Chapter 3: Control Analysis

Synopsis

This chapter documents the emission control measures we applied to simulate attainment with the revised $PM_{2.5}$ daily standard of 35μg/m^3 and alternative more stringent annual standard of 14 μg/m^3 and daily standard of 35 μg/m^3. Section 3.1 describes the decision rules we followed to select cost-effective emission controls to simulate attainment in each projected nonattainment area. Section 3.2 outlines the quality-assurance process our database of stationary source emission controls underwent before we selected them in our control strategies. Section 3.3 describes the sources of our control measures data and summarizes the emission reductions we simulated in each projected nonattainment area.

3.1 Emission Control Strategy Followed in this $PM_{2.5}$ National Ambient Air Quality Regulatory Impact Analysis

3.1.1 Overview of the Control Selection Process

We followed a three-step process to simulate attainment in all areas of the country with the 1997, revised and more stringent alternative standards. First, as we describe below in some detail, we identified cost-effective controls to apply in each projected non-attainment area and then simulated the resulting air quality change in an air quality model. Second, for those areas that we did not simulate attainment with the 1997, revised or more stringent alternative standards, we simulated the application of "supplemental" carbonaceous particle controls to the air quality model results to estimate the change in air quality. Third, and finally, if we did not simulate attainment after applying supplemental emission controls, we made a final determination of attainment or non-attainment by weighing the available monitor, modeling and design value data. These steps are referred to as "modeled," "supplemental," and "extrapolated" controls, or emission reductions (and associated costs) throughout the RIA. The emission controls discussion in this chapter focuses entirely with this first step of the three-step analysis, or "modeled" controls. Chapter 4 presents our analysis of the supplemental controls and the final attainment determinations (e.g. extrapolated emission reductions).

To select controls in the modeling step of the analysis, below we describe the method used to determine the geographic scope and cost-effectiveness of the emission controls we would select to simulate attainment in the air quality model with the current standard and each alternative. First, we established a hierarchy that governed the geographic scope of the controls that we would consider for each standard and standard alternative; generally, the tighter the $PM_{2.5}$ NAAQS, the broader the geographic scope we considered when simulating the application of emission controls. Second, we selected emission controls that were most cost-effective on a per-microgram basis—that is, controls that produced the greatest air quality benefit at the least cost. Third, we selected controls in most areas whose incremental cost remained below an urban-area specific benefit per ton threshold.[1] However, in an effort to reach attainment in California and Salt Lake City, Utah, we applied controls that exceeded the benefit per ton threshold. The subsections below describe how we implemented this process. We should note that a separate methodology was used for selecting and applying mobile source emission control strategies and EGU SO_2 control strategies, as described below.

3.1.2 Step One: Establish a Hierarchy of Emission Controls

To simulate attainment with the revised daily standard of 35µg/m^3, our approach first considered currently available known controls (i.e., known and demonstrated in the U.S. as of 2006), applied to the local projected nonattainment county and immediate surrounding counties. For example, Detroit is projected to not attain the revised standard in 2020. Our control strategy analysis includes the counties considered as part of the Detroit Metropolitan Statistical Area (MSA), as defined by the U.S. Census Bureau. After exhausting the controls available for the MSA (up to the limits set by our control strategy selection process discussed in Section 3.2.3), we then considered cost-effective controls available for surrounding counties of the MSA that touch the geographic border and may have an influence on the MSA attainment strategy. In some cases, a local control strategy did not provide enough emission reductions to attain the target PM concentration. In that case, we explored emission controls among a broader set of counties within the state containing the projected nonattainment area that focused on a key pollutant/sector. Examples include a program to reduce directly emitted $PM_{2.5}$ from non-EGU point sources.

In addition, for the more stringent alternative that would tighten the annual standard to 14 µg/m^3, we considered the use of regional control programs. We simulated the implementation of such a program across a multi-state area to facilitate region-wide attainment with a more stringent annual standard. As chapter two describes, monitored $PM_{2.5}$ speciation data indicates that in the industrial Midwest and eastern United States a substantial fraction of total $PM_{2.5}$ mass is composed of sulfates; these sulfates are formed on a secondary basis from SO_2 emitted from a variety of industrial sources. Both programs are described more fully below and in the case of the analysis of the more stringent alternative, they were applied prior to application of controls at the local level. For this reason, we considered both a control program implemented on a regional basis to control SO_2 at EGUs and another regional control program to control SO_2 emissions from industrial point sources. Note that for mobile source control measures, control costs were not available at the time that we began making decisions on the controls to apply. Therefore, we used the following approach for selecting mobile source controls:

- For the baseline of analysis (i.e., assessing how areas will comply with the current standard of 15/65), we applied all mobile source national rules to applicable sources

[1] We developed benefit per ton thresholds to account for the natural variability in the propensity of each precursor to form $PM_{2.5}$ in several urban areas. For example, sulfates contribute a larger fraction of $PM_{2.5}$ mass in the East than these particles do in the West; conversely, nitrates contribute a larger fraction of $PM_{2.5}$ mass in the West than they do in the East. Thus, the benefit per ton threshold for sulfates will be larger in the East than it will be in the West, and vice-versa. We intended these thresholds to roughly emulate the same decision process that local planners would follow—that, other things being equal, planners will select controls that produce the highest expected benefit in their urban area. Clearly, to the extent that planners have exhausted all available controls, these thresholds are moot. For example, due to the magnitude of the non-attainment problem in California, we selected emission controls whose costs exceeded the benefit per-ton threshold.

nationwide in 2015 because of the higher likelihood that they will be implemented in the near future, and despite the fact that some of these rules (e.g., the small nonroad engine rule) are primarily focused on VOC emission control and may have only a small impact on ambient PM.

- We applied mobile source local measures to applicable sources only in geographic areas where additional reductions were needed after the application of stationary source controls and the application of mobile source national rules

Because we used separate steps for selecting stationary and mobile source control measures, we did not necessarily apply the most cost effective set of control measures for each area. We anticipate that States would choose control measures in a more integrated fashion and there may be occasions in which States would choose mobile control measures prior to the application of certain stationary source controls.

Identification of Currently Available Known Stationary Source Controls Technologies. We used the AirControlNet tool (ACN) to identify and rank stationary source controls. ACN overlays a detailed control measures database onto EPA emissions inventories to compute source and pollutant-specific emission reductions. For this analysis, we linked ACN to the emissions inventory for 2020 to identify potential stationary source controls available in each county of the country. We then used the Least Cost Module of ACN to list control measures in rank order of annualized cost-effectiveness (cost-per-ton reduction) for each pollutant. The Least Cost Module lists the pollutant, sector and source category associated with controllable emissions as well as the control technology, the maximum tons of emission reduction that can be achieved with this technology at a specific plant and stack, and cost information (total average annualized cost and average cost per ton).[2]

Based on updated information, we placed limits on our selection of controls from the ACN database (e.g. excluding controls on point sources emitting less than 5 tons per year), as described in Section 3.2.2. We also constrained our controls of $PM_{2.5}$ precursors based on benefit per ton thresholds that vary by projected non-attainment area. The benefit per ton estimates differ by projected non-attainment county due to variability in the exposed population and the types of $PM_{2.5}$ precursors present in the atmosphere in these areas. For instance, counties with higher population levels have a greater number of people exposed to $PM_{2.5}$ and hence have a higher benefit per ton of emission reduced than in areas with lower population levels because the larger incidence in estimated mortality and morbidity produces a larger estimated benefit of reducing a given ton of precursor in that area. The type of precursors reduced—carbonaceous particles, NOx, SO_2, NH_3—in a given area also affect the estimated benefit per ton because of inherent differences in atmospheric chemistry among precursors. Each precursor has a different propensity to form $PM_{2.5}$ that can vary by geographical area.

[2] Controllable emissions refers to the maximum level of emissions that can be controlled given the control efficiency of technologies available in ACN. Total emissions in the inventory are greater than controllable emissions because technologies are able to control fewer than one hundred percent of all emissions.

In some areas, the benefit per ton threshold is $20,000 while in other areas with higher population levels or for precursors with a greater contribution to ambient $PM_{2.5}$, the benefit per ton threshold is $100,000 – $300,000. This approach follows principles of cost-benefit analysis. It also attempts to emulate what State Implementation Plan (SIP) planners might face when developing a control strategy for their area. SIP planners are not likely to choose control strategies whose estimated costs that far outweigh the estimated benefits. In situations where we exhausted all controls that pass the benefit-cost test, we lifted this restriction, and controls with costs per ton exceed benefits per ton were included in the control strategy. Table 3-1 below summarizes the benefit per ton thresholds that we utilized.

Table 3-1: Benefit per Ton Estimates[1, 2]

State	Emissions Sector	Pollutant	$Benefit/ton
Alabama Georgia	NonEGU	SO2	$130,000
	Area	PM2.5	$110,000
	EGU & NonEGU	PM2.5	$210,000
Illinois Indiana Michigan Missouri Ohio West Virginia	NonEGU	SO2	$22,000
	Area	PM2.5	$85,000
	EGU & NonEGU	PM2.5	$180,000
Pennsylvania	NonEGU	SO2	$35,000
	Area	PM2.5	$170,000
	EGU & NonEGU	PM2.5	$210,000
California Idaho Montana Oregon Utah Washington	NonEGU	SO2	$370,000
	EGU	Nox	$310,000
	NonEGU	Nox	$33,000
	Area	PM2.5	$29,000
	EGU & NonEGU	PM2.5	$87,000

[1] These estimates are used as general approximations of the benefits/ton of emissions for the areas based on extrapolated benefit values in RSM to inform the analysis of least-cost control strategies.

[2] These estimates should not be construed as the true value of benefits for a given area. The benefit-cost analysis conducts a complex and detailed analysis of the benefits attributable to each area based on results of air quality modeling, population demographics, and other factors specific to that area.

Recall from Section 1 that the control strategies provided in this analysis are illustrative and not intended to be specific strategies that EPA recommends for each nonattainment area. Moreover, we expect local areas to select a broader array of mobile source controls than we were able to model for the RIA. There are myriad combinations of controls and levels of reduction that can be imposed to achieve the targeted $PM_{2.5}$ concentration, and each SIP planning body is anticipated to consider a wide variety of issues, including cost and level of PM reduction to achieve, to design strategies that attain the PM NAAQS.

3.1.3 Step Two: Identify Cost-Effective Controls

At proposal, the EPA also introduced the Response Surface Model (RSM), which generates screening-level estimates of air quality changes resulting from a simulated change in pollutant emissions.[3] EPA designed the RSM as a screening tool that would allow EPA, States, and regional planning bodies to consider information on the relative effectiveness of pollutant reductions on design values (annual and daily in an area) without the time and expense of running a more complete and complex air quality model, such as CMAQ. In the Interim RIA, EPA used the RSM to assess the air quality impact of alternative sets of control strategies for five different areas of the country, including: Atlanta, Chicago, Cleveland, Salt Lake City, and Seattle. In Appendix A of the Interim RIA, we presented stacked bar charts of air quality impact at the violating urban area monitor associated with reductions in $PM_{2.5}$ precursors from each of several industrial and mobile source sectors. Below we reproduced one such stacked bar chart for Atlanta as an example.

The figure below illustrates the air quality impact associated with a 30% reduction of emissions in each industrial and mobile sector in the Fulton county area. The first bar chart illustrates the reductions in $PM_{2.5}$ resulting from local-area emission reductions, while the second bar illustrates the changes resulting from regional emission reductions. The resulting changes in concentrations of $PM_{2.5}$ are 1.536 $\mu g/m^3$ due to local emission reductions and 1.77 $\mu g/m^3$ due to the regional emission reductions. Each segment of the stacked bar chart provides the relative contribution of each sector and pollutant to the resulting reduction in $PM_{2.5}$. Dividing the RSM-estimated micrograms reduced by the tons of $PM_{2.5}$ precursor reduced the yields an approximate *µg air quality impact per ton reduced* for each sector and pollutant at the violating monitor. For example, in the figure below, we see the 30% reduction of locally-emitted carbon (i.e., directly emitted $PM_{2.5}$) from the area source sector has the largest impact on PM concentrations as indicated by the largest portion in red on the stacked bar for Fulton county. In total, a 30% reduction in area source carbon is equal to approximately 2,600 tons; this reduction produces a reduction in $PM_{2.5}$ concentration of 0.637 $\mu g/m^3$. Dividing the PM2.5 reduction by the tonnage reduction yields a µg-per-ton estimate for locally-emitted area source carbon in Fulton County, Georgia of about 2.47×10^{-04} µg/ton.

By calculating a microgram-per-ton estimate for each precursor and industrial source in a given urban area, EPA was able to determine which combination of precursor and industrial source was most effective to control when combined with cost per ton information from ACN. The resulting µg per ton estimates from the model runs for stationary sources were used to identify the most cost effective measures and are provided in Appendix C. Note that these estimates are only used in a relative sense to rank the relative effectiveness of controlling different precursors and industrial sources. As described previously, a different approach was used to decide where mobile source measures were applied.

[3] Additional information on the RSM model may be found in Chapter 1 of this RIA.

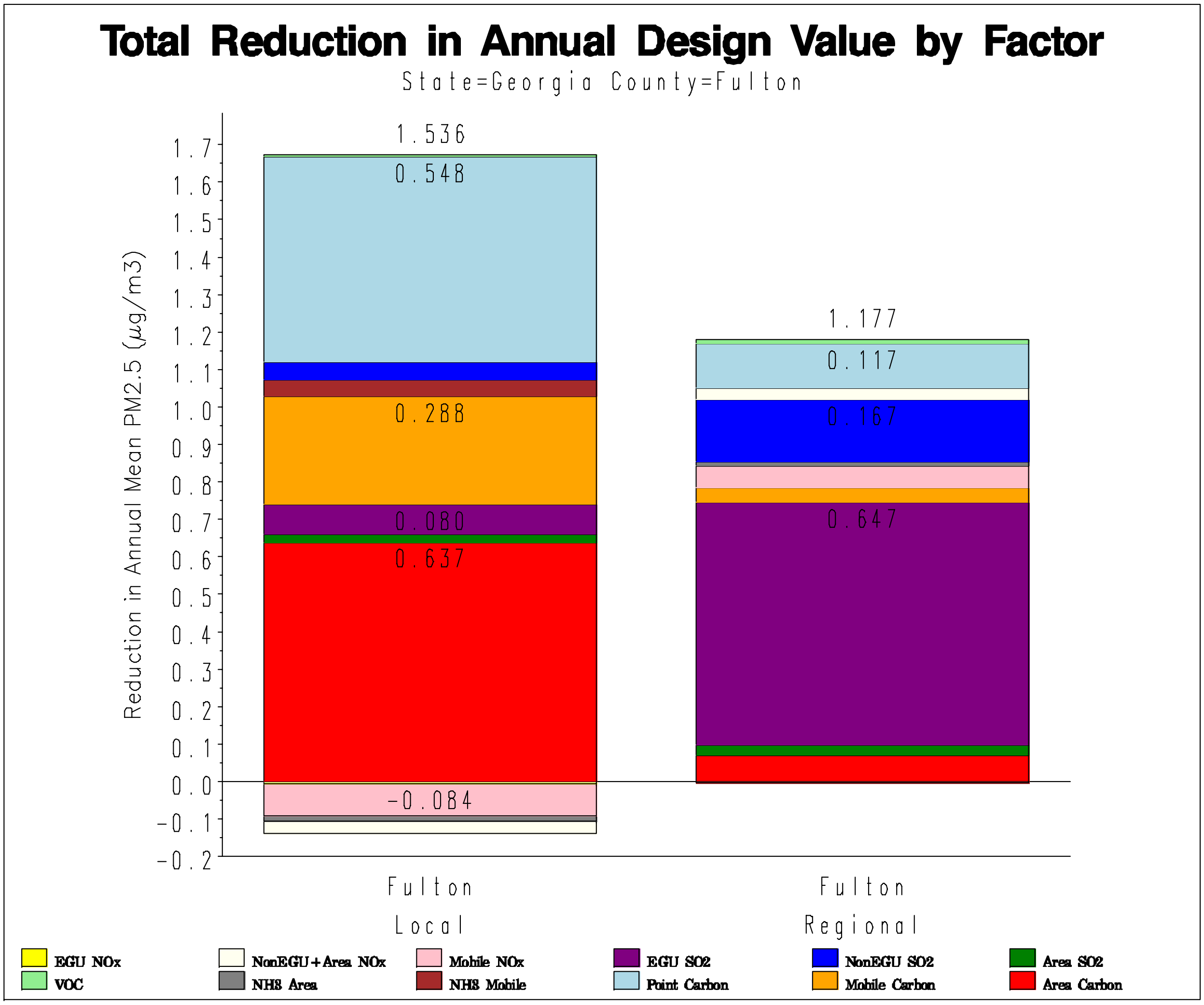

Figure 3-1. Example of Emissions and PM Concentrations from the Response Surface Model: Contributions from each Pollutant/Sector Combination to Total Annual $PM_{2.5}$ in Fulton County, Georgia (Given a 30% emission reduction in each sector)

In our analysis of cost-effective control strategies, we combined air quality effectiveness data from the RSM—that is, the air quality improvement per reduction in $PM_{2.5}$ precursor— with cost information from the ACN tool. By using the two models in this way we were able to develop an emission control strategy that achieved the targeted PM reductions at the lowest cost. We combined the output from the ACN and the RSM models to derive a *cost per µg* estimate for each geographic area of analysis and for each sector and pollutant combination (i.e., direct $PM_{2.5}$ in the non-EGU point source sector). The following figure displays the pollutant and sector combinations provided as outputs by the Least Cost Module of ACN and included in the calculation of cost per µg. As mentioned previously in this chapter, this approach was used for selecting stationary source controls only. Mobile source controls were applied according to the approach described in Section 3.1.2.

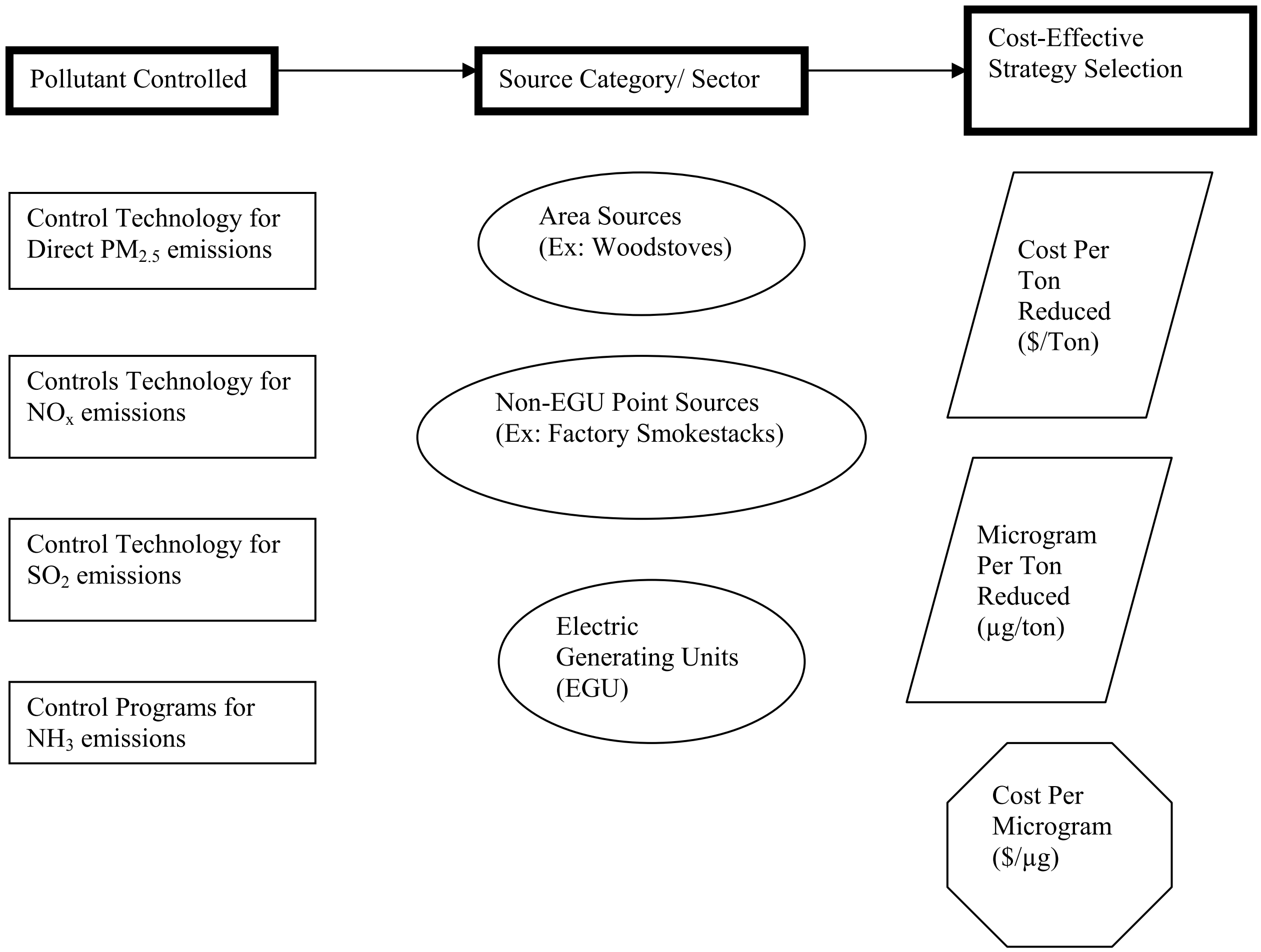

Figure 3-2. Process for Selecting Cost-effective Emission Controls

We used the RSM to assess the cost per microgram of $PM_{2.5}$ reduction for all sectors, including point, area, mobile and EGU's. Calculated values of cost per microgram for stationary sources used in the analysis are presented in Appendix C. To develop the cost per microgram estimates detailed above, EPA used a variety of emission control databases. We used AirControlNet (ACN) to identify $PM_{2.5}$ precursor control measures for the point and area stationary source sector. The ACN tool also provided certain controls for EGUs (limited to pollutants and technologies that are not already considered as part of the CAIR rule). A summary of the control measures in the ACN tool are discussed below in Section 3.2. To identify mobile source control strategies we used a suite of mobile source sector models, including MOBILE6, NONROAD, NMIM and control strategy information from ongoing mobile source studies.

The additional information provided by the RSM has greatly improved our ability to find efficient and cost-effective control strategies. By applying controls that are cost-effective and efficient, we are targeting the pollutants and sectors that are likely to have the largest impact on PM concentrations at the lowest cost. Prior to having information from the RSM on the µg per ton that is anticipated from the more complex air quality models, strategies were developed based on available control technologies, costs, and expert judgment of the sources and pollutants in an area that could be required to control under a SIP development plan. Therefore, it is expected that the analytical approach employed for this RIA will produce control strategies that achieve the targeted reduction in PM at a far lower cost than in prior regulatory analyses of the

PM NAAQS. Furthermore, we expect local areas to employ a broader suite of cost-effective mobile source control measures than we were able to model with RSM, which should further contribute to these lower costs. It should also be noted that a complete evaluation of air quality changes given the selected control technologies is still necessary to account for more complex issues of meteorology, layers of air quality in the atmosphere with air chemistry, and terrain.

For the alternative 14 $\mu g/m^3$ annual and 35 $\mu g/m^3$ daily alternative standard, EPA also modeled a regional SO_2 program for the electric utility sector using the Integrated Planning Model (IPM). The models and data used and results of analyses conducted for the mobile sector and a regional EGU program are discussed further later in this chapter. EPA developed this augmented EGU approach to illustrate the impacts (costs and benefits) of additional EGU controls. If EPA were to study and investigate additional EGU emission reductions in a rulemaking under an alternative standard of 14/35, the Agency would need to go through the regulatory process and perform more complex technical analysis of the merits of additional EGU reductions beyond what is anticipated under CAIR.

Applying Selected Controls to Simulate Attainment

Once the full set of control technologies available for analysis was established along with the cost per µg associated with each pollutant/sector category, we employed a series of database queries to derive the final set of stationary source controls selected for analysis.

We selected stationary source controls from the database by following two steps: first, we selected the pollutant/sector combination with the lowest cost per µg, second, we selected controls with the lowest cost per ton until the targeted $PM_{2.5}$ reduction is achieved or until cost per ton exceeds benefits per ton within that pollutant and sector. If we did not achieve the targeted reduction within pollutant/sector combination chosen, we then selected emission controls from the pollutant/sector combination with the next lowest cost per µg. Finally, if we did not achieve the targeted reduction within the local MSA, we then ranked the cost per µg in counties surrounding the violating county and selected those controls with the lowest estimated cost per ton until the area attained the targeted reduction. If local known controls in the MSA and surrounding area are not enough to bring the area into attainment, then we considered developmental emission controls, which are discussed further in Section 3.3 below. Next, we considered the need for local mobile source programs in the analysis of attainment. To the extent that we did not simulate full attainment by using known and developmental controls, we made a final determination of attainment by weighting the empirical monitoring, modeling and emissions inventory data in an application of "supplemental" controls and "extrapolated" reductions. See Chapter 4 for further discussion of this process.

3.2 Quality Assurance of AirControlNET Control Measures

3.2.1 Description of AirControlNET and Overview of Quality Assurance Process

Before developing the cost per microgram estimates described above, we first revised the controls in the AirControlNET (ACN) tool. As discussed above, we used (ACN) as the source of our point and area source control data. AirControlNET is a desktop-based computer program that overlays a detailed control measures database on EPA emissions inventories to compute source-and pollutant-specific emissions reductions and associated costs at various geographic levels (EPA, 2006). Controls found in ACN are largely well-demonstrated add-on (or "known") control measures for which there is reliable documentation of their control efficiency and costs based on Alternative Control Techniques (ACTs), Control Technique Guidelines (CTGs), and other technical documents prepared by EPA and other entities. ACN contains an extensive set of control measures for achieving direct $PM_{2.5}$ and precursor emission reductions from point and area sources, and a small set of control measures for mobile (onroad and nonroad) sources. The current version of ACN has some control measures for ammonia and area source SO_2 emissions and has some additional area source PM controls as a result of updates made after the interim RIA was completed. These changes are discussed in more detail later in this section.

ACN contains a least-cost module that can generate a list of control measures in rank order of average annualized cost-effectiveness (average cost-per-ton reduction) for each pollutant. Controls applied for a specific pollutant may also result in changes in emissions of other pollutants. These changes are also estimated but are not part of the rank-ordering carried out in the least-cost module. This module was utilized extensively in producing analyses for some of the control strategies listed below.

Types of Stationary Source Controls in AirControlNET

Controls discussed here are taken from ACN and consist primarily of controls already in use (i.e., controls that some sources have already employed and demonstrated to be viable) that illustrate measures that could be chosen by States or local areas controls already in use, and are intended to be illustrative of measures that could be chosen by states or local areas today, with little uncertainty about availability and applicability of controls. Measures such as material substitution, source minimization, work practices, and fuel switching are considered to a lesser degree. Technologies emerging now, or to be developed in the future, may play a key role in attaining the new standards and are discussed below.

AirControlNET contains a variety of control measures available for primary $PM_{2.5}$ and organic and elemental carbon (OC and EC), $PM_{2.5}$ precursors (SO_2, NO_x, NH_3), and volatile organic compounds (VOC). For purposes of brevity, we do not include an exhaustive list of these controls. Readers interested in this detail should consult the AirControlNET control measures documentation report.

All annualized cost/ton estimates for each non-EGU point and area source control measures control measure are in average annualized cost/ton terms. If marginal cost/ton estimates were available for application of these measures, they would likely be higher than the average cost/ton estimates given that pollution control devices typically have costs that slope upwards in an increasing manner as available pollution reductions become fewer. Hence, a control strategy analysis may show fewer of these controls selected using marginal costs as a basis, all other things being equal.

3.2.2 Quality Assurance for Point Source Data in AirControlNET

The interim RIA included point and mobile source controls with very high average annualized cost per ton estimates (some with costs of more than $1 million/ton of emission reduction). Thus, it was difficult to conclude that the strategies we were analyzing for the interim RIA using AirControlNET were truly least-cost for the areas covered. As a result, we took several steps to augment emission control information .

First, we populated the baseline emission inventory used for the control strategy analysis with updated data on such control measures already on or planned for mobile sources. This allowed us to provide more accurate and reasonable estimates of costs for this final RIA. These updates to the inventory are described in more detail in Chapter 2 of this RIA.

Next, we reviewed the applicability of PM control measures to point sources within the ACN tool and made changes if appropriate. In many instances this led to our reducing the applicability of PM control measures to certain sources, including small emitting sources.

These aggregate changes can be summarized as follows:

- No controls to be placed on sources with 5 tons/year of PM emissions or fewer. This recommendation is based on a finding that most point sources with such PM emissions already have PM controls on them and further control is not cost-effective.

- No controls to be placed on direct PM point sources with 50 tons/year of direct PM emissions or fewer. This recommendation is based on a finding that most point sources with emissions of this level or fewer had PM controls already on them. This led to fewer applications of fabric filter controls**,** the major control that had the very high cost/ton estimates alluded to earlier in this section

- No fugitive dust controls or other PM_{10} controls to be applied except in a case where there is a critical need or where such sources are major contributors to $PM_{2.5}$ concentrations. We applied such controls only in California where the extent of nonattainment was so high that we applied every known control available. This recommendation is based on the fact that such controls provide minimal reduction in $PM_{2.5}$ based on CMAQ and other modeling results.

- No controls to be placed on SO_2 point sources with 50 tons/year of emissions or less. This recommendation is based on a finding that most point sources with emissions of this level or less had SO_2 controls already on them,

- Replace the cost equations for cement kiln SO_2 controls with cost/ton estimates for specific controls. This recommendation is based on a finding that these equations in AirControlNET may not be representative enough to continue using in control strategy analyses such as those for this RIA,

- Augment the NH_3 controls in AirControlNET with an ‘emerging’ but tested hog control technology. This addition to AirControlNET is categorized as a “developmental” control (discussed in section 3.3.2). Data on this technology was collected as part of the analyses conducted in support the agreement reached between North Carolina pork producers (Smithfield Foods, Premium Standard Farms, and Frontline Farmers) and the N.C. State's Attorney General. The objective was to identify alternative pork producing approaches to lagoon and sprayfield systems which could reduce the impact on multiple environmental mediums including NH_3 emissions. Similar data on dairy controls were analyzed in California's San Joaquin Valley, not related to the N.C. agreement, were also used to augment current AirControlNET controls.

Third, research identified control measures for pollutants and source categories for which no measures had been previously available (such as SO_2 emissions from area sources). As a result we added a new control measure for area source SO_2 emissions from home heating oil use based on data from NESCAUM study completed in December 2005 (NESCAUM, 2005). This measure is a switch from high-sulfur home heating oil (approximately 2,500 ppm sulfur content) to lower-sulfur home heating oil (500 ppm sulfur content). This measure will lead to an estimated 75% reduction in SO_2 emissions and a co-benefit of 80% reduction in direct PM emissions at an estimated average annualized cost of $2,350/ton of SO_2 emission reduction (1999$). As a result of our research, we also identified a control measure for reduction of PM emissions from commercial cooking facilities (mostly restaurants) in response to this review. This measure is essentially a small electrostatic precipitator that can be applied in some restaurants (particularly larger ones). It can yield up to 99% reduction in PM at an average annualized cost of $7,000/ton (1999$) (Sorrels, 2006).

Finally, we reviewed control measures in ACN to determine if they were consistent with control measures data collected by Regional Planning Organizations (RPOs), organizations such as STAPPA/ALAPCO, States such as California (reports prepared by the California Air Resources Board, or CARB) or local agencies such as the South Coast Air Quality Management District (SCAQMD). Our review of other control measure data sets concluded that there were very little data being used by these bodies that was not already in ACN or that data on control measures used by these bodies not found in ACN were not sufficient to be included in the software tool. In fact, LADCO lists AirControlNET 3.2, a previous version of the software tool, as a reference in a White Paper prepared in April 2005 (MACTEC Engineering and Consulting, Inc., 2005).

The results of this review are available in a memo prepared by EPA and can be found in the docket. The analyses done for non-EGU sources and included in this final RIA reflect the incorporation of the changes that were recommended.

3.3 Sources of Emission Control Estimates

3.3.1 Non-EGU Point and Area Source Controls

We used the AirControlNET (ACN) tool to generate estimates of control cost to non-EGU point and area sources. We supplemented the controls in ACN with additional information regarding PM and precursor controls whose cost and control efficiency is less well characterized in comparison to existing control measures in the database.

PM Emissions Control Technologies[4]

This section summarizes an array of measures available to control emissions of PM from EGU, non-EGU point, and area source categories. Most of the control measures available are add-on (or end of tailpipe) technologies, but some other technologies and techniques that are not add-on in nature can reduce PM emissions[5].

PM Control Measures for Utility and Non-EGU Point Sources. Most control measures on utility and non-EGU point sources are add-on technologies. These technologies include: fabric filters (baghouses), ESPs, and wet PM scrubbers. Fabric filters collect particles with sizes ranging from below 1 micrometer to several hundred micrometers in diameter at efficiencies in excess of 99%, and this device is used where high-efficiency particle collection is required. A fabric filter unit consists of one or more isolated compartments containing rows of fabric bags in the form of round, flat, or shaped tubes, or pleated cartridges. Particle-laden gas passes up (usually) along the surface of the bags than radially through the fabric. Particles are retained on the upstream face of the bags, and the cleaned gas stream is vented to the atmosphere. The filter is operated cyclically, alternating between relatively long periods of filtering and short periods of cleaning. Dust that accumulates on the bags is removed from the fabric surface when cleaning and deposited in a hopper for subsequent disposal.

ESPs use electrical forces to move particles out of a flowing gas stream and onto collector plates. The particles are given an electrical charge by forcing them to pass through a corona, a region in which gaseous ions flow. The electrical field that forces the charged particles to the walls comes from electrodes maintained at high voltage in the center of the flow lane. Once particles are on the collector plates, they must be removed without reentraining them into the gas stream. This is usually accomplished by knocking them loose from the plates, allowing the collected layer of particles to slide down into a hopper from which they are evacuated. This removal of collected particles is typical of a “dry” ESP. A “wet” ESP operates by having a water flow applied intermittently or continuously to wash the collected particles for disposal. The advantage of wet ESPs is that there are no problems with rapping reentrainment or with back coronas. The disadvantage is that the collected slurry must be handled more carefully than a dry product, adding to the expense of disposal. ESPs capture particles with sizes ranging from below 1 micrometer to several hundred micrometers in diameter at efficiencies from 95 to up to 99% and higher.

Wet PM scrubbers remove PM and acid gases from waste gas streams of stationary point sources. The pollutants are removed primarily through the impaction, diffusion, interception and/or absorption of the pollutant onto droplets of liquid. The liquid containing the pollutant is then collected for disposal. Collection efficiencies for wet scrubbers vary by scrubber type, and with the PM size distribution of the waste gas stream. In general, collection efficiency decreases

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[4] The descriptions of add-on technologies throughout this section are taken from the EPA Air Pollution Control Cost Manual, Sixth Edition. This is found on the Internet at http://epa.gov/ttn/catc/products.html#cccinfo.

[5] It should be noted that in addition to the controls discussed in this section, state and local authorities may also consider seasonal local controls to address high daily PM concentrations that are infrequent or seasonal in nature as part of State Implementation Plans to meet the standard. Seasonal controls are considered in this analysis only to the extent that the emissions and controls are seasonal in themselves (e.g. woodstove emissions and controls are applied for the Winter season). We are not able to assess other viable seasonal controls available to local authorities due to the difficulty of modeling such programs in a national-scale analysis.

as the PM size decreases. Collection efficiencies range from in excess of 99% for venturi scrubbers to 40%-60% for simple spray towers. Wet scrubbers are generally smaller and more compact than fabric filters or ESPs, and have lower capital cost and comparable operation and maintenance (O&M) costs. Wet scrubbers, however, operate with a higher pressure drop than either fabric filters or ESPs, thus leading to higher energy costs. In addition, they are limited to lower waste gas flow rates and operating temperatures than fabric filters or ESPs, and also generate sludge that requires additional treatment or disposal. This final RIA only applies wet scrubbers to fluid catalytic cracking units (FCCUs) at petroleum refineries.

Virtually all utility boiler and non-EGU point sources have some type of add-on PM control measure installed to capture $PM_{2.5}$ emissions. For example, as of 2004 84% of all coal-fired EGUs in the US have an ESP installed in the U.S.[6] Fourteen percent of coal-fired EGUs have a fabric filter installed on them, and the remaining units have some type of wet PM scrubber installed.

In addition, we also examined additional add-on control measures specifically for steel mills. Virtually all steel mills have some type of PM control measure, but there is additional equipment that could be installed to reduce emissions further. Capture hoods that route PM emissions from a blast furnace casthouse to a fabric filter can provide 80% to 90% additional emission reductions from a steel mill. Other capture and control systems at blast oxygen furnaces (BOFs) can also provide 80% to 90% additional reductions as well.

This final RIA also selects/uses/presents control measures that are upgrades to existing control measures or are improvements to how existing control measures operate due to increases in monitoring. Such controls can lead to small reductions in PM (5% to 7%). We also include control measures to upgrade ESPs by adding enough collector plates to be equivalent to one or two new fields to increase the collector area and hence increase the control efficiency of the device. Upgrading can lead to an additional 67% emissions reduction in addition to what the ESP provides already for PM reductions.

Finally, we also use/select coal washing as a way to reduce PM emissions from EGU operations. This measure can yield up to 35% reduction in PM. The following table summarizes these point source measures by the sector they apply to.

[6] Spreadsheet files that are input to the Integrated Planning Model (IPM) for analysis applied to a 2020 inventory. Files obtained from E. H. Pechan and Associates, May 2006.

Table 3-2: Example PM Control Measures for Utility Boilers and Non-EGU Point Sources Applied in Modeled Control Strategy Analyses[a]

Control Measure	*Sector(s) to which Control Measure Can Apply*	*Control Efficiency (percent)*	*Average Annualized Cost/Ton*
ESPs—wet or dry[b]	Industrial Boilers, Iron and Steel Mills, Pulp and Paper Mills	95 to 99.9	$1,000–$20,000
ESP Upgrades (Adding enough collector plates to be equivalent to one or two new fields)	Utility Boilers	44 to 67	$3,000–15,000
Fabric Filters[b]	Industrial Boilers, Iron and Steel Mills, Pulp and Paper Mills	98 to 99.9	$2,000–$100,000
Secondary Capture and Control Systems—Capture Hoods for Blast Oxygen Furnaces	Coke Ovens	80 to 90	$5,000
Coal Washing	Utility Boilers (coal-fired only)	35	$2,500–9,000
CEM Upgrade and Increased Monitoring Frequency	Sectors with Utility Boilers and Non-EGUs with an ESP	5 to 7	$600–$5,000

[a] This table presents a sample of PM control measures applied in our "modeled" assessment of attainment. In a limited number of areas, the modeling of control strategies results in areas that do not fully comply with the proposed standards, (i.e. areas of residual nonattainment). In areas of residual nonattainment, we conducted further analysis using supplemental controls and extrapolated reductions (discussed fully in Chapter 4).

[b] AirControlNET contains equations to estimate capital and annualized costs for ESP and FF installation and operation. The annualized cost/ton estimates presented here for these control measures are outputs from our modeling, not inputs. They also reflect applications of control where there is no PM control measure currently operating except if the control measure is an upgrade (e.g. ESP upgrades).

A full listing of PM control measures for utility and non-EGU point sources can be found in Appendix E.

PM Control Measures for Area Sources. Specific controls exist for stationary area sources (e.g., restaurants) and for emissions from agricultural operations (e.g., fugitive dust emissions). Area source PM controls at stationary sources include catalytic oxidizers on conveyorized charbroilers at restaurants that can reduce PM emissions by more than 80%, replacement of older woodstoves with those that are compliant with the New Source Performance Standard (NSPS) for residential wood combustion, which can lead to up to 98% reduction of PM,[7] education and advisory programs to help users to operate woodstoves more efficiently and with fewer emissions (up to 50% reduction in PM), and replacement of older woodstoves with new woodstoves when property is sold or changes hands (up to a 46% reduction in PM over time).

[7] This control measure is largely meant to simulate the effects of a woodstove changeout program as applied to Libby, MT per the efforts of the U.S. EPA and several co-sponsors. For more information, refer to http://www.epa.gov/woodstoves/how-to-guide.html.

Applying diesel particulate filters to existing diesel-fueled compression-ignition (C-I) engines can achieve up to a 90% reduction in fine PM. This measure is likely to be applied to new C-I engines as part of a NSPS that will be implemented beginning in 2006.

Area source PM controls at other area sources include controls or techniques that are primarily designed toward PM_{10} reductions such as dust control plans for construction sites, soil conservation plans for farm tilling, watering of beef cattle feedlots, the use of wood waste chipping for landfill disposal instead of open burning of wood waste. While these controls are geared towards reducing PM_{10}, they also yield reductions of $PM_{2.5}$ at the same or lower percentages compared to PM_{10}. Reductions in fine PM from these measures can range from 25 to up to 100 tons.

Table 3-3: Example PM Control Measures for Area Sources Applied in Modeled Partial Attainment Control Strategy Analyses[a, b]

Control Measures	*Sectors to which These Control Measures Can Apply*	*Control Efficiency (percent)*	*Average Annualized Cost/ton*
Catalytic oxidizers for conveyorized charbroilers	Restaurants	83	$1,300
Changeout of older woodstoves for new ones by a woodstove changeout campaign or on sale of property, or an education and advisory program for woodstove users	Residential wood combustion sources	46 to near 100	$1,900
Dust control plans[c]	Construction activities	63	N/A[d]
Soil conservation plans[c]	Agricultural tilling	12	N/A[d]
Watering[c]	Beef cattle feedlots	50	N/A[d]
Replace open burning of wood waste with chipping for landfill disposal	Residential waste sources	Near 100	$3,500

[a] This table presents a sample of PM control measures applied in our “modeled” assessment of attainment. In a limited number of areas, the modeling of control strategies results in areas that do not fully comply with the proposed standards, (i.e. areas of residual nonattainment). In areas of residual nonattainment, we conducted further analysis using supplemental controls and extrapolated reductions (discussed fully in Chapter 4).

[b] The estimates for these control measures reflect applications of control where there is no PM area source control measure currently operating.

[c] Given that the available evidence regarding adverse health effects associated with exposure to thoracic coarse particles is strongest with respect to urban and industrial ambient mixes of those particles, EPA encourages States to focus control programs on urban and industrial sources to the extent that those sources are contributing to air quality violations. The information here is provided for illustrative purposes only and should not be used to justify control requirements until additional information is available.

[d] These control technologies are primarily selected for control of PM10 emissions, but may also have some impact on PM2.5. In the analysis of the revised and alternative standards, the costs of controls for PM10 are attributable to a program presumed to be implemented by 2020 to meet the PM10 standards, and therefore, are not assigned a cost to the PM2.5 standards.

SO_2 Emissions Control Measures

This section describes available technologies for controlling emissions of SO_2 for industrial, commercial, and institutional (ICI) boilers[8] and other source categories. In general, Flue Gas Desulfurization (FGD) scrubbers are applied most commonly as the control technology for utility boilers and many non-EGU point and SO_2 sources because of their possible application to most any combustion source application. While all controls presented in this analysis are considered generally technically feasible for each class of sources, source-specific cases may exist where a control technology is in fact not technically feasible.

SO_2 Control Technology for Point Sources. FGD scrubbers can achieve 90% control of SO_2 for non-EGU point sources and 95 percent for utility boilers. This control is the predominant technology available in our database for most of the source categories covered by utility boilers and non-EGU point sources. Spray dryer absorbers (SDA) are another commonly selected technology, and they can achieve up to 90% control of SO_2. For specific source categories, other types of control technologies are available that are more specific to the sources controlled. The following table lists these technologies. For more information on these technologies, please refer to the AirControlNET 4.1 control measures documentation report.[9]

Table 3-4: Example SO_2 Control Measures for Non-EGU Point Sources Applied in Modeled Control Strategy Analyses[a]

Control Measure	*Sectors to which These Control Measures Can Be Applied*	*Control Efficiency (percent)*	*Average Annualized Cost/ton*
FGD scrubbers and SDA	ICI boilers—all fuel types, kraft pulp mills, Portland cement plants (all fuel types)	90—FGD scrubbers or SDA	\$800-\$8,000—FGD \$900 – 7,000—SDA
Increase percentage sulfur conversion to meet sulfuric acid NSPS (99.7% reduction)	Sulfur recovery plants	75 to 95	\$4,000
Sulfur recovery and/or tail gas treatment	Sulfuric Acid Plants	95	\$3,000 – 6,000
Vacuum carbonate + sulfur recovery plant	Coke ovens	82	\$5,000

Source: AirControlNET 4.1 control measures documentation report (May 2006). The estimates for these control measures reflect applications of control where there is no SO_2 control measure currently operating.

[a] This table presents a sample of PM control measures applied in our “modeled” assessment of attainment. In a limited number of areas, the modeling of control strategies results in areas that do not fully comply with the proposed standards, or areas of residual nonattainment. In areas of residual nonattainment, we conducted further analysis using supplemental controls and extrapolated reductions (discussed fully in Chapter 4).

[8] The terms “ICI boiler” and “industrial boiler” are used interchangeably in this RIA.
[9] For a complete description of AirControlNET control technologies see AirControlNET 4.1 control measures documentation report, prepared by E.H. Pechan and Associates. May 2006.

SO_2 Control Technology for Area Sources. Fuel switching from high to low-sulfur fuels is the predominant control measure available for SO_2 area sources. For home heating oil users, our analyses include switching from a high-sulfur oil (approximately 2,500 parts per million (ppm) sulfur content) to a low-sulfur oil (approximately 500 ppm sulfur). A similar control measure is available for oil-fired industrial boilers. More information on the industrial boiler fuel-switching measure is available later in this chapter. For more information on these measures, please refer to the AirControlNET 4.1 control measures documentation report.

NO_x Emissions Control Measures

This section describes available measures for controlling emissions of NO_x from non-EGU point sources. In general, low-NO_x burners (LNB) are often applied as a control technology for industrial boilers and many other non-EGU sources because of their possible application to almost any industrial boiler and other combustion source application. While all controls presented in this analysis are considered generally technically feasible for each class of sources, source-specific cases may exist where a control technology is in fact not technically feasible.

NO_x Control Measures for Non-EGU Point Sources. Several types of NO_x control technologies exist for non-EGU sources : SCR, selective noncatalytic reduction (SNCR), natural gas reburn (NGR), coal reburn, and low-NO_x burners. The two control measures chosen most often were LNB and SCR because of their breadth of application. In some cases, LNB accompanied by flue gas recirculation (FGR) is applicable, such as when fuel-borne NO_x emissions are expected to be of greater importance than thermal NO_x emissions. When circumstances suggest that combustion controls do not make sense as a control technology (e.g., sintering processes, coke oven batteries, sulfur recovery plants), SNCR or SCR may be an appropriate choice. Finally, SCR can be applied along with a combustion control such as LNB with overfire air (OFA) to further reduce NO_x emissions. All of these control measures are available for application on industrial boilers.

Besides industrial boilers, other non-EGU source categories covered in this final RIA include petroleum refineries, kraft pulp mills, cement kilns, stationary internal combustion engines, glass manufacturing, combustion turbines, and incinerators. NO_x control measures available for petroleum refineries, particularly process heaters at these plants, include LNB, SNCR, FGR, and SCR along with combinations of these technologies. NO_x control measures available for kraft pulp mills include those available to industrial boilers, namely LNB, SCR, SNCR, along with water injection (WI). NO_x control measures available for cement kilns include those available to industrial boilers, namely LNB, SCR, and SNCR. In addition, mid-kiln firing (MKF), ammonia-based SNCR, and biosolids injection can be used on cement kilns where appropriate. Non-selective catalytic reduction (NSCR) can be used on stationary internal combustion engines. OXY-Firing, a technique to modify combustion at glass manufacturing plants, can be used to reduce NO_x at such plants. LNB, SCR, and SCR + steam injection (SI) are available measures for combustion turbines. Finally, SNCR is an available control technology at incinerators. Table 3-4 lists the control measures available for these categories. For more information on these measures, please refer to the AirControlNET 4.1 control measures documentation report.

Table 3-5: Example NO_x Control Measures for Non-EGU Source Categories

Control Measures	*Sectors to Which These Control Measures Apply*	*Control Efficiency (percent)*	*Average Annualized Cost/ton*
LNB	Industrial boilers—all fuel types, Petroleum refineries, Cement manufacturing, Pulp and Paper mills	25 to 50%	$200 to $1,000
LNB + FGR	Petroleum refineries	55	$4,000
SNCR (urea-based or not)	Industrial boilers—all fuel types, Petroleum refineries, Cement manufacturing, pulp and paper mills, incinerators	45 to 75	$1,000 to $2,000
SCR	Industrial boilers—all fuel types, Petroleum refineries, Cement manufacturing, pulp and paper mills, Combustion turbines	80 to 90	$2,000 to 7,000
OXY-Firing	Glass manufacturing	85	$2,500 to 6,000
NSCR	Stationary internal combustion engines	90	500
MKF	Cement manufacturing—dry	25	–$460 to 720
Biosolids Injection	Cement manufacturing—dry	23	$300
SCR + SI	Industrial boilers—all fuel types	95	$2,700

Source: AirControlNET 4.1 control measures documentation report (May 2006). Note: a negative sign indicates a cost savings from application of a control measure. The estimates for these control measures reflect applications of control where there is no NOx control measure currently operating except for post-combustion controls such as SCR and SNCR. For these measures, the costs presume that a NOx combustion control (such as LNB) is already operating on the unit to which the SCR or SNCR is applied.

3.3.2 Developmental Emission Controls

During the planning and scoping stage of this analysis we determined that the number and effectiveness of emission controls in the AirControlNET database was likely insufficient to simulate attainment in all areas. For this reason, we investigated the existence of new and developing control measures that would complement those in the AirControlNET database; as previously noted, AirControlNET contains well-documented controls that have seen broad application and for this reason would not include more speculative and nascent control technologies. Due to the increased uncertainty of these developmental controls, we chose to apply them after first considering the AirControlNET control measures. Application of developmental controls is limited to only those areas in which we were not able to model attainment with local known controls on point and area sources, and local programs for mobile sources. Chapter 6 provides details of when developmental controls are applied and the cost of application.

The developmental controls generally fall into three categories. Developmental controls in this RIA are:

1. *Adaptations of existing controls to a new source*. In particular cases we used engineering judgment to transfer a well-characterized control from one source type to another.
2. *Modifications of existing controls to incorporate new information*. Certain controls such as wood stove change-outs in AirControlNET incorporate assumptions regarding the extent to which a nonattainment county will adopt that control. For some counties that we projected to be in significant nonattainment, we adjusted these assumptions so that the county will adopt the control at a much higher rate.
3. *Adoptions of state-level strategies*. States such as California have generated comprehensive analyses of sector-based emission reductions programs. In this RIA we have adapted the control measures and costs found in these strategies.

Table 3-5 below summarizes each control by providing the pollutant it controls, its control efficiency, total possible emission reductions, cost per ton, and information regarding its derivation.

Table 3-6: Developmental Emission Control Measures Applied in Modeled Attainment Strategies for the PM NAAQS RIA

Control Measure	*Primary Pollutant Controlled*	*Control Efficiency*	*Average Cost per Ton*	*Notes*
Adaptation of Existing Control Technology				
Fuel switching for industrial boilers	SO_2	80%	$2,300	This control transfers a home-heating oil fuel control to industrial boilers by substituting "red dye" distillate oil for high-sulfur fuel. Distillate has 500 ppm versus 2,500 to 3,000 ppm for high-sulfur diesel.
Emerging animal feeding operation control technologies (swine)	NH_3	70%	≤$10,000	This control is a solids separation-tangential flow separator combined with a fan separation system.
Emerging animal feeding operation control technologies (dairy)	NH_3	55%	≤$10,000	Efficiency and cost estimates derived from technologies assessed by San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel and those recommended to the San Joaquin Valley Air Pollution Control Officer by the Dairy Permitting Advisory Group.
Stationary Internal Combustion Engine Controls	$PM_{2.5}$	90%	$9,000	Applies diesel particulate filter retrofits to stationary internal combustion engines.
Modification and Improvement to Existing Control Technology				
Wood Stove Change-out	$PM_{2.5}$	Up to 100%	$2,000	Increasing the assumed adoption rate can take place by increasing the rate of housing stock turnover and assuming NSPS-compliant wood stoves are installed in place of older conventional wood stoves at the time of turnover.
Adoption of State Emission Reduction Strategies				
California Goods Movement Initiative	$PM_{2.5}$	80%	$50,000	Control efficiencies and costs derived from California analysis
Substitution of land-filling for open burning of land clearing debris	$PM_{2.5}$	50 to 100%	$3,500	Uses state-level emission reduction and control cost data

Below we provide additional information regarding each of these developmental controls.

Fuel Switching for Industrial Boilers

Overview: This control is an adaptation of the residential home heating oil fuel switching control currently in AirControlNET. The home heating oil control substitutes lower sulfur "red dye" distillate fuel for higher sulfur diesel fuel. Where red dye distillate has a sulfur content of approximately 500 ppm, higher sulfur diesel fuel has as sulfur content of between 2,500 and 3,000 ppm. This reduced sulfur content will reduce SO_2 emissions, which will in turn reduce the formation of $PM_{2.5}$.

Control Efficiency and Cost: We have adopted the AirControlNET control efficiency and cost for this control for two reasons: (1) we do not believe that the control efficiency will change when red dye distillate is burned at industrial boilers; (2) we do not anticipate that boilers would incur a cost for red dye distillate fuel that is different from the cost borne by users of residential home heating oil.[10] We estimate that the control efficiency for this control is 80% and that the average annualized cost is approximately $2,300 a ton of SO_2 abated.

Major Uncertainties: For this control we assume that the control efficiency and cost are identical to the AirControlNET residential fuel switching control. If industrial boilers are not capable of using this fuel, or if this source faces significantly higher costs for this fuel than residential users, then our estimates of emission control and cost will be too incorrect.

Emerging animal feeding operation control technologies (Swine)

Overview: The system is one the 'Environmentally Superior Technologies' that was tested and analyzed for North Carolina swine operations as part of the agreement between North Carolina State's Attorney General and Smithfield Foods as well as Premium Standard Farms and Frontline Farmers. The system treats waste from finishing barns. Manure flushed from the barns flows first to a collection pit, then to an above-ground feed tank, then to a separator on a raised platform. The liquid that flows through the separator screen flows to a second feed tank, then to two tangential flow gravity settling tanks sited parallel to each other. Tangential flow in the first tank causes solids to concentrate in the center of the tank and settle to the bottom. This settled slurry is then pumped to the second tank for sludge thickening. Once an hour the settled slurry from the second tangential flow settling tank is pumped back to the tank that feeds the separator, where the settled slurry is combined with the flushed manure that is being pumped to the separator. Effluent gravity runs to a stabilization and treatment pond which is the source of the recycled liquid used for flushing the barns.

Control Efficiency and Cost: Based on tests performed on a single site in North Carolina. The system demonstrated an NH_3 emission control efficiency of 71.8 percent from barns and water holding structures during cold months and 66 percent reduction efficiency during warm months from the same structures in North Carolina. These efficiencies average 68.9 percent for the year. According the Agreement report, the costs are

[10] U.S. Environmental Protection Agency. AirControlNET 4.1 Control Measure Documentation Report. Prepared by E. H. Pechan and Associates. May 2006.

estimated at $114.56 per 1000 lbs. steady state live weight at a 4,320 head finishing farm. EPA used this cost number to estimate costs on a farm and state level in order to then estimate the per source cost adjusted to 1999 dollars. It should be noted that, in order to minimize the manipulation of results from the reports provided as part of the Agreement between the North Carolina Attorney General, Smithfield Foods, et al., costs are as reported by the Agreement and, therefore, are at an eight percent discount rate (10 years) as opposed to the seven percent rate used for other control technologies.

Major Uncertainties: The control efficiency information is based on tests at a single North Carolina hog operation. Although the Agreement report did not provide any uncertainty analysis on its results, it stated that its test results were within a range of possible values and, therefore, could be higher or lower than reported. Furthermore, the values reported above are likely to vary by region, type of swine operation, and type of manure management system both within North Carolina and nationally. It is expected that the NAEMS will provide a more scientific assessment of emissions from animal operations and how those emissions differ according to various factors, including type and size of animal, type of housing and manure management systems, geography, time of day, and seasonality. Taking into account the limited control and cost information available for this technology, and the yet undertermined need for control of these emissions, the information here is provided for illustrative purposes and should not be used to determine control costs or justify control requirements until additional information is available.

The cost information is based on converting an existing lagoon and spray field system to a system based on the proposed technology. As a result, costs may be different for converting a deep pit system in the Midwest or other systems in different geographic areas. In addition, costs are presented per 1000 lbs. of steady state live weight on a 4,320 head finishing farm, which is not the standard size of all hog operations in the U.S. Therefore, EPA recognizes that costs could vary depending on the season, size of an operation, the system in place to raise hogs, the growing phase of the hogs in each operation, and the number of hogs per operation, as well as the geographic location of the operation.

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Emerging animal feeding operation control technologies (Dairy)

Overview: In 2006, the Dairy Permitting Advisory Group recommended a set of Best Available Control Technologies for Dairy operations in the San Joaquin Valley, CA (a PM2.5 nonattainment area) to the San Joaquin Valley Air Pollution Control Officer. These recommendations were presented in their final report released in January of the same year. In December of 2005, the San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel prepared a similar report assessing dairy technologies in the San Joaquin Valley, CA. The dairy technologies assessed for efficiency and cost for the PM NAAQS are based on information provided in these San Joaquin Valley documents and consist of solids separations/nutrient removal systems, a phototrophic lagoon processing system, a liquid manure injection and spreading system, and a man-made wetlands system for N removal..

Control Efficiency and Cost: The control efficiency is estimated at 55 percent and represents an average or expected value from six technologies in the aforementioned reports that contained both cost and efficiency data. Costs are averaged from the same six technologies and, similar to the hog control costs, are estimated on a farm ($64,428 per farm) and state level in order to then estimate the cost per source in 1999 dollars. In order to maintain a consistency with the hog technologies, these costs were annualized at an eight percent discount rate for ten years.

Major Uncertainties: Similar to the hog technologies, these emerging dairy manure control technologies are expected to vary in efficiency and cost by region, season, head count, and operation size. Furthermore, the values used for cost and emission reduction efficiency are not based on one specific control technology. Instead, these values are averages derived from a range of estimates of different systems with each system likely to have a degree of uncertainty with its numbers. It is likely that the level of uncertainty with the dairy controls' cost and efficiency numbers is greater than that of the hog controls. Taking into account the limited control and cost information available for this technology, and the yet undertermined need for control of these emissions, the information here is provided for illustrative purposes and should not be used to determine control costs or justify control requirements until additional information is available.

Stationary Internal Combustion Engine Controls

Overview: This control incorporates directly-emitted $PM_{2.5}$ reductions from stationary internal combustion engines that will be affected by the compression-ignition internal combustion engine new source performance standard (NSPS). The expected impacts from this NSPS are not accounted for in our future year emission inventories since this NSPS was not promulgated until June 28, 2006 (after proposal of the $PM_{2.5}$ standard). Because this rule was recently promulgated, control technology data such as control efficiency and costs were not part of the AirControlNET control measures database. Diesel particulate filters (DPF) are likely to be the control technology required for these engines to meet the NSPS requirements. The control is applied here as a retrofit to existing stationary internal combustion engines in our inventory.

Control Efficiency and Cost: We have taken the control efficiency and cost data from technical support documents prepared for the U.S. EPA as part of analyses undertaken for the final NSPS.[11] The control efficiency for $PM_{2.5}$ reductions from applying DPF is 90 percent at an average cost of $9,000/ton.

[11] U.S. Environmental Protection Agency. "Emission Reduction Associated with NSPS for Stationary CI ICE." Prepared by Alpha-Gamma, Inc. June 3, 2005, and U.S. Environmental Protection Agency. "Cost per Ton for NSPS for Stationary CI ICE." Prepared by Alpha-Gamma, Inc. June 9, 2005.

Major Uncertainties: The analysis assumes that all affected engines will be using ultra-low sulfur fuel (ULSD) in the analysis year of 2020. To the extent that these existing engines are not using ULSD, the level of control is likely to be lower than estimated in this RIA since DPFs will clog if the engine being controlled uses a higher-sulfur fuel than ULSD (15 ppm sulfur) and thus yield lower reductions of $PM_{2.5.}$

Wood Stove Change-out

Overview: The existing wood stove change-out control in AirControlNET assumes that 10% of residents in a non-attainment area will elect to replace their older wood-burning stoves with NSPS-compliant wood stoves. Planners in non-attainment areas that we project to be in severe non-attainment with the proposed daily standard may elect to require residents to install these stoves at a higher rate. For this reason, we modified the AirControlNET wood stove control to incorporate a higher rate of change-out and thus a higher control efficiency of directly-emitted $PM_{2.5}$. There are two variants to this developmental control. The first variant assumes that stoves must be replaced as the housing stock turns over; owners must replace their non-NSPS stoves with NSPS-compliant stoves when they sell their home. The second variant assumes that projected non-attainment areas would require all home owners to replace their non-NSPS stoves with NSPS-compliant stoves within a certain time frame. The chief difference between these two controls is in the implementation time frame; areas projected to be in severe non-attainment with the proposed daily standard are more likely to implement the more ambitious wood stove control.

Control Efficiency and Cost: The housing-stock turnover variant of this wood stove control derives its control efficiency by multiplying estimates of annual housing stock turn-over, which is about 4.7%, by the $PM_{2.5}$ control efficiency of a the control technology, which is 100%.[12] Thus, for a given county, PM2.5 emissions would be reduced by 4.7% per year, or about 47% over ten years and about 71% over 15 years. The cost per ton of $PM_{2.5}$ abated from this control measure would be approximately $2,000 a ton, which is the estimate found in AirControlNET.

The more ambitious wood stove change-out variant assumes that 100% of non-NSPS compliant wood stoves would be replaced with NSPS compliant wood stoves in a give year. For this reason, the control efficiency would be 100%. The estimated average cost per ton of $PM_{2.5}$ abated from this control measure would be approximately $2,000 a ton, which is the estimate found in AirControlNET.

Major Uncertainties: To the extent that residents in non-attainment areas do not adopt this control at the rate we assume, then our estimate of emission reduction will be too high.

California Goods Movement Emission Reduction Plan

[12] Reference: National Association of Realtors; U.S. Environmental Protection Agency. AirControlNET 4.1 Control Measure Documentation Report. Prepared by E. H. Pechan and Associates. May 2006.

Overview: California recently developed a strategy to reduce $PM_{2.5}$, SO_2 and NOx emissions from ships, harbor craft, cargo handling equipment, trucks and trains.[13] This strategy includes a comprehensive analysis of the emissions reductions and costs associated with this plan. To avoid double-counting emission reductions that may already be achieved by national mobile source rules (the recent non-road rule, the upcoming diesel locomotive rule, etc.), we elected to adopt the ship and harbor craft reductions only; these emission reductions were able to be "unbundled " from the national mobile source rules.

Control Efficiency and Cost: In its report California provides a list of control measures for ships and harbor craft, the annual emission reductions associated with these controls, as well as a gross estimate of the annualized cost of these controls at 5-year intervals. To develop a control efficiency for these controls, we simply divided the reduction in precursor emissions by the total emissions. We then multiplied this efficiency by the appropriate source category classification code in the EPA emissions inventory to derive a total emission reduction. It was not possible to simply use the total emission reduction from the California report because of differences in the way in which California and US EPA classify port emissions. To estimate control cost, we divided the total annualized cost by the total emission reductions and multiplied this average cost per-ton estimate by the controllable emissions in the National Emissions Inventory (NEI).

Major Uncertainties: The principal source of uncertainty with this control is the process by which we estimated emission reductions in the US EPA emissions inventory. The California report apportions emission reductions at a finer resolution than the NEI. Where California applied controls to ships and harbor craft, the NEI lists a single source category classification for all mobile source marine vessel diesel emissions.

Substitution of Chipping and Shredding and Land-Filling for Open Burning

Overview: Several states have enacted ordinances that require residents to either landfill or chip and shred yard waste instead of burning it. This substitution can substantially reduce directly-emitted $PM_{2.5}$.

Control Efficiency and Cost: Efficiency is near 100% because burning would not occur. Emissions and emissions factors based on Documentation for the Draft 2002 Nonpoint Source National Emissions Inventory for Criteria and Hazardous Air Pollutants (March 2005 Version) , pp A-105 and A-106. Landfill tipping fees estimate as $30/ton (1999 dollars) based upon national average in National Sold Waste Management Associations 2005 Tipping Fee Survey. Overall estimate of emissions of 0.68 tons per acre and cost of $2400 per acre results in estimate of about $3,500/ton.

Major Uncertainties: Landfill costs based upon limited cost information. Average landfill costs, and average debris/acre, may not well represent costs in some locations. Significant uncertainties exist in emissions factors for open burning.

[13] The analysis can be found at: http://www.arb.ca.gov/planning/gmerp/march21plan/march22_plan.pdf.

3.3.3 Mobile Source Control Information

To estimate emission reductions that could be obtained for mobile sources as part of our illustrative attainment strategies, we identified a set of viable onroad and nonroad mobile source control options and compiled emission reduction and cost information for each. Mobile source control options included in the RIA can be broken into two categories, with important differences between them. The first category includes federal rules that are likely to be developed and implemented in a timeframe such that emission reduction impacts would be relevant to this RIA. These "national rules" are in various stages of conceptual or regulatory development, and EPA has not conducted full-scale analyses on these rules' cumulative costs or emissions impacts. Ideally, such calculations would be included in the baseline values used in an analysis. Given the timeline of this RIA and the rules in question, however, and assuming these rules are likely to be in effect during the years of analysis, it makes sense to include *approximations* of their effects as part of our illustrative control strategies. These estimates are based on highly preliminary analyses and should not be construed as the product of in-depth analysis on the rules.

The federal rules incorporated into this analysis were applied nationally, regardless of an area's attainment status. The rules analyzed affect the following sources:

- Diesel Locomotives
- Diesel Marine Vessels
- Ocean Going Vessels
- Ocean Going Vessels (residual fuel)
- Small Nonroad Gasoline Engines

The recent proposal to reduce mobile source air toxics (71 FR 15804, March 29, 2006) discusses data showing that direct PM2.5 emissions from gasoline vehicles are elevated at cold temperatures. The proposed vehicle hydrocarbon standards contained in the March 29, 2006 action would reduce these elevated PM emissions. This RIA does not include the effects of this proposed rule because we do not currently have the data to model the impacts of elevated cold-temperature PM emissions across the entire in-use fleet. As a result, these emissions are not included in our baseline emission inventories. We are currently analyzing the data from a large collaborative test program with industry, and our next emissions model (MOVES) will include cold temperature effects for PM.

Because these mobile source national rules were applied across the country as part of the analysis of meeting the current standard of 15/65, they were not applied as an incremental control for the analysis of meeting the revised and alternative standards. Therefore, the cost for implementation of these national mobile source rules is discussed in Appendix A with the discussion of costs for the current standard.

The second set of strategies are referred to as "local measures," and are those control strategies that are likely to be employed at the state or local level to achieve emissions reductions. Many of these programs are already in place in various areas around the country. It should be emphasized that this list is in no way an exhaustive catalog of steps that state and local authorities can take to reduce mobile source emissions. Instead, it represents a smaller sample of measures that we find to be cost-effective and analytically quantifiable for purposes of this RIA. State and local governments may very well identify and implement numerous other local mobile measures that also serve to cost-effectively reduce emissions of direct PM or its precursors. Due to analytical and time constraints, local mobile measures were utilized only in certain areas once other measures had been exhausted. The local measures employed in this analysis as follows:

- Diesel Retrofits and Retirement
- Reduction of Idling Emissions
- Intermodal Transfer
- Best Workplaces for Commuters (BWC)

It should be emphasized that, with regard to lowering direct PM and precursor emissions reductions from the mobile sector, many of the most significant and cost-effective reductions will come from EPA national mobile source rules that have already been developed and are currently being implemented. As noted in Chapter 2, these rules, which include the Clean Air Nonroad Diesel Rule, the Light-Duty Vehicle Tier 2 Rule, and the Heavy Duty Diesel Rule, will produce substantial reductions in directly emitted $PM_{2.5}$, SO_2, and NO_x at the following levels:

Table 3-7. National Emission Reductions in Base Case Emission Projections (thousands of tons per year)

Rule	*Year*	*NOx*	*PM2.5*
Clean Air Nonroad Diesel Rule	2015	195	53
	2020	445	86
Light Duty Vehicle Tier 2 Rule	2015	1,800	28
	2020	2,200	31
Heavy Duty Diesel Rule	2015	1,300	61
	2020	1,800	82

These rules are included in the base case emissions projections for this analysis, and will significantly reduce the target reductions many states will set during implementation of the revised $PM_{2.5}$ NAAQS.

In the remainder of this section, we first provide information on the national rules, and second on the chosen local measures. Note that where "PM" is indicated, the term encompasses PM_{10} and $PM_{2.5}$ emissions. For all percent reductions in the tables below, the values refer to reductions from the projected base case in the noted year (i.e., 2015 or 2020).

National Rules

Diesel Locomotives

EPA is developing a proposal for more stringent locomotive engine emission standards that are modeled after the Clean Air Nonroad Diesel Engines Program, likely to be issued in early 2007. Such standards would require the use of advanced emission-control technologies similar to those already upcoming for heavy-duty diesel trucks and buses. Based on such a standard for diesel locomotives, we used the following emission reductions for the years included in this analysis:

Table 3-8: National Emission Reduction Estimates for Diesel Locomotives

National Emission Reduction Estimates for Diesel Locomotives in 2020

	2015	*2020*
PM	35%	60%
NO_x	5%	10%

These estimates are based on control of both new locomotives and in-use locomotives at the time of rebuild:

- New locomotives, 90% control efficiency in PM and NOx beginning in 2012
- Tier 2 locomotives: 90% control efficiency in PM at rebuild beginning in 2012
- Tier 0 and Tier 1 locomotives: 50% reduction in PM beginning in 2010

Diesel Marine Vessels, Category 1 and 2

Similar to diesel locomotives, EPA is developing a proposal for more stringent emission standards for all new commercial, recreational, and auxiliary marine diesel engines except the very large engines used for propulsion on deep-sea vessels, likely to be issued in early 2007. These standards, which are modeled after the Clean Air Nonroad Diesel engines program, would require the use of advanced emission-control technologies. For Diesel Marine Engines, Category 1 and 2, we estimated a 90 percent reduction in NOx and PM from all new engines, beginning in 2012.

Table 3-9: National Emission Reduction Estimates for Diesel Marine Engines

National Emission Reduction Estimates for New Diesel Category 1 and 2 Marine Engines

	2015	*2020*
PM	16%	44%
NO_x	11%	35%

Ocean Going Vessels

Current negotiations at the International Maritime Organization offer the potential for additional reductions in PM and NOx from what are sometimes called category 3 marine engines. Category 3 marine diesel engines are very large engines (≥30 liters displacement per cylinder) used for propulsion power on ocean-going vessels. Because of the uncertainty as to the outcome of this program, we considered two possible scenarios: one scenario where new engine NOx and PM are reduced by 50%, and one scenario where they are both reduced by 90%. We estimated both of these scenarios could begin in 2012. Because of the very long turn-over rates for these products, the reductions take a long time to impact the fleet. The numbers in the tables below are reductions in the entire fleet of vessels.

Table 3-10: National Emission Reduction Estimates for Ocean Going Vessels

90% Reduction in New Engine PM and NO_x			*50% Reduction in New Engine PM and NO_x*		
	2015	*2020*		*2015*	*2020*
PM	10%	30%	PM	5%	15%
NO_x	10%	3%	NO_x	5%	15%

Residual Fuel in Ocean Going Vessels

EPA is an active participant in the International Maritime Organization (IMO), and has analyzed one IMO treaty annex which allows signatories to the treaty to declare a "Sulphur Emission Control Area" (SECA). The sulfur cap for a SECA is 15,000 ppm sulfur fuel (or an equivalent reduction in the engine's SOx emissions using a scrubber). Although the U.S. has not ratified this particular treaty, we think it is reasonable to project that we may be in a position of having a SECA in place for all of the U.S. coasts by 2015; this is the basis for the 2015 SOx emission reduction identified in the table below. At least one state has encouraged further development of SECAs as part of its efforts to address nonattainment concerns. IMO is also starting another round of discussions of future standards for ocean-going vessels. We believe it is possible a lower sulfur cap may result from that discussion, allowing for lower SECAs to be enforced. That is the basis for the 2020 SOx emission reduction in the table below.

Table 3-11: National Emission Reduction Estimates for Residual Fuel in Ocean Going Vessels

Emission Reductions from Ocean-going Marine Vessels fueled with Residual Fuel		
	2015	*2020*
SO_x	45%	95%

Small Nonroad Gasoline Engines

EPA is developing a proposal to reduce emissions from certain small nonroad gasoline engines, likely to be issued by the end of 2006. This rule will include reductions from three categories of equipment:

- Small Spark-Ignition Non-handheld Category I
- Small Spark-Ignition Non-handheld Category II
- Gasoline Recreational Marine

Non-handheld spark-ignition equipment includes lawnmowers, generator sets, and riding mowers. Handheld spark-ignition equipment includes trimmers, edgers, brush cutters, leaf blowers, leaf vacuums, chain saws, augers, and tillers. Small engines, those below 225 cc of displacement, are called "Category I." Larger engines, those with displacement greater than or equal to 225 cc, are called "Category II." Gasoline recreational marine engines include outboard motors, personal watercraft, and sterndrive and inboard engines.

Below are the values we applied for reductions from control of these small nonroad gasoline engines.

Table 3-12: National Emission Reduction Estimates for Small Nonroad Gasoline Engines

Emission Reductions for Small Nonroad Gasoline Engines

	Year: 2015			*Year: 2020*		
Category	*VOC*	*NO_x*	*PM*	*VOC*	*NO_x*	*PM*
Small Gasoline, Nonhandheld Class I	45%	25%		50%	25%	
Small Gasoline, Nonhandheld Class II	30%	35%		40%	40%	
Gasoline Recreational Marine						
– Outboard Marine Engines	20%	10%	25%	45%	15%	50%
– Personal Watercraft Engines	40%	–10%	50%	65%	–20%	80%
– Sterndrive/Inboard Marine Engines	10%	30%		25%	45%	

<u>Local Measures</u>

Diesel Retrofits and Vehicle Replacement

Retrofitting heavy-duty diesel vehicles and equipment manufactured before stricter standards are in place – in 2007 for highway engines and in 2008 for most nonroad equipment – can provide PM, NO_x, HC, and CO benefits. The term "retrofit" can mean any number of modifications or technological add-ons; the specific retrofit strategies included in the RIA retrofit measure are:

- Installation of emissions after-treatment devices:
  - diesel oxidation catalysts ("DOCs")
  - diesel particulate filters ("DPFs")
- Rebuilding nonroad engines ("rebuild")
- Early replacement and retirement of onroad vehicles ("replacement")

More in-depth information on retrofit technologies can be found at http://www.epa.gov/otaq/retrofit/retrofittech.htm.

We chose to focus on these strategies due to their potential for both substantial emissions reductions and for widespread application. Emissions reductions through retrofits vary significantly by strategy and by the type and age of the engine and its application. For this analysis, we first isolated the target vehicles: all heavy-duty engines (except for 5% of the nonroad fleet) that do not meet EPA's more stringent standards and are still expected to be operating in 2015 and 2020. Then we set two "cut-points:" we analyzed the emission reduction potential of retrofitting the first 50% of targeted vehicles (used only in the 15/65 control scenario), and then 100% of targeted vehicles (used in both the 15/35 and 14/35 scenarios). We expect that most areas will target less than 100% of their diesel engines for implementation of retrofit controls.

To estimate the potential emissions reductions from this measure, we applied a mix of four retrofit strategies (DOCs, DPFs, rebuild, replacement) for the 2015 and 2020 inventories of:

- Heavy-duty highway trucks class 5 & above and all buses, Model Year 1990-2006
- All nonroad engines, Model Year 1988-2007, except for locomotive, marine, pleasure craft, & aircraft engines

Eliminating Long Duration Truck Idling

Emissions from virtually all long duration truck idling that lasts for longer than 15 minutes – from heavy-duty diesel class 8a and 8b trucks, can be eliminated with two strategies:

- Truck stop & terminal electrification (TSE)
- Mobile idle reduction technologies (MIRTs) such as auxiliary power units, generator sets, and direct-fired heaters

A number of State and local governments have already taken steps to reduce emissions from idling, and we expect this trend to continue. A discussion of alternatives to long-duration idling can be found at EPA's website for the SmartWay Transport partnership, at http://www.epa.gov/smartway/idlingalternatives.htm. For the two measures listed above, our analysis limited the emission reductions to a 3.4 percent decrease in all pollutants to be consistent with the existing MOBILE 6.2 inventory assumptions.

Intermodal Transport

Intermodal transport refers to the transportation of goods through a combination of local truck and long-distance rail transport. Intermodal transport usually involves moving a container by truck (called drayage) to a rail facility where the container is moved from the truck to a rail car. The container is transported by rail for the majority of the trip, and then is usually transferred to another truck for final delivery. Intermodal transport is almost always a more fuel-efficient and less polluting way to transport goods on a ton-per-mile basis compared to truck-only transport. For the purposes of this RIA, we employ a 1% shift from truck-only transport to intermodal transport in 2015 and 2020.

For 2015, we estimated emissions reductions from this measure as follows:

- 1% decrease in all pollutants from all relevant highway truck SCC codes
- 0.4% corresponding increase in all pollutants from all locomotive and rail equipment SCC codes

For 2020, we estimated emissions reductions as follows:

- 1% decrease in all pollutants from all highway truck SCC codes
- 0.3% corresponding increase in all pollutants from all locomotive and rail equipment SCC codes

Best Workplaces for Commuters

Best Workplaces for Commuters (BWC) is an EPA program that recognizes and supports employers who provide incentives to employees to reduce light-duty vehicle emissions. Employers implement a wide range of incentives to affect change in employee commuting habits including transit subsidies, bike-friendly facilities, telecommuting policies, and preferred parking for vanpools and carpools. The BWC measure in this RIA reflects a mixed package of incentives, and reduces multiple pollutants (NO_x, VOC, SO_2, NH_3, PM 10, and PM 2.5).

We calculated that when employed, BWC would reduce light-duty gasoline emissions by 0.4% and 1% with a 10% and 25% program penetration rate, respectively. The lower program penetration level was used only in the 15/65 control scenario, while the higher level was used in both the 15/35 and 14/35 scenarios.

3.3.4 Electrical Generating Unit Emission Control Technologies

The Integrated Planning Model v2.1.9 (IPM) includes SO_2, NO_x, and mercury (Hg) emission control technology options for meeting existing and future federal, regional, and state, SO_2, NO_x and Hg emission limits. Table 3-12 summarizes the emission control technologies available in IPM.

Table 3-13. Summary of Emission Control Technology Retrofit Options Available in IPM

SO_2 Control Technology Options	*NO_x Control Technology Options*
Limestone Forced Oxidation (LSFO) Scrubber	Selective Catalytic Reduction (SCR) System
Magnesium Enhanced Lime (MEL) Scrubber	Selective Non-Catalytic Reduction (SNCR) System
Lime Spray Dryer (LSD) Scrubber	Combustion Controls

It is important to note that besides the emission control options listed in Table 3-11, IPM offers other compliance options for meeting emission limits. These include fuel switching, repowering, and adjustments in the dispatching of electric generating units.

Sulfur Dioxide Control Technologies
IPM includes three commercially available wet and semi-dry Flue Gas Desulfurization (FGD) technology options for removing SO2 produced by coal-fired power plants. The three types of FGD options or scrubbers - Limestone Forced Oxidation (LSFO), Magnesium Enhanced Lime (MEL), and Lime Spray Dryer (LSD) - are available to "unscrubbed" existing units, potential units, and "scrubbed" units with reported removal efficiencies of less than fifty percent.

Existing unscrubbed units that are selected to be retrofit by the model with scrubbers achieve removal efficiencies ranging from 90% to 96%, depending on the type of scrubber used. Detailed cost and performance derivations for each scrubber type are discussed in detail in the EPA's documentation of IPM (http://www.epa.gov/airmarkets/epa-ipm).

Nitrogen Oxides Control Technology
IPM includes two categories of NOx reduction technologies: combustion and post-combustion controls. Combustion controls reduce NOx emissions during the combustion process by regulating flame characteristics such as temperature and fuel-air mixing. Post-combustion controls operate downstream of the combustion process and remove NOx emissions from the flue gas. All the specific combustion and post-combustion technologies included in IPM are commercially available and currently in use in numerous power plants.

NOx Combustion Controls
Cost and performance of combustion controls are tailored to the boiler type, coal type, and combustion controls already in place and allow appropriate additional combustion controls to be exogenously applied to generating units based on the NOx emission limits they face. IPM includes two post-combustion retrofit control technologies for existing coal and oil/gas steam units: Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction (SNCR).

NOx Post-combustion Controls
IPM includes two post-combustion retrofit control technologies for existing coal and oil/gas steam units: Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction (SNCR). the performance assumptions for each NOx control technology.

Existing coal-fired units that are retrofit with SCR have a NOx removal efficiency of 90%, with a minimum controlled NOx emission rate of 0.06 lb/mmBtu in EPA Base Case 2004. Potential (new) coal-fired, combined cycle, and IGCC units are modeled to be constructed with SCR systems and designed to have emission rates ranging between 0.02 and 0.06 lb NOx/mmBtu.

Detailed cost and performance derivations for NOx controls are discussed in detail in the EPA's documentation of IPM (http://www.epa.gov/airmarkets/epa-ipm).

Direct $PM_{2.5}$ Controls Applied to EGUs

For certain EGUs it is possible to upgrade the existing $PM_{2.5}$ controls to increase their capture efficiency. EGUs generally employ three different $PM_{2.5}$ control devices. The first is an electrostaic precipitator (ESP), which is the predominant PM control technology available at

EGUs. Second is the fabric filter and third is the wet $PM_{2.5}$ scrubber.[14,15] EPA's National Electric Energy System Database (NEEDS) indicates that as of 2004, 84% of all coal-fired EGUs have an ESP in operation, about 14% of EGUs have a fabric filter and roughly 2% have wet $PM_{2.5}$ scrubbers.[16] Upgrading an existing ESP appears to be cost effective because it increases control efficiency at a potentially small expense. Given the large proportion of EGUs that currently use an ESP, EPA believed it would be possible to control EGUs contributing to downwind nonattainment in projected nonattainment areas.

The most common way to upgrade an ESP is to increase the specific collector area (SCA), which is an important variable in characterizing ESP performance. One of the most common routes by which to increase SCA is to simply increase the collector plate area by adding additional collector plates. The ESP modifications considered as control measures in this RIA include adding enough collection plate area to be equivalent to one or two new fields. The $PM_{2.5}$ reductions from adding 1 plate are about 44%, and about 67% from adding 2 plates. These levels will vary depending on how much SCA resides in each field. If an ESP designer has installed a large number of fields, with a relatively low amount of surface area in each field, the additional $PM_{2.5}$ reductions obtained by adding additional fields would be relatively low.

Another method for adding more surface area to an ESP is to change the existing plates to taller plates. This method will be effective if the resulting aspect ratio remains at a reasonable level. The additional fields can also be added by building a new box either on top of the existing ESP (closer to the outlet), on side of, or behind the chimney. Much depends on the existing layout constraints and how these constraints affects the ease of the retrofit.

A final ESP modification is the Indigo Agglomerator. This technology can be installed in the high velocity ductwork leading to the ESP. It uses both electrostatic and fluidic methods to pretreat all of the dust particles entering the ESP, agglomerating small and large particles together. This creates larger and more easily collected particles and reduces the number of small particles for the ESP to collect. The electrostatic method charges the dust half positively and half negatively in the treatment zone and then mixes them in a specially designed mixing field. The fluidic agglomeration method uses a highly specialized mixing regime to increase the interaction, and therefore impact rate, between large and small particles, thus agglomerating them.[17] The agglomerator therefore increases the overall $PM_{2.5}$ control efficiency of the ESP. There are now three commercial installations of the Indigo Agglomerator and one pilot scale installation in the U.S., and a prototype agglomerator in Australia. Test runs show a $PM_{2.5}$ control efficiency of 40%. Cost equations derived for installation and operation of the Agglomerator can be found in Section 6.1. We did not utilize the Agglomerator technology in our control strategies for this RIA since the 2 additional collector plate control measure was more cost-effective. There are other methods by which ESP collection efficiency can be improved – flue gas conditioning, adding a second "polishing" baghouse, and adding filter bags to the last field of an ESP – but we do not have cost or control efficiency data for these methods available for these control strategy analyses.

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[14] A wet $PM_{2.5}$ scrubber is a control device that removes PM along with acid gases from waste gas steams from point sources.
[15] U.S. Environmental Protection Agency. 2004 NEEDS database.
[16] U.S. Environmental Protection Agency. 2004 NEEDS database.
[17] Overview of Indigo Agglomerator technology found at http://www.indigotechnologies.com.au/agg_overview.php.

SO$_2$ and NO$_x$ Controls Applied to EGUs

Certain EGUs in, or near, Western State nonattainment areas did not use NO$_x$ or SO$_2$ controls, indicating a possible opportunity to reduce NO$_x$ emissions from these EGUs in a cost-effective manner. These EGU controls include SCR and LNB for NO$_x$ control, and repowering for SO$_2$ control, for which we considered year-round operation. The cost and control efficiency data in AirControlNET for these controls is identical to that found in the Integrated Planning Model (IPM), but EPA adjusted the applicability of these controls to ensure consistency with IPM. EPA made two adjustments in the control applicability: (1) apply controls only to EGUs with unit capacity of 25 MW or greater; (2) remove repowering as a control option.

Having applied these constraints, we found opportunities to apply LNB to two EGUs in California and SCR to ten EGUs in Utah and three EGUs in Washington. Each of these units are coal-fired, and we considered these controls to apply incrementally to a 2020 emissions inventory that incorporates EGU controls reflecting Best Available Retrofit Technology (BART) as mentioned in Chapter 2 of this RIA. We did not apply any SO$_2$ controls outside the CAIR region using AirControlNET because we did not identify any EGUs for which repowering would be a cost-effective control. For more information on these control measures, please refer to the AirControlNET 4.1 control measures documentation report.

Within the CAIR region, except in the 14/35 case, EPA did not consider controls for EGU SO$_2$ and NO$_x$ emissions beyond those already in the baseline– existing rules on the books and the Clean Air Interstate Rule cap-and-trade system. In the 14/35 case, EPA simulated an approach for EGUs that adjusts the CAIR emission caps to require additional SO$_2$ controls (see discussion below for further details).

3.3.5 Summary of Emission Controls for Each Standard Alternative

The section below summarizes the control measures we applied to simulate attainment, and partial attainment, with the revised and alternative more stringent standards. EPA selected these control strategies on the basis of cost-effectiveness, using the techniques described above. We analyzed the more stringent alternative standards incrementally to the current standard of 15/65.

15/35 Proposed Revised Standards

To simulate attainment with the tighter daily standard of 35 $\mu g/m_3$ by 2020, additional controls are applied incrementally to the controls required to attain the current standard by 2015. In the eastern part of the country we apply additional controls to all available pollutant sector combinations in Pittsburgh, Cleveland, and Detroit except those that the RSM estimates to have a negative impact upon PM$_{2.5}$ air quality. An example of this negative impact is the application of NO$_x$ control technologies in the Pittsburgh area.

Table 3-14 provides a summary of the hierarchy of control strategies employed in each metropolitan statistical area (MSA) analyzed based on the approach described in detail in section 3.1.

Table 3-14: Applications of the Control Strategy Hierarchy by Area for the 15/35 Standard

Location[a]	No Additional Controls Required After Compling with 15/65 Standard[b]	MODELED PARTIAL ATTAINMENT[c]		ANALYSIS OF RESIDUAL NONATTAINMENT	
		Local Known Controls	Developmental	Supplemental	Extrapolated
EAST					
Atlanta	✓				
Birmingham	✓				
Chicago	✓				
Cincinnati	✓				
Cleveland		✓		✓	
Detroit		✓	✓	✓	
Gary, IN	✓				
Pittsburgh		✓	✓		
Portsmouth, OH	✓				
St. Louis	✓				
WEST					
Eugene, OR		✓	✓		
Klamath Falls, OR		✓	✓		
Medford, OR		✓	✓		
Lincoln County, MT		✓	✓		
Missoula, MT		✓	✓		
Shoshone County, ID		✓	✓		
Logan, UT		✓	✓		
Salt Lake City, UT		✓	✓		✓
Seattle, WA		✓	✓		
Tacoma, WA		✓	✓		
CALIFORNIA[d]					
South Coast District			✓		✓
San Joaquin Valley			✓		✓
Other Affected Counties		✓	✓		✓

a For each location, controls are selected in the counties identified in the Metropolitan Statistical Area (MSA) first and then in counties surrounding the MSA if necessary to demonstrate attainment.

b Areas in th East comply with the revised daily standard of 35 ug/m3 after complying with the 15/65 standard. Areas in the West are new nonattainment areas identified for analysis of 15/35, and which already comply with 15/65.

c In a limited number of areas, the modeling of control strategies results in areas that do not fully comply with the proposed standards, (i.e. areas of residual nonattainment). In areas of residual nonattainment, we conducted further analysis using supplemental controls and extrapolated reductions (discussed fully in Chapter 4).

d In California, all available known local controls are applied when modeling compliance with the current standard of 15/65, which impacts counties in the South Coast Air Quality District and the San Joaquin Valley. For the analysis of control strategies to comply with the revised standards of 15/35, several new counties are indicated as exceeding the revised daily standard of 35 ug/m3 (but comply with the annual standard). These counties are located north of the San Joaquin Valley and therefore, we employ available local known controls to this area.

Table 3-15 summarizes the reductions we modeled by sector, pollutant and region. The majority of controls we applied in the East apply to non-EGU SO_2 point sources, followed by SO_2 area sources. We found that applying direct $PM_{2.5}$ is the most effective and efficient method of reducing PM concentrations locally. We applied several available controls to analyze compliance with the current standard of 15/65 (see Appendix A), We applied remaining available direct PM2.5 controls in the analysis of the revised standards. Next, the SO_2 reductions were the second most cost-effective way to achieve the proposed revised daily standard. Examples of control technologies applied to sources emitting SO_2 are flue gas desulfurization (FGD), fuel switching, and dual absorption. Finally, we also applied developmental ammonia controls on agricultural sources to a limited extent and only in areas that could not attain with other control technologies. The developmental control for dairy operations was applied in one county in California, and developmental control for swine operations was applied in Pittsburgh county only.

In the western part of the country our modeling indicates that several new areas outside of California will violate the proposed revised standard, including Salt Lake City,Utah; Seattle, Washington; Eugene, Oregon; and Libby, Montana. In Salt Lake City we applied NO_x controls to EGUs. These reductions were achieved through the application of SCR. We achieved NO_x reductions in the Seattle area primarily through control measures applied to non-EGU point sources and area sources. Examples of controls measures we applied to these categories include: low NO_x burners combined with SCR, RACT to 25 tpy, and water heater + LNB space heaters. The next largest categories of control were sources of direct $PM_{2.5}$, in Oregon direct $PM_{2.5}$ reductions from area sources were the greatest.

In California, we projected additional counties to violate the proposed revised daily standard that did not violate the 1997 standards. Of the additional control technologies applied the largest percent of the reductions are achieved through direct $PM_{2.5}$ area source controls. A small percentage of reductions are from SO_2 area controls, with the remainder being made up of $PM_{2.5}$ point sources and NH_3 area sources, outside of the San Joaquin valley.

Table 3-15: Incremental Emission Reductions by Region Applied in the Modeled Analysis of the Revised Standards of 15/35

Region	*Pollutant*	*Sector*	*Percent of Reduction*	*Tons*[a]
East	NH_3	Area	<1%	197
	$PM_{2.5}$	Area	11%	5,336
		EGU	18%	8,330
		non-EGU	4%	1,844
	SO_2	Area	17%	8,161
		non-EGU	50%	23,451
		Total East	**100%**	**47,320**
West	NH_3	Area	<1%	6
	NO_x	Area	1%	1,091
		EGU	46%	42,928
		non-EGU	24%	22,153
	$PM_{2.5}$	Area	16%	14,780
		EGU	1%	1,239
		non-EGU	6%	5,882
	SO_2	Area	4%	3,484
		EGU	2%	2,111
		Total West	**100%**	**93,674**
California	NH_3	Area	1%	126
	$PM_{2.5}$	Area	95%	13,500
		non-EGU	4%	641
		Total California	**100%**	**14,267**

[a] Reductions are based upon a slightly different emissions inventory than the 2020 baseline inventory used for the rest of this analysis. This discrepancy is discussed in Chapter 2.

14/35 Alternative Revised Standards

We applied an SO_2 control program for EGUs in the CAIR region (complete description contained later in this Chapter) and a regional control program to reduce SO_2 emitted from non-EGU point sources across 6 midwestern and two southern States. These programs were not based on a cost-effectiveness analysis. Instead they were based on developing reasonable programs to illustrate the potential costs and impacts of regional programs for comparison with the impacts of local strategies evaluated in the attainment strategies for the current and selected standards. After applying the regional SO2 strategies, we employed the hierarchy of control strategy selection similar to that which was applied for 15/35 until an area reached attainment. Table 3-16 displays the hierarchy of control strategies applied to the analysis of the 14/35 alternative. As the table indicates, some areas comply with the 14/35 standard after application of the SO2 regioanl strategies and local known controls. However, some areas also require developmental controls, supplemental controls, and/or extrapolated emission reductions. In addition to the developmental controls applied under the 15/35 analysis in California and Pittsburgh, we applied developmental agricultural controls in only one other area for the alternative standards. Developmental controls for for swine operatons were applied in Detroit as part of the 14/35 analysis.

Table 3-16: Application of Control Strategy Hierarchy by Area for the 14/35 Standard

Location[a]	SO2 Regional Program		MODELED PARTIAL ATTAINMENT[b]		ANALYSIS OF RESIDUAL NONATTAINMENT	
	EGU	Non-EGU	Local Known Controls	Developmental	Supplemental	Extrapolated
East						
Atlanta	✓	✓	✓			
Birmingham	✓	✓	✓		✓	
Chicago	✓	✓	✓		✓	
Cincinnati	✓	✓	✓			
Cleveland	✓	✓	✓	✓	✓	
Detroit	✓	✓	✓	✓		
Gary, IN	✓	✓			✓	
Pittsburgh	✓	✓	✓	✓		
Portsmouth, OH	✓	✓	✓			
St. Louis	✓	✓	✓			
West						
Eugene, OR			✓	✓		
Klamath Falls, OR			✓	✓		
Medford, OR			✓	✓		
Lincoln County, MT			✓	✓		
Missoula, MT			✓	✓		
Shoshone County, ID			✓	✓		
Logan, UT			✓	✓		
Salt Lake City, UT			✓	✓		✓
Seattle, WA			✓	✓		
Tacoma, WA			✓	✓		
CALIFORNIA[c]						
South Coast District				✓		✓
San Joaquin Valley				✓		✓
Other Affected Counties			✓	✓		✓

a For each location, controls are selected in the counties identified in the Metropolitan Statistical Area (MSA) first and then in counties surrounding the MSA if necessary to demonstrate attainment.

b In a limited number of areas, the modeling of control strategies results in areas that do not fully comply with the proposed standards, (i.e. areas of residual nonattainment). In areas of residual nonattainment, we conducted further analysis using supplemental controls and extrapolated reductions (discussed fully in Chapter 4).

c In California, all available known local controls are applied when modeling compliance with the current standard of 15/65, which impacts counties in the South Coast Air Quality District and the San Joaquin Valley. For the analysis of control strategies to comply with the revised standards of 14/35, several new counties are indicated as exceeding the revised daily standard of 35 ug/m3 (but comply with the annual standard). These counties are located north of the San Joaquin Valley and therefore, we employ available local known controls to this area.

Non-EGU SO_2 Regional Control Program. The non-EGU regional control program applied to six Midwestern and two southern states that each contained projected nonattainment areas for the alternative revised standards. These two areas contain the following states: Michigan, Illinois, Indiana, Ohio, Missouri and Kentucky in the midwest and Alabama and Georgia in the south. In these two areas we controlled all non-EGU sources emitting SO_2 with the same restrictions set on our analysis as described earlier in this chapter. We applied a cost per ton cut-off for this subregion of $5,000 per ton.[18] In simulating the implementation of this control strategy we were attempting to illustrate the air quality impacts associated with controlling the regional transport of SO_2 from industrial sources located among a multi-state area. While we did not explicitly design, or model, this strategy to be a regional trading program, States could develop such a program if they so chose.

In the eastern part of the country, ninety-eight percent of the initially modeled reductions are a result of the SO_2 non-EGU regional control program and the EGU control program. The remaining two percent are reductions of direct $PM_{2.5}$ from point and area sources. For a complete breakdown of pollutant sector reduction by region see Table 3-15 below.

[18] This cost cut-off was the product of a policy decision informed by an understanding of the relationship between the cost per-ton of non-EGU SO_2 controls and the total amount of SO_2 that would be abated in this region for that cost per ton.

Table 3-15: Incremental Emission Reductions by Region in 2020 for the Modeled Analysis of the Alternative More Stringent Standards of 14/35[a]

Region	*Pollutant*	*Sector*	*% of Reduction*	*Tons[b]*
East	NH_3	Area	<1%	243
	NO_x	Area	<1%	1,060
		non-EGU	<1%	8,983
	$PM_{2.5}$	Area	<1%	5,481
		EGU	<1%	7,592
		non-EGU	<1%	1,930
	SO_2	Area	1%	10,805
		Regional EGU & non-EGU	98%	346,825 + 474,000
		Total East	**100%**	**382,919 + 474,000**
West	NH_3	Area	<1%	6
	NO_x	Area	1%	1,091
		EGU	47%	42,928
		non-EGU	24%	22,153
	$PM_{2.5}$	Area	16%	14,780
		EGU	1%	1,239
		non-EGU	6%	5,882
	SO_2	Area	4%	3,484
		Total West	**100%**	**91,563**
California	NH_3	Area	1%	126
	NO_x	Area	1%	224
		non-EGU	6%	861
	$PM_{2.5}$	Area	88%	13,500
		non-EGU	4%	641
		Total California	**100%**	**15,353**

[a] The more stringent 14/35 standard was modeled incrementally to the 15/65 current standard

[b] Reductions are based upon a slightly different emissions inventory than the 2020 baseline inventory used for the rest of this analysis. This discrepancy is discussed in Chapter 2.

[C] Note that tons of different pollutants are expected to have different air quality impacts. See Appendix C for a summary of estimated µg/ton impacts for each urban area.

Control technologies applied in the western part of the country are very similar to those applied for the revised standard (described above). Some additional controls were needed to achieve the lower annual standard in Lincoln County, Montana. These controls were NO_x controls applied to non-EGU and area sources.

To partially attain both the lower daily and lower annual standard in CA, additional controls are needed incremental to the current standard. Of the additional controls applied most of the reductions are $PM_{2.5}$ area sources, another smaller amount was from SO_2 area sources and NO_x

sources. Negligible amount of NH_3 reductions occur in additional counties which were violating the daily standard.

EGU SO_2 Regional Control Program. The data and projections presented here cover the electric power sector, an industry that will achieve significant emission reductions under the Clean Air Interstate Rule (CAIR) over the next 10 to 15 years. Based on an assessment of the emissions contributing to interstate transport of air pollution and available control measures, EPA determined that achieving required reductions in the identified States by controlling emissions from power plants is highly cost effective. CAIR will permanently cap emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) in the eastern United States. CAIR achieves large reductions of SO_2 and/or NO_x emissions across 28 eastern states and the District of Columbia.

When fully implemented, CAIR will reduce SO_2 emissions in these states by over 70% and NO_x emissions by over 60% from 2003 levels. This will result in significant environmental and health benefits and will substantially reduce premature mortality in the eastern United States. The benefits will continue to grow each year with further implementation. CAIR was designed with current air quality standard in mind, and requires significant emission reductions in the East, where they are needed most and where transport of pollution is a major concern. CAIR will bring most areas in the Eastern US into attainment with the ozone and current $PM_{2.5}$ standards. Some areas will need to adopt additional local control measures beyond CAIR. CAIR is a regional solution to address transport, not a solution to all local nonattainment issues. The large reductions anticipated with CAIR, in conjunction with reasonable additional local control measures for SO_2, NO_x, and direct PM, will move States towards attainment in a deliberate and logical matter. The suite of control options presented in this RIA shows how this could be done.

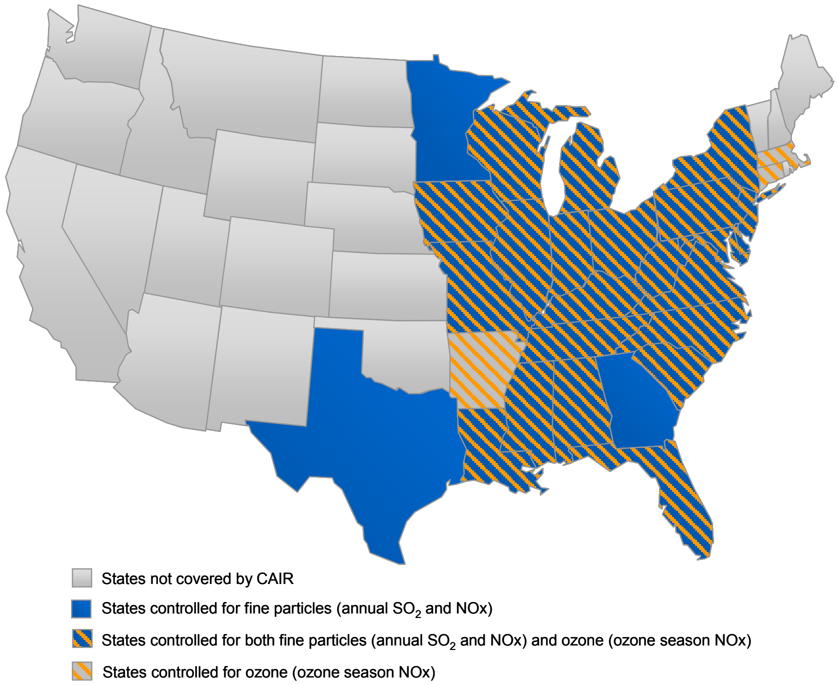


Figure 3-3: CAIR Affected Region

States must achieve the required emission reductions using one of two compliance options. One option is to meet the state's emission budget by requiring power plants to participate in an EPA-administered interstate cap and trade system that caps emissions in two stages—this is EPA's recommended choice because of the cost effectiveness of regional cap-and-trade programs. Or, States can meet an individual state emissions budget through measures of the state's choosing. CAIR provides a Federal framework requiring states to reduce emissions of SO_2 and NO_x, and EPA anticipates that states will achieve this primarily by reducing emissions from the power generation sector. These reductions will be substantial and cost-effective, so in many areas, the reductions are large enough to meet the air quality standards. The Clean Air Act requires that states meet the new national, health-based air quality standards for ozone and $PM_{2.5}$ standards by requiring reductions from many types of sources, and some areas may need to take additional local actions. However, the reductions required by CAIR will lessen the need for additional local controls. The analysis in this section reflects these realities and attempts to show, in an illustrative fashion, the costs and impacts of meeting both current and alternative air quality standards for $PM_{2.5}$ for the power sector.

<u>Modeling Background</u>

CAIR was designed to achieve significant emissions reductions in a highly cost-effective manner to reduce the transport of fine particles that have been found to contribute to nonattainment. EPA analysis has found that the most efficient method to achieve the emissions reduction targets is through a cap-and-trade system on the power sector that States have the option of adopting. The power sector accounted for 67% of nationwide SO_2 emissions and 22% of nationwide NO_x emissions in 2002. States, in fact, can choose not to participate in the optional cap-and-trade program and can choose to obtain equivalent emissions reductions from other sectors. However, EPA believes that a region-wide cap-and-trade system for the power sector is the best approach for reducing emissions. The modeling done with IPM assumes a region-wide cap and trade system on the power sector for the States covered.

The economic modeling using IPM presented in this and other chapters has been developed for specific analyses of the power sector. EPA's modeling is based on its best judgment for various input assumptions that are uncertain, particularly assumptions for future fuel prices and electricity demand growth. To some degree, EPA addresses the uncertainty surrounding these two assumptions through sensitivity analyses. More detail on IPM can be found in the model documentation, which provides additional information on the assumptions discussed here as well as all other assumptions and inputs to the model (www.epa.gov/airmarkets/epa-ipm).

Updated Modeling in Support of the Alternative 14 $\mu g/m^3$ Annual and 35 $\mu g/m^3$ Alternative More Stringent Standard

In addition to the changes in IPM previously discussed, an additional change was made to the power sector modeling for the 14/35 case. As discussed in chapter one, monitored $PM_{2.5}$ speciation data indicates that a substantial fraction of total $PM_{2.5}$ mass is composed of sulfates in the Midwest and eastern United States. These sulfates are formed on a secondary basis from SO_2 emitted from a variety of sources. In light of this fact, a control strategy for $PM_{2.5}$ in this area of the country that considers controlling SO_2 emissions where it is cost-effective to do so is a reasonable approach to demonstrating attainment with the standards.

Considering the alternative 14/35 case in the context of air quality issues, chemistry, future emissions for all anthropogenic sources, and cost-effectiveness has led the EPA to investigate and analyze a reduction in the CAIR SO_2 cap (increase in allowance surrender ratios) for the power sector in the 2020 timeframe. The illustrative analytical approach for the analysis of the 14/35 case is intended to build off the significant reductions already anticipated with CAIR. EPA chose to illustrate the impact of additional EGU emission reductions under a new and tighter standard although the cap levels set in CAIR represent EPA views on the maximum reductions that can be achieved within a cost-per-ton range that EPA considers to be highly cost-effective for addressing interstate transport under the 15/65 PM NAAQS (See CAIR preamble, 70 F.R. 25201).

The result is an illustrative "extended" approach to CAIR, with consideration of an additional third phase SO_2 cap (higher surrender ratio) to come into effect in 2020 for the affected region. Key factors in considering the extended approach to CAIR were the longer time horizon, impacts on the power sector, and impacts on consumers. However, EPA developed this augmented EGU approach to illustrate the impacts (costs and benefits) of additional EGU controls. If EPA were to study and investigate additional EGU emission reductions in rulemaking under an alternative standard of 14/35, the Agency would need to go through the regulatory process and perform more complex technical analysis of the merits of additional EGU reductions beyond what is anticipated under CAIR.

Table 3-16: SO_2 Reduction Requirements of CAIR and an Illustrative CAIR Extended

	CAIR		Illustrative CAIR Extended	
	% Reduction from title IV	*Retirement Ratio*	*% Reduction from title IV*	*Retirement Ratio*
2010	50%	2.00	50%	2.00
2015	65%	2.86	65%	2.86
2020	N/A	N/A	75%	4.00

The illustrative CAIR requirements were developed by applying caps consistent with a 50% reduction in the final title IV SO_2 cap levels in 2010 and a 65% reduction in 2015. These caps could be met through retirement of title IV SO_2 allowances (see Final CAIR preamble for further discussion). For the illustrative CAIR Extended, a third phase cap was added consistent with a 75% reduction in the final title IV SO_2 cap levels in 2020.

Figure 3-4. Projected Nationwide SO_2 Emissions from EGUs (1,000 tons)

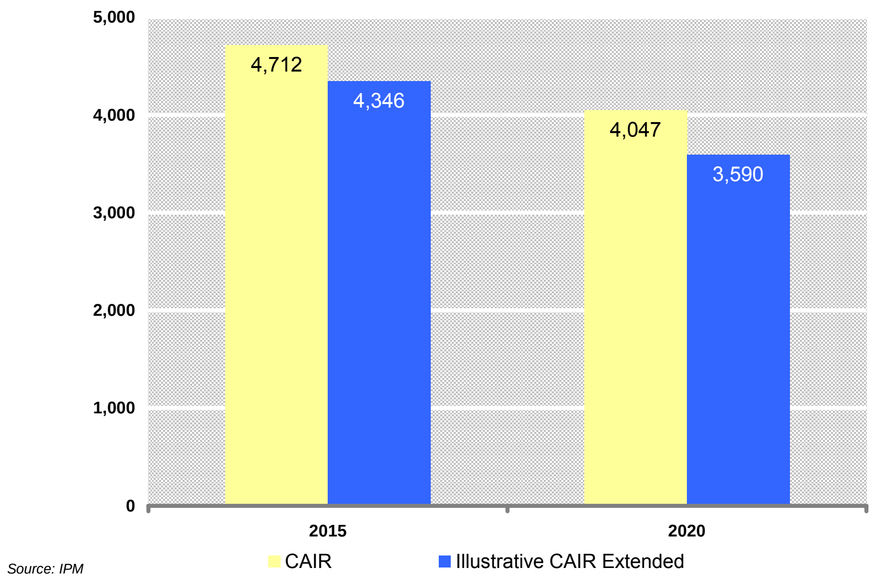
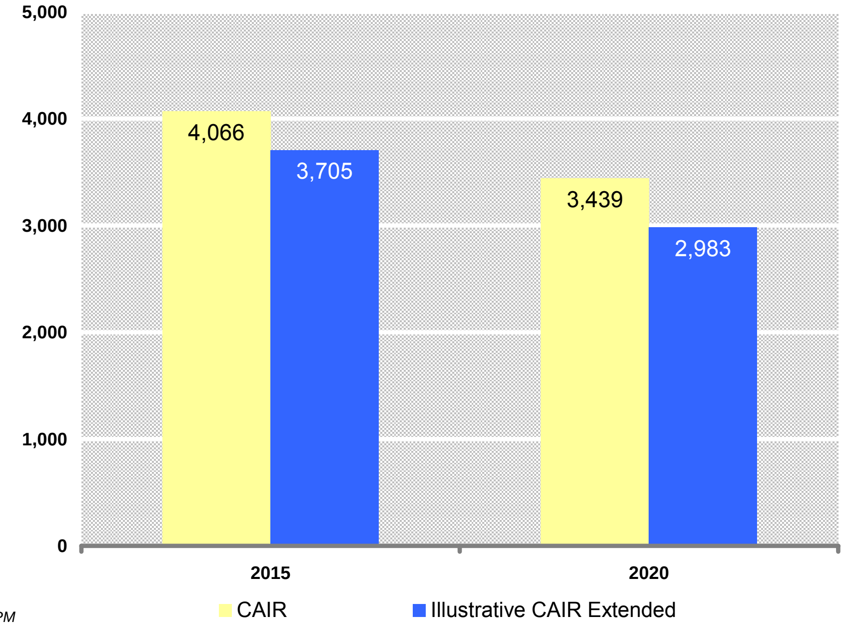


Figure 3-5. Projected SO_2 Emissions from EGUs in the CAIR Region (1,000 tons)



Source: IPM

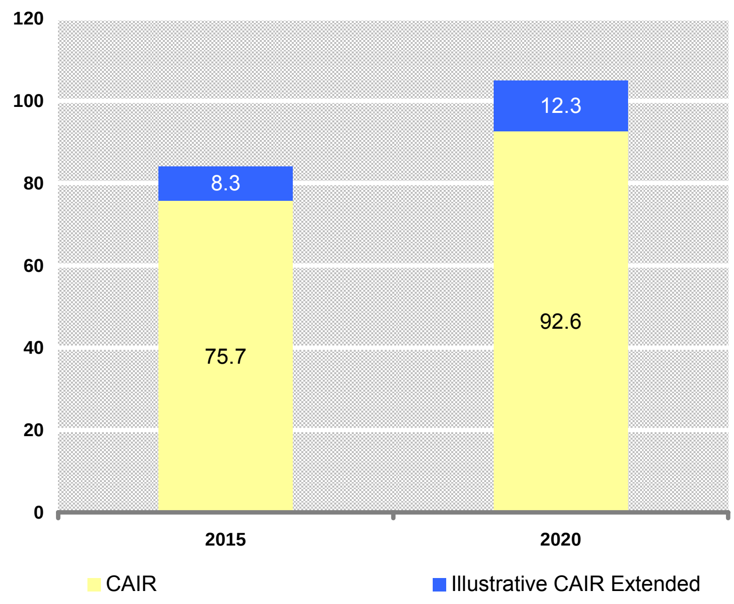
Figure 3-6. 2020 SO_2 Emissions by State (1,000 tons)

Source: IPM

Figure 3-7. 2015 SO_2 Emissions by State (1,000 tons)

Source: IPM

Figure 3-8. Projected Control Technology Retrofits, Incremental FGD (GW)



3.3.5 Limitations and Uncertainties of Analysis

The estimates of emission reductions associated with our control strategies above are subject to important limitations and uncertainties. For each sector we outline, and qualitatively assess the impact of, those limitations and uncertainties that are most significant.

Non-EGU Point and Area Sector

A number of limitations and uncertainties are associated with the analysis of non-EGU point and area source emission controls:

- The technologies applied and the emission reductions achieved in these analyses may not reflect emerging control devices that could be available in future years to meet any BART requirements in SIPs or upgrades to some current devices that may serve to increase control levels. For example, there is increasing use of SCR/SNCR hybrid technologies that can serve to lower the expected capital costs and lead to NO_x control at high levels (90 percent).
- The emission reduction estimates for point and area sources do not reflect potential effects of technological change that could be available in future years. As emission control technologies change, one effect is an increase in performance due to improvements in the capabilities in the underlying technology that are utilized. For example, SCR technology now can provide 90 percent reduction of NOx emissions from a variety of sources; twenty years ago, no more than 60 percent reduction could occur. Hence, we may understate the emission reductions estimated by these analyses.
- The effects from "learning by doing" are not accounted for in the emission reduction estimates for point and area sources. It is possible that an emissions control technology may have better performance in reducing emissions due to greater understanding of how best to operate and maintain the technology. As a result, we may understate the emission reductions estimated by these analyses. The mobile source control measures do account for these effects.
- The effectiveness of the control measures in these analyses is based an assumption that these controls are well maintained throughout their equipment life (the amount of time they are assumed to operate). To the extent that a control measure is not well maintained, the control efficiency may be less than estimated in these analyses. Since these control measures must operate according to specified permit conditions, however, it is expected that the maintenance of controls should yield control efficiencies at or very close to those used in these analyses. As a result, we may overstate the emission reductions estimated by these analyses.
- The application of area source control technologies in these analyses assume that a constant estimate for emission reduction is reasonable despite variation in the extent or scale of application (e.g. amount of watering at cattle feed lots). To the extent that there are economies of scale in area source control applications, we may overstate the emission reductions estimated by these analyses.

EGU Sector

EPA's modeling is based on its best judgment for various input assumptions that are uncertain. As a general matter, the Agency selects the best available information from available engineering studies of air pollution controls and has set up what it believes is the most reasonable modeling framework for analyzing the cost, emission changes, and other impacts of regulatory controls.

The annual cost estimates of the private compliance costs that are provided in this analysis are meant to show the increase in production (engineering) costs of CAIR to the power sector. In simple terms, the private compliance costs that are presented are the annual increase in revenues required for the industry to be as well off after CAIR is implemented as before. To estimate these annual costs, EPA uses a conventional and widely-accepted approach that is commonplace in economic analysis of power sector costs for estimating engineering costs in annual terms. For estimating annual costs, EPA has applied a capital recovery factor (CRF) multiplier to capital investments and added that to the annual incremental operating expenses. The CRF is derived from estimates of the cost of capital (private discount rate), the amount of insurance coverage required, local property taxes, and the life of capital. The private compliance costs presented earlier are EPA's best estimate of the direct private compliance costs of CAIR.

The annualization factor used for pure social cost calculations (for annual costs) normally includes the life of capital and the social discount rate. For purposes of benefit-cost analysis of this rule, EPA has calculated the annual social costs using the discount rates from the benefits analysis for CAIR (3 percent and 7 percent and a 30 year life of capital. The cost of added insurance necessary because of CAIR was included in the calculations, but local taxes were not included because they are considered to be transfer payments, and not a social cost). Using these discount rates, the incremental social costs of the Illustrative CAIR Extended is $0.45 billion in 2020 using a discount rate of 3 percent and $0.53 billion using a discount rate of 7 percent.

The annual regional cost of the illustrative CAIR Extended, as quantified here, is EPA's best assessment of the cost of implementing the additional reductions beyond CAIR, assuming that States adopt the model cap and trade program. These costs are generated from rigorous economic modeling of changes in the power sector due to additional emission control requirements beyond CAIR. This type of analysis using IPM has undergone peer review and federal courts have upheld regulations covering the power sector that have relied on IPM's cost analysis.

The direct private compliance cost includes, but is not limited to, capital investments in pollution controls, operating expenses of the pollution controls, investments in new generating sources, and additional fuel expenditures. EPA believes that the EGU cost assumptions used in the analysis for CAIR reflect, as closely as possible, the best information available to the Agency today.

Cost estimates for SO_2 reductions from EGUs are based on results from ICF's Integrated Planning Model. The model minimizes the costs of producing electricity (including abatement costs) while meeting load demand and other constraints (full documentation for IPM can be found at www.epa.gov/airmarkets/epa-ipm). The structure of the model assumes that the electric utility industry will be able to meet the environmental emission caps at least cost. Montgomery

(1972) has shown that this least cost solution corresponds to the equilibrium of an emission permit system.[19] See also Atkinson and Tietenburg (1982), Krupnick et al. (1980), and McGartland and Oates (1985).[20] [21] [22] However, to the extent that transaction and/or search costs, combined with institutional barriers, restrict the ability of utilities to exhaust all the gains from emissions trading, costs are underestimated by the model. Utilities in the IPM model also have "perfect foresight." To the extent that utilities misjudge future conditions affecting the economics of pollution control, costs may be understated as well.

As a counterweight, the most current of these well-respected assessments was published a decade before empirical evidence was available on cap and trade programs. Comparing empirical evidence (actual market prices of allowances) with forecasts from IPM (and its predecessor, the Coal Electric Utility Model) show that models have significantly overestimated projected compliance costs; industry takes advantage of cap and trade more effectively than EPA can predict.

From another vantage point, this modeling analysis does not take into account the potential for advancements in the capabilities of pollution control technologies for SO_2 and NO_x removal as well as reductions in their costs over time. Market-based cap and trade regulation serves to promote innovation and the development of new and cheaper technologies. As an example, recent cost estimates of the Acid Rain SO_2 trading program by Resources for the Future (RFF) and MIT's Center for Energy and Environmental Policy Research (CEEPR) have been as much as 83 percent lower than originally projected by the EPA.[23] It is important to note that the original analysis for the Acid Rain Program done by EPA also relied on an optimization model like IPM. Ex ante, EPA cost estimates of roughly \$2.7 to \$6.2 billion[24] in 1989 were an overestimate of the costs of the program in part because of the limitation of economic modeling to predict technological improvement of pollution controls and other compliance options such as fuel switching. Ex post estimates of the annual cost of the Acid Rain SO_2 trading program range

[19] Montgomery, W. David. 1972. "Markets in Licenses and Efficient Pollution Control Programs." *Journal of Economic Theory* 5(3):395-418.

[20] Atkinson, S., and T. Tietenberg. 1982. "The Empirical Properties of Two Classes of Design for Transferable Discharge Permit Markets." *Journal of Environmental Economics and Management* 9:101-121

[21] Krupnick, A., W. Oates, and E. Van De Verg. 1980. "On Marketable Air Pollution Permits: The Case for a System of Pollution Offsets." *Journal of Environmental Economics and Management* 10:233-47.

[22] McGartland, A., and W. Oates. 1985. "Marketable Permits for the Prevention of Environmental Deterioration." *Journal of Environmental Economics and Management* 12:207-228.

[23] See (1) Carlson, Curtis; Burtraw, Dallas R.; Cropper, Maureen, and Palmer, Karen L. 2000. Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade? *Journal of Political Economy* 108 (#6): 1292_1326, and (2) Ellerman, Denny. January 2003. Ex Post Evaluation of Tradable Permits: The U.S. SO_2 Cap and Trade Program. Massachusetts Institute of Technology Center for Energy and Environmental Policy Research.

[24] 2010 Phase II cost estimate in \$1995.

from $1.0 to $1.4 billion. Harrington et al. have examined cost analyses of EPA programs and found a tendency for predicted costs to overstate actual implementation costs in market-based programs.[25]

It is also important to note that the capital cost assumptions for scrubbers used in EPA modeling applications are highly conservative. These are a substantial part of the compliance costs. Data available from recent published sources show the reported FGD costs from recent installations to be below the levels projected by IPM.[26] In addition, EPA also conducted a survey of recent FGD installations and compared the costs of these installations to the costs used in IPM. This survey included small, mid-size, and large units. Examples of the comparison of recently published FGD capital cost data with the FGD capital cost estimates obtained from IPM are provided in the Final CAIR docket.

EPA's latest update of IPM incorporates State rules or regulations adopted before March 2004 and various NSR settlements. Documentation for IPM can be found at www.epa.gov/airmarkets/epa-ipm. A very limited set of State and/or settlement actions since that time have been included in EPA analysis for EGUs.

As configured in this application, IPM does not take into account demand response (i.e., consumer reaction to electricity prices). An increase in retail electricity prices would prompt end users to curtail (to some extent) their use of electricity and encourage them to use substitutes.[27] The response would lessen the demand for electricity, resulting in electricity price increases slightly lower than IPM predicts, which would also reduce generation and emissions. Because of demand response, certain unquantified negative costs (i.e., savings) result from the reduced resource costs of producing less electricity because of the lower quantity demanded. To some degree, these saved resource costs will offset the additional costs of pollution controls and fuel switching that we would anticipate with CAIR. Although the reduction in electricity use is likely to be small, the cost savings from such a large industry ($250 billion in revenues in 2003) is likely to be substantial. EIA analysis examining multi-pollutant legislation under consideration in 2003 indicates that the annual costs of CAIR may be overstated substantially by not considering demand response, depending on the magnitude and coverage of the price increases.[28]

Recent research suggests that the total social costs of a new regulation may be affected by interactions between the new regulation and pre-existing distortions in the economy, such as

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[25] Harrington, W. R.D. Morgenstern, and P. Nelson, 2000. "On the Accuracy of Regulatory Cost Estimates," Journal of Policy Analysis and Management 19(2): 297-322.

[26] There is evidence that scrubber costs will decrease in the future because of the learning-by-doing phenomenon, as more scrubbers are installed. See Manson, Nelson, and Neumann, 2002. "Assessing the Impact of Progress and Learning Curves on Clean Air Act Compliance Costs," Industrial Economics Incorporated.

[27] The degree of substitution/curtailment depends on the price elasticity of demand for electricity.

[28] See "Analysis of S. 485, the Clear Skies Act of 2003, and S. 843, the Clean Air Planning Act of 2003." Energy Information Administration. September, 2003. EIA modeling indicated that the Clear Skies Act of 2003 (a nationwide cap and trade program for SO_2, NO_x, and mercury), demand response could lower present value costs by as much as 47% below what it would have been without an emission constraint similar to CAIR.

taxes. In particular, if cost increases due to a regulation are reflected in a general increase in the price level, the real wage received by workers may be reduced, leading to a small fall in the total amount of labor supplied. This "tax interaction effect" may result in an increase in deadweight loss in the labor market and an increase in total social costs. Although there is a good case for the existence of the tax interaction effect, recent research also argues for caution in making prior assumptions about its magnitude. Chapter 8 of EPA's draft "Guidelines for Preparing Economic Analysis" discusses in detail the tax interaction effect in the context of environmental regulation. These economic analysis guidelines are still under review within EPA. The limited empirical data available to support quantification of any such effect leads to this qualitative identification of the costs.

On balance, after consideration of various unquantified costs (and savings that are possible), EPA believes that the annual private compliance costs that we have estimated are more likely to overstate the future annual compliance costs that industry will incur, rather than understate those costs.

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