nearby States. The modeled 48-State cap simulates a control program that is very similar to the program we are now proposing to control SO_2 in only the 28-State and DC region. Most of the SO_2 emissions and reductions would occur in the 28-State and DC control region and therefore a very similar result is expected. Based on IPM modeling, the SO_2 emissions in 2015 from the proposed 28-State and DC region would be 92 percent of national emissions under base case conditions (*i.e.*, without implementation of today's proposed program). In addition, emissions reductions in the 28-State and DC region would be 96 percent of total national reductions, under the 48 State cap that was modeled. Thus, the 48-

State cap that was modeled very closely represents the proposed 28-State and DC cap.

We modeled NO_X controls in a 31 and one-half State region that includes Minnesota, Iowa, Missouri, Arkansas, Louisiana, Eastern Texas and all of the States to the east, and DC. The NO_X control region proposed in today's action (28-States and the District of Columbia, plus ozone season only control in Connecticut) is very similar to this region used for modeling.

Because the regions used for modeling SO_2 and NO_X controls encompass a significant amount of the electricity generation in the country, they provide information that could be applied to somewhat smaller or larger regions. We believe that costs (both marginal and average) in a somewhat smaller or larger region would be similar.[83]

In this modeling case, EPA assumes interstate emissions trading. While EPA is not requiring States to participate in an interstate trading program for EGUs, EPA believes it is reasonable to evaluate control costs assuming States choose to participate in such a program since the program will result in less expensive reductions.

The modeled case discussed below assumes a phased program, with the first set of reductions occurring in 2010 and the second phase occurring in 2015. For SO_2 in particular, it should be noted that the regional reductions or budget levels are not actually achieved in the year that they are implemented. This is because of the existence of an SO_2 emission bank. The availability of the SO_2 emission bank allows sources to make emission reductions earlier and then use the allowances that are saved at a later date. Banking has less of an effect on NO_X emissions because in the existing ozone-season only program, NO_X allowances are more expensive than they are expected to be in an annual program. Thus, there is not an incentive to make early NO_X emission reductions to create allowances to be used in the future.

3. Timing, Engineering and Financial Factor Impacts

While cost considerations are one of the primary components in establishing emission reduction requirements, another important consideration is the time by which the emission reductions may be achieved. The EPA has determined that for engineering and financial reasons, it would take substantial time to install the projected controls that would be necessary to reach the ultimate control levels proposed. We seek to require implementation of the reductions on a schedule that will provide air quality benefits as soon as feasible to as many nonattainment areas as possible. Therefore, we propose to require the implementation of as much of the reductions as possible by an early date and to set a later date for the remaining amount of reductions.

Specifically, EPA proposes that the first phase must be implemented by January 1, 2010. This date is based upon the following schedule: EPA finalizes today's proposed rule by mid-2005; States submit SIPs by the end of 2006; and sources install the first phase of required controls by January 1, 2010, and the second phase by January 1, 2015.

EPA recognizes that this two-phase approach assumes that States will achieve the reduction requirements imposed by the rules proposed today through controls on EGUs. Of course, States may choose to control different sources, and if so, the specific engineering constraints applicable to EGU compliance may not apply to these other sources.[84] Nevertheless, EPA believes it appropriate to authorize a two-phase approach for all States, regardless of how they choose to achieve the reduction requirements. This approach is consistent with the fact that EPA calculated the amount of reductions required on the basis of assumed controls on EGUs, as well as the fact that as a practical matter, most (if not all) States are likely to adopt EGU controls as their primary (if not exclusive) way to achieve the required reductions.

a. Engineering Assessment To Determine Phase 1 Budgets

When designing an emissions reductions program such as EPA is proposing in today's action, the Agency must consider the effect that the timing and reduction stringency of the program will have on the quantity of resources required to complete the control technology installation and the ability of markets to adjust and to provide more resources where needed. We used IPM to predict the number and size of facilities that would install new emissions control equipment to meet the implementation dates and emissions reductions in today's proposed rule. Then, we estimated the resources required for the installation of those control technologies.

Today's proposed rule does not require the imposition of controls on any particular source and instead leaves that matter to the affected States. However, the cost effectiveness of EGU controls makes it likely that many States will achieve reductions through EGU controls. Accordingly, EPA considers it appropriate to evaluate the timing of the reduction requirements with reference to the EGU control implementation schedule. Therefore, today's proposed rule assumes the installation of significant numbers of SO_2 and NO_X controls on EGUs. To meet the existing Federal title IV program and NO_X SIP Call requirements, there has been a reliance on low sulfur coal and limited use of scrubbers (also called FGD) for SO_2 reductions and low NO_X burners and post-combustion controls (*e.g.*, SCR) for NO_X reductions, as well as shifting of dispatch to more efficient and less polluting units for each air pollutant. However, to meet the future requirements proposed in today's rule, for SO_2 control we predict there will be heavy reliance on scrubbers in the decade following finalization of today's rule. For NO_X control, we predict there will be heavy reliance on SCR and, to a much lesser degree, selective non-catalytic reduction (SNCR) and gas reburn.

The installation of the advanced post-combustion controls required under today's proposal will take significant resources and time. Installation of these controls are large-scale construction projects that can span several years, especially if multiple units are being installed at a single power plant. If EPA were to allow sources all of the time they needed to install controls to meet the ultimate cap levels without the imposition of intermediate caps, the consequences for SO_2 and NO_X would be different. For SO_2, the existence of the title IV program and the ability to bank would likely encourage sources to run their SO_2 emission controls as soon as they were installed. While these early reductions would be environmentally beneficial, they would also allow sources to continue to increase their SO_2 banks. By creating an intermediate cap, the ability to bank would be limited. For NO_X, there would be little incentive to turn on controls and achieve additional reductions, particularly in the non-ozone season and in the States not affected by the NO_X SIP Call. Therefore, in order to get any additional NO_X reductions—either during the winter

[83] We began our emissions and economic analysis for today's proposal before the air quality analysis, which affects the States we are proposing for control requirements, was completed. Thus, we modeled emissions and economic effects on regions that are similar but not identical to the region proposed today. We intend to publish revised emissions and economic modeling in a supplemental action.

[84] Other sources may face similar or other timing constraints for implementation purposes.

months from already installed SCRs or year-round from newly installed SCRs outside of the SIP Call region—it is necessary to impose an intermediate cap.

We believe that 3 years is a reasonable amount of time to allow companies to install emission controls that could be used to comply with the first phase reduction requirements of today's proposed rule. In certain circumstances, some individual units could install emissions reduction equipment in considerably less time than 3 years.[85] In the report, "Engineering and Economic Factors Affecting the Installation of Control Technologies for Multi-pollutant Strategies' (October 2002), EPA projected that it would take on average about 21 months to install a SCR on one unit and about 27 months to install a scrubber on one unit. However, many times, companies must install controls on units at the same plant. To do so, companies will often stagger installations to minimize operational disruptions, thereby taking more time. We project that seven SCRs could be installed at a single facility in 3 years. Also, we project that three scrubber modules (scrubbing a total of six units) could be installed in 3 years. Since we believe that 3 years is enough time to install controls on all the units required at a large power plant, EPA believes that 3 years is a reasonable amount of time to allow for the first phase of compliance.

The availability of skilled labor—specifically, boilermakers—is an important constraint for the installation of significant amounts of emission controls. Boilermakers are skilled steel workers who are specially trained to install both NO_X controls such as SCR and SO_2 controls such as scrubbers.

Since the availability of boilermaker labor affects the installation of both SO_2 controls and NO_X controls, it is also necessary to decide what mix of pollution reductions is desired in the first phase. In today's rulemaking, EPA is proposing to require similar percentage reductions of both SO_2 and NO_X in the first phase. In developing the first phase control levels, we intended to maximize the total control installations possible (and thus total reductions) considering the constraint on boilermaker labor, while getting similar reductions for both pollutants. This results in predicted reductions of between 40 and 50 percent for both pollutants, in the first phase.

[85] For instance, a SCR was installed on a 675 MW unit in about 13 months (Engineering and Economic Factors, p.21).

Based on all of these constraints, EPA is proposing a two-phase reduction requirement, with a first phase cap on SO_2 in 2010 based on a 50 percent reduction from title IV levels. This represents about a 40 percent reduction in emissions from the Base Case. This strategy would require about 63 GW of scrubbers to be installed by 2010. Of these, 49 GW of scrubbers would be incremental to the Base Case. (We based this analysis on the assumption that States choose to control EGUs.)

The EPA's proposed NO_X reduction requirement would also be implemented in two phases, with a first phase cap based, in a comparable manner, on about a 49 percent decrease in emissions from the Base Case. (The calculation of this first phase cap is discussed more below.) This cap would require installation of about 39 GW of SCR between 2005 and 2010. Of this, 24 GW are incremental to the Base Case. (We based this analysis on the assumption that States choose to control EGUs.)

Since the NO_X SIP Call experience showed that many power companies are averse to committing money to install controls until after State rules are finalized, EPA analyzed availability of boilermakers assuming companies did not begin installing controls until after the State rules were finalized. While boilermakers are one of the key components in building SCRs and scrubbers, most of their work cannot begin until well into the construction project. First, the power company must do preliminary studies to determine which controls to install, then jobs must be bid and design must begin. After the installation is designed, foundations must be poured and pieces of the control equipment must be built in machine shops. It is only after all of this activity has taken place that the boilermakers can erect the control equipment.

We assumed, therefore, that most of the demand for boilermakers came in the last 21 months of the 3 year period to install controls. Furthermore, in order to have controls fully operational in time for the compliance deadline, companies would likely complete installation well before the deadline to allow for testing of the controls. Assuming that most companies would try to complete controls in time to provide for a 3-month testing period, most of the demand for boilermaker labor will come in an 18-month window.

It is EPA's projection that approximately 12,700 boilermaker years would be needed to install all of the required equipment for the first phase of compliance. We project that approximately 14,700 boilermaker years would be available during the time when first phase controls would be installed. This projected number of boilermakers is based on the assumption that all the boilermakers that EPA projects are available for work on power sector environmental retrofit projects would be fully utilized (*e.g.*, 40 hours a week for 50 weeks of the year). In reality, it would be difficult to achieve this full utilization of boilermakers. For instance, boilermakers will be unable to work when moving from job-site to job-site, during inclement weather, *etc.* We believe that the availability of approximately 15 percent more boilermaker years than are required assures that there are enough boilermakers available to construct all of the required retrofits.

b. Financial and Other Technical Issues Regarding Pollution Control Installation

The EPA recognizes that the power sector will need to devote large amounts of capital to meet the control requirements of the first phase. Controls installed by 2010 will generally be the largest and easiest to install. Subsequent controls will need to be installed at more plants and under more challenging circumstances. We believe that deferring the second phase to 2015 will provide enough time for companies to overcome these technical challenges and raise additional, reasonably-priced capital needed to install controls.

4. Interactions With Existing Title IV Program

As EPA developed this regulatory action, great consideration was given to interactions between the existing title IV program and today's proposed rule designed to achieve significant reductions in SO_2 emissions beyond title IV. Requiring sources to reduce emissions beyond what title IV mandates has both environmental and economic implications for the existing title IV SO_2 trading program. In the absence of a method for accounting for the statutory requirements of title IV, a new program that imposes a tighter cap on SO_2 emissions for a particular region of the country would likely result in an excess supply of title IV allowances and the potential for increased emissions in the area not subject to the more stringent emission cap. The potential for increased emissions exists in the entire country for the years prior to the proposed implementation deadline and would continue after implementation for any areas not affected by the proposed rule. These excess emissions could negatively affect air quality,

disrupt allowance markets, and erode confidence in cap and trade programs.

In view of the significant reductions in SO_2 emissions under title IV of the CAA, the large investments in pollution controls that firms have made under title IV that enable companies to sell excess emissions reductions, and the potential for emissions increases, it is necessary to consider ways to preserve the environmental benefits achieved through title IV and maintain the integrity of the title IV market for SO_2 allowances. The EPA does not have authority to address this issue by tightening the requirements of title IV. In any event, title IV has successfully reduced emissions of SO_2 using the cap and trade approach, eliminating millions of tons of SO_2 from the environment. Building on this existing program to further improve air quality by requiring additional reductions of SO_2 emissions is appropriate.

We have developed an approach to incorporate the title IV SO_2 market to ensure that the desired reductions under today's action are achieved in a manner consistent with the previously stated environmental goals. Our proposed approach effectively reduces the title IV cap for SO_2 and allows title IV allowances for compliance with this rule at a ratio greater than one-to-one. Section VIII provides more detail on our initial analysis of the interactions between the title IV Acid Rain program and today's proposed cap and trade program and outlines a solution for creating a new rule that builds off of title IV.

D. Methodology for Setting SO_2 and NO_X Budgets

In section D, EPA describes in detail how it proposes to establish the reduction requirements and, to the extent applicable, budget requirements for EGUs. The first step for both SO_2 and NO_X was determining the total amount of emissions reductions that would be achievable based on the control strategy determined to be highly cost effective. Our evaluation of cost effectiveness for the proposed 2010 and 2015 emissions caps was explained in the preceding subsection as was the need to split these budget requirements into two phases to assure that emission reductions were achieved expeditiously considering factors that could limit the amount of emission controls that could be installed in a given time period.

There were then two more steps that followed. In the second step, EPA determined the amount of emissions reductions that were needed across the region covered by this proposal and, for EGUs, set annual emissions caps accordingly in 2010 and 2015. These caps remain at the 2015 levels thereafter, to maintain air quality in the downwind areas. In the third step, EPA partitioned the cap levels into State emissions budgets that they may use for granting allowances for SO_2 and NO_X emissions.

1. Approach for Setting Regionwide SO_2 and NO_X Emission Reductions Requirements

a. SO_2 Budgets for EGUs

The EPA is proposing a two-phase SO_2 reduction program. The first phase, in 2010, would reduce SO_2 emissions in the 28-State and DC region by the amount that results from making a 50 percent reduction from title IV Phase II allowance levels. The second phase, in 2015, would further reduce SO_2 emissions by the amount that results from making a 65 percent reduction from the title IV Phase II allowance level.

These amounts may be calculated in terms of regionwide EGU caps for the first and second phases, assuming that all the affected States control only EGUs. Similarly, it is necessary to calculate the amount of regionwide SO_2 reductions for the first and second phase, for States that choose to control sources other than (or in addition to) EGUs. This calculation of the amount of the regionwide cap or emissions reductions is a useful step because this amount may then be apportioned to individual State. In addition, the methodology for calculating regionwide amounts should accommodate revisions in the universe of States in the region—adding or subtracting individual States—based on refinement to the air quality modeling that EPA expects to complete and publish in the SNPR.

The EPA proposes that the regionwide SO_2 budgets may be calculated by adding together the title IV Phase II allowances for all of the States in the control region, and making a 50 percent reduction for the 2010 cap and a 65 percent reduction for the 2015 cap. This results in a first phase SO_2 cap of about 3.9 million tons and a second phase cap of about 2.7 million tons, in the 28-State and DC control region.

Modeling predicts nationwide SO_2 emissions of about 5.4 million tons in 2015 with today's proposed controls. (This compares to approximately 9.1 million tons without today's proposed controls.) Predicted emissions in the 28-State and DC region that EPA is proposing to find significantly contribute to $PM_{2.5}$ nonattainment are about 4.6 million tons in 2015. (These emission estimates are from modeling using the 48-State region as described above.) The projected SO_2 emissions are higher than the caps due to use of banked allowances resulting from the incentive for early reductions. Accordingly, the 2015 annual SO_2 emissions reductions amount to about 3.7 million tons, and the 2010 annual SO_2 emissions reductions amount to about 3.6 million tons.

b. NO_X Budgets for EGUs

The EPA is proposing a two-phased annual NO_X control program, with a first phase in 2010 and a second phase in 2015, which would apply to the same control region as the SO_2 requirements, that is, 28-States and DC. In addition, Connecticut would be required to control NO_X during the ozone season.

On a regionwide basis, the control requirements EPA is proposing would result in a total EGU NO_X budget of about 1.6 million tons in 2010 and 1.3 million tons in 2015, in the 28-State and DC region that would be affected by today's rulemaking (assuming each State controlled only EGUs and thereby subjected themselves to the proposed caps). In addition, the control requirements would lead to 2015 annual NO_X emissions reductions of about 1.8 million tons from the base case, and 2010 annual NO_X emissions reductions of about 1.5 million tons from the base case.

Calculating the regionwide budget and emissions reductions requirements serve the same purposes as in the case of SO_2, described above. Our methodology proposed today determines historical annual heat input data for Acid Rain Program units in the applicable States and multiplies by 0.15 lb/mmBtu (for 2010) and 0.125 lb/mmBtu (for 2015) to determine total annual NO_X mass. For the annual heat input values to use in this formula, EPA proposes to take the highest annual heat input for any year from 1999 through 2002 for each applicable State. This proposed approach provides a regionwide budget for 2010 that is approximately 37,500 tons more than the budget that would result from using the highest annual regional heat input for any of the 4 years, and about 60,700 tons more than using the average regional heat input for the 4-year period. We believe that this cushion provides for a reasonable adjustment to reflect that there are some non-Acid Rain units that operate in these States that will be subject to the proposed budgets.

Note that EPA proposes today that Connecticut contributes significantly to downwind ozone nonattainment, but not to fine particle nonattainment. Thus, Connecticut would not be subject to an

annual NO_X control requirement, and is not included in the 28-State and DC region we are proposing for annual controls. Connecticut would be subject to an ozone season-only NO_X cap.[86] Because Connecticut is required to make reductions only during the ozone season, compliance for sources would not be required to begin until May 1, 2010. If Connecticut chooses to participate in the regional trading program on an annual basis, compliance would begin on January 1, 2010.

Although EPA proposes to determine the regionwide amount of EGU NO_X emissions by using historic heat input and emission rates of 0.15 lb/mmBtu and 0.125 lb/mmBtu, we take comment on using, instead, heat input projected to the implementation years of 2010 and 2015 and/or different emission rates. Under this approach, we take comment on whether to use the same method for projecting heat input as used in the NO_X SIP Call, or a different method. The NO_X SIP Call method is described in 67 FR 21868 (May 1, 2002).

2. State-by-State Emissions Reductions Requirements and EGU Budgets

This section describes the methodologies used for apportioning regionwide emission reduction requirements or budgets to the individual States. State budgets may be set with a methodology different from that used in setting the regionwide budgets, for reasons described in this section.

In practice, if States control EGUs and participate in the regional trading program, the choice of method used to impose State-by-State reduction requirements makes little difference in terms of total regionwide SO_2 and NO_X emissions. The cap and trade framework would encourage least-cost compliance over the region, an outcome that does not depend on the individual State budgets.

However, the distribution of budgets to the States is important in that it can have economic impacts on the State's sources. Should a State receive a disproportionate share of the regionwide budget, there would be fewer allowances to allocate to its sources. This may adversely affect compliance costs for sources within that State as they are forced to increase their level of emission control or became net buyers from sources in States that may have received a greater share of regionwide cap.

For SO_2, we propose determining State SO_2 budgets for EGUs on the basis of title IV allowances, which is in line with the planned interactions of this rule with title IV of the CAA Amendments. See section VIII for a more detailed discussion of interactions with title IV. Such budgets would be easy to understand, would be straightforward to set, would reflect previously implemented allocations and would allow for the smoothest transition to the new program proposed today.

For the proposed 28 State SO_2 control region, the proposed annual State EGU SO_2 budgets are presented in Table VI–9, below.

TABLE VI–9.—28-STATES AND DISTRICT OF COLUMBIA ANNUAL EGU SO_2 BUDGETS

State	28-State SO_2 budget 2010 (tons)	28-State SO_2 Budget 2015 (tons)
Alabama	157,629	110,340
Arkansas	48,716	34,101
Delaware	22,417	15,692
District of Columbia	708	495
Florida	253,525	177,468
Georgia	213,120	149,184
Illinois	192,728	134,909
Indiana	254,674	178,272
Iowa	64,114	44,879
Kansas	58,321	40,825
Kentucky	188,829	132,180
Louisiana	59,965	41,976
Maryland	70,718	49,502
Massachusetts	82,585	57,810
Michigan	178,658	125,061
Minnesota	50,002	35,001
Mississippi	33,773	23,641
Missouri	137,255	96,078
New Jersey	32,401	22,681
New York	135,179	94,625
North Carolina	137,383	96,168
Ohio	333,619	233,533
Pennsylvania	276,072	193,250
South Carolina	57,288	40,101
Tennessee	137,256	96,079
Texas	321,041	224,729
Virginia	63,497	44,448
West Virginia	215,945	151,162
Wisconsin	87,290	61,103
Total	3,864,708	2,705,293

[86] If Connecticut, or any State subject to an existing NO_X ozone season-only budget program, chooses to participate in the interstate NO_X trading program proposed today, that State would need to operate under an annual NO_X cap rather than ozone season only. Interstate trading is discussed in more detail in section VIII, below.

If alternatively, EPA were to adopt an 0.10 $\mu g/m^3$ as the air quality criterion, Oklahoma and North Dakota would also receive SO_2 budgets. Oklahoma's 2010 State SO_2 budget would be 63,328 tons and its 2015 SO_2 budget would be 44,330 tons. North Dakota's 2010 SO_2 budget would be 82,510 tons and its 2015 SO_2 budget would be 57,757 tons.

If the State EGU SO_2 budget is entirely based on the title IV retirement ratio, then the budget would equal the title IV allowances multiplied by the retirement ratio (as discussed earlier in this section). However, under the CAA, the title IV SO_2 allowances are allocated on the basis of activity as of 1985, and as a result, they do not take into account any of the significant changes and growth in the sectors since that time.

An alternate method of determining State SO_2 EGU budgets would consist of two parts:

(1) The first part of the budget would be based on title IV allocations—but with a tighter title IV retirement ratio than that proposed for the region.

(2) The tighter retirement ratio would result in some un-allocated EGU allowances (reflecting the difference between the regionwide budget and State budgets calculated based on part (1)). These could be allocated to States' budgets for their non-title IV EGUs, or as a way to redistribute or update allowances to the title IV EGUs. This allocation could be done on the basis of methods discussed in more detail below. Such a two-part EGU budget would recognize the fact that the sector has grown and changed since title IV allocations were initially made.

For NO_X, we propose determining State NO_X budgets for EGUs on the basis of current/historic heat input rates. Regionwide budgets would be distributed to States based on an average of several years of historical data. We are proposing to use data from 1999 to 2002.

A similar approach was taken by the SO_2 program under title IV of the CAA. As a result, States with significant projected increases in growth were required to either: (1) Reduce their emissions further, or (2) burn fuel more efficiently in order to compensate. (For such States, the ability to trade emissions regionwide was particularly attractive because States with low increases or decreases in utilization could trade emissions with States having significantly increased utilization).

Most of the States within the proposed control region are part of the NO_X SIP Call, with a regionwide budget that on a seasonal basis constrains increases in NO_X emissions for the region as a whole. States with high growth (measured from a historic baseline to the start of the new program) would already be provided incentives to control NO_X emissions as they would need to use additional NO_X SIP Call allowances to emit during the ozone season. Consequently, growth in generation in the years after the proposed State budgets have been set would not necessarily lead to increased emissions. Furthermore, the majority of the growth (of heat input, or output) through 2010 is expected to be met by recently built natural gas units, with no SO_2 and very low NO_X emissions.

Such an option is also appropriate to consider if it is decided that SO_2 budgets for non-title IV sources should be developed as explained below.

Among the advantages of a budget methodology based on historic/current activity is that it is relatively simple to implement and would not need to be changed as a result of future data.

For the proposed 28 State Annual NO_X control region, the proposed annual State EGU NO_X budgets based on this methodology are presented in Table VI–10, below.

TABLE VI–10.—28-STATES AND DISTRICT OF COLUMBIA ANNUAL EGU NO_X BUDGETS

State	28-State NO_X Budget 2010 (tons)	28-State NO_X Budget 2015 (tons)
Alabama	67,414	56,178
Arkansas	24,916	20,763
Delaware	5,039	4,199
District of Columbia	215	179
Florida	115,489	96,241
Georgia	63,567	52,973
Illinois	73,613	61,344
Indiana	102,283	85,235
Iowa	30,454	25,378
Kansas	32,433	27,027
Kentucky	77,929	64,940
Louisiana	47,333	39,444
Maryland	26,604	22,170
Massachusetts	19,624	16,353
Michigan	60,199	50,165
Minnesota	29,300	24,417
Mississippi	21,930	18,275
Missouri	56,564	47,137
New Jersey	9,893	8,245
New York	52,448	43,707
North Carolina	55,756	46,463
Ohio	101,692	84,743
Pennsylvania	84,542	70,452
South Carolina	30,892	25,743
Tennessee	47,734	39,778
Texas	224,181	186,818
Virginia	31,083	25,903
West Virginia	68,227	56,856
Wisconsin	39,039	32,533
Total	1,600,392	1,333,660