Appendix A: The Costs and Benefits of Attaining the 1997 Standards in 2015

A.1 Role of this Appendix in Supporting the $PM_{2.5}$ Implementation Rule

This Appendix includes a detailed attainment analysis of the costs and monetized human health benefits of meeting the 1997 standards by the 2015 attainment deadline. This separate analysis is intended to inform the public about the costs and benefits of the $PM_{2.5}$ implementation rule, and as such is included as a stand-alone document. We estimate that the total cost of our attainment scenario is approximately $6.7 billion (1999$) and the total benefits to be between $43 and $97 billion (1999$), using the lower and upper-bound benefits estimates. Below we summarize the important differences between this analysis and the one found in the main body of the RIA.

A.1.1 Differences between 2015 and 2020 Attainment Analysis for Current Standard

The design of the analysis in this appendix is in most respects identical to the main analysis, with the principle divergence being the baseline year used to model attainment. The main analysis used a baseline of 2020 to model attainment of 15/65 and then used that attainment scenario as the regulatory base case with which to model attainment of the revised and more stringent alternative standards. Conversely, this analysis uses a baseline year of 2015 in which to model attainment of 15/65. We selected 2015 as the modeling year for the implementation rule because that is the year when areas have to attain the current standard.

While the baseline years differ between the two analyses, this 2015 analysis shares the same control scenario that we used to simulate attainment of 15/65 in 2020. This 15/65 control scenario must be identical in both years, because our analysis assumes that states implement controls in 2015 to attain the standard in that same year and that states then supplement these same controls in 2020 to attain the revised and more stringent alternative standards.

A.1.2 Analytical Implications of Using 2015 as a Base Year

By 2015, key national and regional rules such as CAIR and the Non-Road rule will not yet be fully implemented. As a result, these rules will yield a smaller amount of the total expected emission reductions in 2015 versus 2020. Thus, most states must design control scenarios that reduce a larger quantity of emissions to attain the current standard of 15/65 in 2015 than they would if they were attaining the current standard in 2020. For this reason, our analysis assumes—and our air quality modeling indicates—that states will just attain the current standard in 2015 and then "over-attain" the current standard in 2020 as the requirements for these national rules are implemented.[1]

The use of a 2015 baseline also has implications for our cost analysis. While we are applying identical controls in 2015 and 2020, the engineering cost estimate varies for these two years due to discounting.

[1] See section 1.6 in the introduction for a comprehensive discussion of the affect of these national rules on attainment pathways.

A.2 Emission Controls Analyzed

The section below summarizes the control measures we applied to simulate attainment with the 1997 standards. EPA selected these control strategies on the basis of cost-effectiveness, using the techniques described in Chapter 3.

Several areas that do not currently attain the 1997 standards make significant progress by 2015 due to multiple national rules that are implemented by that date. Areas that CMAQ projects still not to attain the 1997 standards in 2015 include: Atlanta, Pittsburgh, Cincinnati, Cleveland, Detroit, Chicago, and several California counties.

EPA selected and applied emission controls in 2015 to attain the standard by the statutory deadline. According to the control hierarchy described in Chapters 1 and 3, to simulate attainment with these standards we applied control measures principally in and around the projected nonattaining urban areas.

To simulate attainment with the 1997 standards in the East, our control strategy consisted mainly of controls on directly-emitted $PM_{2.5}$. EPA determined that in general controls applied to direct $PM_{2.5}$ from point and area emissions are the most cost-effective—based on the cost per microgram of reduction/change—to reduce overall particulate matter concentrations in eastern nonattainment areas (defined as the CAIR region).[2] Examples of control technologies applied to $PM_{2.5}$ non-EGU point sources include: diesel particulate filters, continuous emissions monitor (CEM) upgrades and increased monitoring frequency (IMF) of PM controls, and Wet ESP's. We also applied controls to reduce $PM_{2.5}$ emissions from coal-fired EGU's with ESPs by adding two ESP collector fields to increase the surface area for particle collection. The control technologies applied most frequently to area sources of $PM_{2.5}$ included: catalytic oxidizers applied to commercial cooking sources, education and advisory programs, and NSPS compliant woodstoves.[3] See Table A-1 below for a breakdown of pollutant sector reductions by region.

[2] For a list of these cost per microgram estimates, see Appendix C.
[3] 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.

Table A-1: 15/65 Standard Reduction by Region

Region	*Pollutant*	*Sector*	*% of Reductions*	*Tons*
East	$PM_{2.5}$	Area	9%	3,036
		non-EGU	35%	11,442
		EGU	56%	18,439
		Total East	100%	32,917
West	NO_x	Area	54%	9
	$PM_{2.5}$	Area	46%	7
		Total West	100%	16
California	NH_3	Area	24%	25,948
	NO_x	Area	4%	4,315
		EGU	<1%	146
		non-EGU	43%	47,036
	$PM_{2.5}$	Area	15%	16,653
		EGU	<1%	412
		non-EGU	2%	2,643
	SO_2	non-EGU	12%	12,892
		Total California	100%	110,061

In the West, outside of California, Lincoln County, Montana is the only projected nonattainment area. To achieve the current standard we applied controls to area sources emitting $PM_{2.5}$ as described above, and to area sources emitting NO_X. Examples of controls applied to area sources with NO_X emissions are RACT to 25 tpy (low NO_X burners, or LNB), and the combination of a new water heater and space heater that includes a low NO_X burner for improved NO_X control.

To attempt to simulate attainment with the current standard in California, due to the severity of the projected non-attainment problem, EPA applied all available control measures. Even with this level of control, we did not expect to model attainment with the 1997 standards. Forty-seven percent of the emission control measures applied in California are NO_X controls, half of that is from area and non-EGU point sources, and the remainder is from mobile national rules and local controls. Another 24% of the reductions are achieved through developmental controls placed on agricultural sources of ammonia emissions. According to local air pollution control officials in California, applying ammonia emissions controls in this area of California are not expected to result in large air quality benefits because this area is NO_x limited. California state officials have recommended focusing on sources of NO_x. Another 15% is achieved through controls placed on area sources of $PM_{2.5}$. We applied the remainder of to SO_2 non-EGU point sources and point sources emitting direct $PM_{2.5}$. When developing our control scenarios for each of these projected non-attainment areas, we exhausted our controls database for several counties in California as well as Chicago.

A.3 Air Quality Impacts

Table A-2 below summarizes the CMAQ-projected 2015 base and 2015 control design values for those counties projected to violate the 1997 standards in the base case.

Table A-2: Projected annual and daily $PM_{2.5}$ design values (µg/m^3) for scenarios modeled with CMAQ

		2015 Base		**2015 Control**	
State	**County**	*Annual*	*Daily*	*Annual*	*Daily*
California	Riverside Co	27.8	73.5	23.27	62.81
California	San Bernardino Co	24.6	65.7	21.62	57.54
California	Los Angeles Co	23.7	62.2	21.66	57.63
California	Kern Co	21.3	81.4	19.22	72.33
California	Tulare Co	21.2	77.2	19.51	69.53
California	Fresno Co	20.1	73.0	17.86	62.69
California	Orange Co	20.0	41.1	18.27	36.61
Michigan	Wayne Co	17.4	39.0	16.99	38.39
California	Kings Co	17.2	70.6	15.99	64.37
California	Stanislaus Co	16.6	61.9	14.96	54.61
Pennsylvania	Allegheny Co	16.5	53.4	16.15	52.26
Alabama	Jefferson Co	15.9	36.9	15.40	33.81
California	Merced Co	15.8	54.4	14.66	49.28
California	San Diego Co	15.8	40.7	13.98	35.63
Ohio	Scioto Co	15.6	34.3	15.40	33.96
Georgia	Fulton Co	15.5	32.2	15.20	31.57
Illinois	Cook Co	15.5	37.1	14.82	36.11
California	San Joaquin Co	15.4	51.1	13.92	44.78
Ohio	Cuyahoga Co	15.4	40.0	15.05	39.39
Illinois	Madison Co	15.2	35.5	14.79	34.80
Montana	Lincoln Co	15.0	42.4	14.90	42.24

We project that by 2015 Detroit and Pittsburgh will be the only two urban areas located outside of California to not attain the 1997 annual standard of 15 µg/m^3. Detroit is projected to exceed the current annual standard by about 2 µg/m^3 and Pittsburgh is projected to exceed the annual standard by about 1 µg/m^3. There are several reasons why our analysis projects these areas to remain in projected non-attainment.

There is a single monitor in Detroit (AIRS #26163003) that is projected to violate the 1997 standard of 15 µg/m^3. As the attainment determinations section of Chapter 4 describes, our analysis of emissions data indicates that this monitor is likely to be highly influenced by nearby emissions sources located within 3 km of the site. The course resolution of the CMAQ air quality modeling used to estimate the air quality at this monitor is unlikely to have characterized the impact of controlling these near-field sources. While the local-scale AERMOD modeling indicated that controlling local sources of direct $PM_{2.5}$ would have a substantial impact on the design value at the violating monitor, many of these sources may not have been characterized with the precision needed for a local scale assessment for these locations. Moreover, the source apportionment studies highlight the importance of mobile sources and suggest that we may not have fully captured the air quality benefits associated with controlling these sources. Taken together, these data argue that for the purpose of this illustrative analysis Detroit would attain the 1997 standards.

In Pittsburgh, a single monitor is projected to violate the annual 1997 standard of 15 $\mu g/m^3$ (AIRS #420030064). This monitor is situated close to several large industrial facilities, including Clairton Coke Works and U.S. Steel Irvin Plant. Pollution roses indicate that most of the highest $PM_{2.5}$ concentrations result when the wind blows from the southeast where the Clairton facilities are located. As with our analysis of Detroit, the course-scale CMAQ modeling is unlikely to have adequately captured the air quality impact of having controlled these sources. The local-scale AERMOD modeling results indicate high annual concentration gradients of primary $PM_{2.5}$ within typical photochemical modeling grid resolutions; the modeling also indicates that controlling these local sources may yield a substantial reduction in the projected annual design value. It is noteworthy that our 15/35 and 14/35 control strategies were successful in simulating attainment with the 1997 annual standard of $\mu g/m^3$, suggesting that Pittsburgh may attain the 1997 standards if it applies either of these control strategies. Thus, for the purposes of this illustrative analysis, we believe the monitoring, emissions and air quality monitoring data indicate that Pittsburgh would attain the 1997 standards in 2015.

A.4 Benefits Analysis and Results

This section reports EPA's analysis of a subset of the public health and welfare impacts and associated monetized benefits to society of illustrative implementation strategies to attain the 1997 fine particulate matter ($PM_{2.5}$) NAAQS by the year 2015. Accordingly, the analysis presented here attempts to answer two questions: (1) what are the estimated nationwide physical health and welfare effects of changes in ambient air quality resulting from reductions in precursors to particulate matter (PM) including directly emitted carbonaceous particles, NO_x, SO_2, and NH_3 emissions? and (2) what is the estimated monetary value of the changes in these effects?

The analysis presented here uses a methodology generally consistent with benefits analyses performed for the recent analysis of the Clean Air Interstate Rule (EPA, 2005).

The benefits analysis takes as inputs the results of air quality modeling designed for this rulemaking. Reductions in certain $PM_{2.5}$ precursors such as NO_x and VOC may also lead to changes in ambient concentrations of ozone. These changes in ozone will also have health and welfare effects. However, for this analysis, because the majority of the illustrative strategies evaluated do not affect NO_x and VOC emissions (with the exception of nonattainment areas in parts of the western U.S., where we do not have adequate models for ozone), we focus on estimating the health and welfare effects associated with changes in ambient $PM_{2.5}$. This adds some uncertainty to the overall results, but given the expected small magnitude of the impacts (due to the small amount of NOx controls applied); this uncertainty will likely be small relative to other modeling uncertainties.

A wide range of human health and welfare effects are linked to ambient concentrations of $PM_{2.5}$. Potential human health effects associated with $PM_{2.5}$ range from premature mortality to morbidity effects linked to long-term (chronic) and shorter-term (acute) exposures (e.g., respiratory and cardiovascular symptoms resulting in hospital admissions, asthma exacerbations, and acute and chronic bronchitis [CB]). Welfare effects potentially linked to PM and its precursors include materials damage and visibility impacts, as well as the impacts associated with deposition of nitrates and sulfates. Although methods exist for quantifying the benefits associated with many of these human health and welfare categories, not all can be evaluated at this time because of limitations in methods and/or data. We estimate that the annual monetized health and welfare benefits associated with the illustrative implementation strategies for implementation of the 1997 PM 2.5 NAAQS in 2015, when the standards are expected to be fully attained. These strategies are evaluated after application of existing federal (such as CAIR), state, and local programs. These benefits are shown below.

Table A-3 Estimated Reduction in Incidence of Adverse Health and Welfare Effects Associated with Attaining the 1997 Standards (90 Percent Confidence Intervals Provided in Parentheses): Primary Estimate

	1997 Standards (15/65)	
Estimate	*Modeled Attainment*	*Full Attainment*
Mortality Based on American Cancer Society Cohort [a]	3,900 (1,500 - 6,200)	6,600 (2,600 - 11,000)
Chronic bronchitis (age >25 and over)	2,900 (550 - 5,300)	5,000 (940 - 9,000)
Nonfatal myocardial infarction (age >17)	7,300 (4,000 - 11,000)	12,000 (6,900 - 18,000)
Hospital admissions—respiratory (all ages)[b]	820 (410 - 1,200)	1,400 (700 - 2,100)
Hospital admissions—cardiovascular (age >17)[c]	1,600 (1,000 - 2,300)	2,800 (1,700 - 3,800)
Emergency room visits for asthma (age <19)	2,400 (1,400 - 3,300)	3,700 (2,200 - 5,200)
Acute bronchitis (age 8–12)	8,200 (-290 - 16,000)	15,000 (-520 - 29,000)
Lower respiratory symptoms (age 7–14)	82,000 (40,000 - 120,000)	150,000 (75,000 - 230,000)
Upper respiratory symptoms (asthmatic children, age 9–18)	61,000 (19,000 - 100,000)	110,000 (36,000 - 190,000)
Asthma exacerbation (asthmatic children, age 6–18)	75,000 (8,300 - 220,000)	140,000 (16,000 - 400,000)
Work loss days (age 18–65)	540,000 (470,000 - 610,000)	980,000 (850,000 - 1,100,000)
Minor restricted-activity days (age 18–65)	3,200,000 (2,700,000 - 3,700,000)	5,800,000 (4,900,000 - 6,600,000)

[a] Based on Pope et al 2002, used as primary estimate in recent RIAs.

Table A-4. Estimated Monetary Valuation of Reduction in Incidence of Adverse Health and Welfare Effects Associated with Attaining the 1997 Standards (90 Percent Confidence Intervals Provided in Parentheses): Primary Estimate

	1997 Standards (15/65)	
Estimate	*Modeled Attainment*	*Full Attainment*
Mortality Based on American Cancer Society Cohort [a]		
3% discount rate	$28,000 ($6,100 - $57,000)	$43,000 ($9,700 - $90,000)
7% discount rate	$23,000 ($5,200 - $48,000)	$37,000 ($8,200 - $76,000)
Chronic bronchitis (age >25 and over)	$1,500 ($120 - $5,400)	$2,400 ($190 - $8,300)
Nonfatal myocardial infarction (age >17)		
3% discount rate	$790 ($220 - $1,700)	$1,200 ($340 - $2,600)
7% discount rate	$760 ($200 - $1,700)	$1,200 ($310 - $2,600)
Hospital admissions—respiratory (all ages)[b]	$16.0 ($8.2 - $25.0)	$26.0 ($13.0 - $39.0)
Hospital admissions—cardiovascular (age >17)[c]	$45.0 ($28.0 - $62.0)	$68.0 ($43.0 - $94.0)
Emergency room visits for asthma (age <19)	$0.81 ($0.44 - $1.20)	$1.20 ($0.64 - $1.80)
Acute bronchitis (age 8–12)	$3.80 (-$0.14 - $10.00)	$6.10 (-$0.24 - $15.00)
Lower respiratory symptoms (age 7–14)	$1.60 ($0.61 - $3.00)	$2.70 ($1.00 - $5.10)
Upper respiratory symptoms (asthmatic children, age 9–18)	$2.00 ($0.51 - $4.20)	$3.40 ($0.89 - $7.20)
Asthma exacerbation (asthmatic children, age 6–18)	$3.70 ($0.40 - $12.00)	$6.50 ($0.70 - $21.00)
Work loss days (age 18–65)	$77 ($67 - $87)	$130 ($120 - $150)
Minor restricted-activity days (age 18–65)	$93 ($8 - $180)	$160 ($14 - $310)

[a] Based on Pope et al 2002, used as primary estimate in recent RIAs.

The tables below summarize the estimates of mortality and morbidity that use effect estimates derived from the expert elicitation effort described above in section 1.3.4. In these tables we provide incidence and valuation estimates based on data-derived and expert-elicitation derived mortality functions, for both our modeled and full attainment scenarios. The expert-elicitation derived incidence and valuation estimates include upper and lower-bound estimates based on the two experts who provided the highest and lowest mortality impact functions. Chapter 5 of this RIA complements these summary tables by including the results of the full-scale study.

Table A-5. Estimated Reduction in Incidence of Adverse Health and Welfare Effects Associated with Attaining the 1997 Standards

Modeled Attainment

Based on Mortality Function from American Cancer Society and Morbidity Functions from Epidemiology Literature[a]

3,900

Confidence Intervals

(1,500 - 6,200)

Based on Expert Elicitation Derived Mortality Functions and Morbidity Functions from Epidemiology Literature

Lower-bound EE:
1,400
Upper-bound EE:
13,000

Confidence Intervals

CI for lower bound EE result:
(0 - 6,600)
CI for upper bound EE result:
(6,800 - 20,000)

Full Attainment

Based on Mortality Function from American Cancer Society and Morbidity Functions from Epidemiology Literature[a]

6,600

Confidence Intervals

(2,600 - 11,000)

Based on Expert Elicitation Derived Mortality Functions and Morbidity Functions from Epidemiology Literature

Lower-bound EE:
2,300
Upper-bound EE:
22,000

Confidence Intervals

CI for lower bound EE result:
(0 - 11,000)
CI for upper bound EE result:
(11,000 - 32,000)

[a] Based on Pope et al 2002, used as primary estimate in recent RIAs.

Table A-6. Estimated Monetary Valuation of Reduction in Incidence of Adverse Health and Welfare Effects Associated with Attaining the 1997 Standards (billions 1999$)

Based on Mortality Function from American Cancer Society and Morbidity Functions from Epidemiology Literature[a]	
Using a 3% discount rate	$48 + B *Confidence Intervals* ($11 - $100)
Using a 7% discount rate	$41 + B *Confidence Intervals* ($9.5 - $88)
Based on Expert Elicitation Derived Mortality Functions and Morbidity Functions from Epidemiology Literature	
Using a 3% discount rate	$20 + B to $160 + B CI for lower bound EE result ($1.4--95) CI for upper bound EE result ($39—$310)
Using a 7% discount rate	$18 + B to $130 + B CI for lower bound EE result ($1.4—$82) CI for upper bound EE result ($33—$260)

[a] Based on Pope et al 2002, used as primary estimate in recent RIAs.

A.5 Engineering Cost Estimates

In this section, we provide engineering cost estimates of the control strategies identified above that include control technologies on non-EGU stationary sources, area sources, electric generating units, and mobile sources. Engineering costs generally refer to the capital equipment expense, the site preparation costs for the application, and annual operating and maintenance costs. The total annualized cost of each control scenario is provided in Table 13 and reflects the engineering costs across sectors that are annualized at an interest rate of 7% and 3%, respectively. Total annualized costs of meeting the 1997 standards based on our illustrative analysis is approximately $6.7 billion (1999$).

As is discussed throughout this report, the technologies and control strategies selected for analysis are illustrative of one way in which nonattainment areas can meet the revised standards. There are numerous ways to compile and evaluate potential control programs to comply with the standards, and EPA anticipates that State and Local governments will consider those programs that are best suited for local conditions. As such, the costs described in this chapter generally cover the costs of purchasing and installing the referenced technologies. Because we are not certain of the specific actions that State Agencies will take to design State Implementation Plans to meet the revised standards, we do not present estimated costs that government agencies may incur for managing the requirement and implementation of these control strategies or for offering incentives that may be necessary to encourage or motivate the implementation of the technologies, especially for technologies that are not necessarily market driven. Control measure costs referred to as "no cost" may require limited government agency resources for administration and oversight of the program, but those costs are outweighed by the saving to the industrial, commercial, or private sector. This analysis does not assume specific control measures that would be required in order to implement these technologies on a regional or local level.

Table A-6: Comparison of Total Annualized Costs Across PM NAAQS Scenarios from Attaining the 1997 Standards (millions of 1999 dollars, 7% interest rate)

Source Category	*1997 Standards: 15/65 μg/m³*
EGU's	
Local Controls on direct PM	$130
Local Controls for NO_X	< $1
Total	
Mobile Sources	
National Rules	$1,400
Local Rules	$20
Total	**$1,400**
Non-EGU's	
Point Sources (Ex: Pulp & Paper, Iron & Steel, Cement, Chemical Manu.)	
Local Known Controls	$450
Area Sources (Ex: Res. Woodstoves, Agriculture)	$50
Developmental Controls	$50
Total	**$600**
Incremental Cost of Residual Nonattainment	
California	$4,600
Grand Total	**$6,700**

Using a 3% discount rate the overall costs would not be significantly different given the degree of precision in these estimates. For the purposes of comparing the costs to benefits in the subsequent section we use the $6.7 billion figure.

Table A-7: Total Annualized Costs Applied to Non-EGU Stationary Sources (millions of $1999)

State	*Pollutant*	*Total Annualized Cost of 15/65*	*Comments & Notations*
Alabama	$PM_{2.5}$	$12	Controls were selected to meet the annual standards of 15.
	Total	***$12***	
California	NO_x	$230	All available controls are applied to meet 15/65.
	$PM_{2.5}$	$19	
	SO_2	$160	
	Total	***$410***	
Georgia	$PM_{2.5}$	<$1	
	Total	***<$1***	
Illinois	$PM_{2.5}$	$4	
	Total	***$4***	
Indiana	$PM_{2.5}$	$14	
	Total	***$14***	
Kentucky	$PM_{2.5}$	$69	
	Total	***$69***	
Michigan	$PM_{2.5}$	$5	
	Total	***$5***	
Ohio	$PM_{2.5}$	$6	
	Total	***$6***	
Pennsylvania	$PM_{2.5}$	$4	Control strategies required non-EGU stationary controls.
	Total	***$4***	
West Virginia	$PM_{2.5}$	$2	Although West Virginia attains the scenarios analyzed, controls strategies identified areas that may contribute to nonattainment issues in other locations. This analysis assumes State authorities will coordinate to define control strategies that bring an area into attainment at the lowest social cost.
	Total	$2	
Wisconsin	$PM_{2.5}$	<$1	Although Wisconsin attains the current standard, control strategies identified areas that may contribute to nonattainment issues in other locations. This analysis assumes State authorities will coordinate to define control strategies that bring an area into attainment at the lowest social cost.
	Total	***<$1***	
Total Annualized Costs for the Non-EGU point source sector		***$456***	

Table A-8: Total Annualized Costs Applied to Non-EGU Area Sources (millions of $1999)

State	*Pollutant*	*Total Annualized Cost of 15/65*	*Observations*
California	NH_3	$41	All available controls are applied to meet 15/65.
	NO_x	$6	
	$PM_{2.5}$	$36	
	SO_2	<$1	
	Total	***$82***	
Georgia	$PM_{2.5}$	$2	
	Total	***$2***	
Illinois	$PM_{2.5}$	$4	
	Total	***$4***	
Indiana	$PM_{2.5}$	<$1	
	Total	***<$1***	
Kentucky	$PM_{2.5}$	<$1	
	Total	***<$1***	
Michigan	$PM_{2.5}$	$5	Controls for direct $PM_{2.5}$ emissions are most effective to meet the current standard.
	Total	***$5***	
Montana	NO_x	<$1	
	$PM_{2.5}$	<$1	
	Total	***<$1***	
Ohio	$PM_{2.5}$	$4	
	Total	***$4***	
Pennsylvania	$PM_{2.5}$	$1	
	Total	***$1***	
West Virginia	$PM_{2.5}$	<$1	Although West Virginia attains the scenarios analyzed, controls strategies identified areas that may contribute to nonattainment issues in other locations. This analysis assumes State authorities will coordinate to define control strategies that bring an area into attainment at the lowest social cost.
	Total	***<$1***	
Wisconsin	$PM_{2.5}$	$2	Although Wisconsin attains the current standard, control strategies identified areas that may contribute to nonattainment issues in other locations. This analysis assumes State authorities will coordinate to define control strategies that bring an area into attainment at the lowest social cost.
	Total	***$2***	
Total Annualized Cost for the Area Source Sector		***$100***	

A.5.2 EGU Sources

Costs of Controls Outside the CAIR Region and Costs of Direct PM Controls Nationwide

Controls selected are focused on those controls that are not considered part of the CAIR rule, such as direct $PM_{2.5}$ control technologies, and in the Western U.S. controls for NO_x emissions from these sources. The direct PM and NO_x controls for EGU's were selected only when this sector was identified as a cost-effective and cost-efficient category for control strategies. In Table A-9, incremental EGU controls for the selected standard are chosen only in a limited number of States, including: Ohio, Pennsylvania, Utah, and Washington, and are selected to help these areas attain a more stringent daily standard.

Table A-9: Total Incremental Annualized Costs Applied to EGU Sources using AirControlNET

State	*Pollutant*	*Total Annualized Cost of 15/65*
California	NO_x	$441,684
	$PM_{2.5}$	$16,529,576
	Total	*$16,971,260*
Georgia	$PM_{2.5}$	$15,249,636
Illinois	$PM_{2.5}$	$421,706
Indiana	$PM_{2.5}$	$4,713,815
Kentucky	$PM_{2.5}$	$2,831,073
Michigan	$PM_{2.5}$	$39,323,118
Ohio	$PM_{2.5}$	$33,284,252
Pennsylvania	$PM_{2.5}$	$8,727,457
West Virginia	$PM_{2.5}$	$11,884,446
Wisconsin	$PM_{2.5}$	$509,499
Total Annualized Cost for EGU sources from ACNet		***$133,474,578***

A.5.3 Mobile Sources

This section presents cost information for each mobile source control technology included in the analysis. Costs for the individual technologies are in terms of $/ton of emissions reduced and are based on a 7% discount rate. These values were applied to the tons of emissions reduced in each geographic area and were then summed to determine total costs for each scenario. Note that control technologies or measures that affect emissions from mobile sources frequently have impacts on multiple pollutants. Where this is the case, we attempt to provide information on our cost calculation methodology with respect to the pollutants of concern.

Note Regarding Mobile Source Air Toxics Rule

The recent proposal to reduce mobile source air toxics (71 FR 15804, March 29, 2006) discusses data showing that direct $PM_{2.5}$ emissions from gasoline vehicles are elevated at cold temperatures. The proposed vehicle hydrocarbon standards contained in the March 29, 2006 action would also 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 cold-temperature emissions are not included in our baseline emission inventories, which may understate the baseline—and consequently projected—inventory of mobile source $PM_{2.5}$ emissions. The final mobile source air toxics rule would thus reduce $PM_{2.5}$ emissions, and improve air quality, by an amount not reflected in our analysis of these standards and may make compliance easier by reducing the need for some control strategies. EPA is currently analyzing these data from a large collaborative test program with industry, and our next emissions model (MOVES) will include cold temperature effects for PM.

Geographical Scope of Mobile Source Controls

It is important to clarify the sequence by which mobile source control measures were applied within the broader context of all control measures. In applying the cost information for the 15/65 scenario, we first applied cost-effective local stationary source (point and area) controls and national mobile source control rules. Next, due to time and analytical constraints, we applied local mobile source control measures only in areas that we had identified as needing a small additional amount of emission reductions would to reach attainment (in this case, only in Chicago) and areas where all available control measures were needed (e.g., parts of southern California). However, this does not imply that State and local authorities will sequence application of control measures in a similar fashion. State and local governments may have numerous reasons for employing mobile source control strategies *before* a set of measures that control point or area sources (for example, further point source controls would be less cost-effective than mobile measures, and/or an area's stationary sources are already well-controlled).

Table A-10: Geographic Areas to which Mobile Source Controls were applied for 15/65

Geographic Area	15/65 Scenario
National Rules	All counties in the U.S.
Local Measures	Southern California Chicago MSA

We divide control costs into two broad categories: national rules and local measures.

Estimated Costs of National Rules

The national mobile source rules discussed in this analysis are at various stages of regulatory development, but in all cases they are pre-proposal. Therefore, EPA has not developed new cost estimates. Rather, the costs used in this analysis are based on cost-per-ton estimates of previous EPA rulemakings for controls of similar sources using similar control technologies. No new analysis has been performed as of yet since regulatory development is still underway. We therefore assume for the purposes of this analysis that the costs of controls on these sources to be on the same order of magnitude as our experience in recent mobile source rulemakings, but these cost estimates are based on limited information and broad assumptions about the measures we would include for the final rulemaking.

PM and NOx cost-per-ton estimates for diesel locomotives and diesel marine categories 1 and 2 engines are based on the estimates developed by EPA for the highway heavy-duty 2007 rule and the nonroad land-based diesel Tier 4 rule. These cost-per-ton values are shown in Table A-11 below. In both cases, these previous rule cost estimates were based on the application of advanced PM and NOx after treatment systems (e.g., catalyzed diesel particulate filters and NOx catalysts).

Table A-11: Cost-per-ton Estimates from EPA's Highway Heavy-duty 2007 Rule and Nonroad Land-based Diesel Tier 4 Rule

	30-yr discounted life-time cost-per ton (7% discount)	
Previous National Mobile Source Rule	*PM*	*NMHC+NOx*
Highway HD 2007 (66 FR 5102, 1999$)	$13,607	$2,149
Nonroad Diesel Tier 4 (69 FR 39131, 2002$)	$11,800	$1,160

For the C3 marine Scenario 1, 50% reduction from today's ocean-going vessels for NOx and PM were based on EPA's nonroad land-based diesel Tier 2 and Tier 3 standards. The nonroad land-based Tier 2 and Tier 3 program cost-per-ton estimates were based on in-cylinder control technologies such as improved fuel injection systems, intake charge-air-cooling, and exhaust gas recirculation. The nonroad land-based diesel Tier 2 and 3 standards cost-per-ton estimates were in the $400 - $600/ton range for NMHC+NOx. The nonroad land-based diesel Tier 2 cost-per-ton estimate for PM was $2,300/ton. For PM, EPA did not estimate any addition reduction from the land-based diesel Tier 3 program, and the PM $/ton estimate for the Tier 2 land-based diesel program was a combined estimate for the Tier 1 and Tier 2 standards.

The estimate used in this analysis for a national mobile source rule covering small gasoline engines less than 25 horsepower and gasoline marine engines was based on previous rulemakings for these two source categories. EPA's small gasoline engine Phase 2 standards for nonhandheld engines estimated a cost-per-ton for HC+NOx was $2,000, excluding any cost-savings due to improved fuel consumption. EPA's existing gasoline outboard and personal watercraft marine engine program estimated a cost-per-ton of $2,000 for HC. These estimates of cost-effectiveness for mobile source national rules can be found in Table A-12.

Note that some of these rules, especially the small gasoline engine rule, have little impact on PM but were included in an attempt to be as comprehensive as possible.

Table A-12: Cost Effectiveness of Mobile Source National Rules

	Estimated cost ($/ton)		
National Rule	*PM*	*HC*	*NOx*
Diesel locomotive and marine C1&C2	$10,000		$2,000
C3 marine, Scenario 1 (50% reduction)	$2,500		$500
C3 marine, Scenario 2 (90% reduction)	$10,000		$2,000
Small gasoline and recreational gasoline marine		$2,000	$2,000
Ocean-going vessels (SO_x: cost info TBD)			

*Note: While SOx reduction from residual oil in ocean-going vessels could be accomplished by a variety of measures, the cost presented above is taken from a technology similar to the option of applying a scrubber. As a surrogate we use the cost for flue-gas desulfurization (FGD) scrubbing at an industrial boiler greater than 250 MMBtu/hr (AirControlNET Documentation Report, May 2006).

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.

Estimated Costs of Local Measures

Diesel Retrofits and Vehicle Replacement - For purposes of modeling, we divided the retrofit measure into two categories: the 1st 50% of retrofit potential (low end) and the 2nd 50% of retrofit potential (high end) to provide modeling and analytical flexibility with how such measures are applied. For example, such a division would help when applying retrofit measures to a nonattainment area in which only 50% of retrofit potential is adequate to achieve attainment. We categorize the low end as the most cost-effective retrofits since, ideally, states and local governments would first retrofit the most cost-effective fleets in terms of expected emissions reduction (based on vehicle miles traveled or VMT, expected life, model year, engine type, etc.) and cost of retrofit (based on technology and installation costs).

The cost-effectiveness ($/ton of PM) estimates for retrofits are based on EPA's recent study of DOC and catalyzed DPF (CDPF) retrofits for school buses as well as class 6, 7, and 8b trucks; and just DOC retrofits for 250 hp bulldozers (the "C-E study"). The C-E study is available at http://www.epa.gov/cleandiesel/documents/420s06002.pdf. For purposes of this analysis, we believe this study is the best source of information since it is based on the most current data available. However, the C-E study was intentionally narrow in scope, and in using its data for an analysis as comprehensive as this analysis, raises a number of limitations that affect the data's applicability. For example:

- The C-E study does not address several categories of engines analyzed in the retrofit measure for this analysis (e.g. Class 5 trucks, most nonroad engines).
- The C-E study does not estimate cost-effectiveness for repower or replacement, which are both included in the retrofit measure for this analysis.
- The C-E study is based on 2007 costs for technologies and emissions data for fleets. VMT, technology costs, and other variables will be different in 2015 and 2020.
- For highway engines, the C-E study is based on emission factors from recent testing which are roughly 2.3 times higher than emissions factors found in MOBILE 6.2. EPA used the MOBILE 6.2 model to develop the inventory for this analysis and to analyze emissions reduction potential from retrofits. EPA will integrate the recent highway vehicle testing data into the next highway emissions model, MOVES. In the meantime, states and local governments will continue to use MOBILE 6.2 to estimate highway vehicle emissions for SIP and transportation conformity purposes.

For estimating the more cost-effective highway vehicle retrofits, we averaged the low end of the cost-effectiveness range of both measures (DOC and CDPF) for all three groups of highway vehicles in the C-E study (school buses, class 6 & 7 trucks, and class 8b trucks). For estimating the less cost-effective highway retrofits, we used the average of the range of cost-effectiveness of both measures and all three groups of vehicles. We used the average, rather than the high end of the cost-effectiveness range, because we believe that technology and installation costs are likely to decrease by 2015.

For the estimate of the cost-effectiveness of the low end potential of nonroad engine retrofits, we used the low end of the cost-effectiveness range for DOC retrofits of 250 hp bulldozers. For the estimate of the cost-effectiveness of the high end potential of nonroad engine retrofits, we used the average of the range of cost-effectiveness for DOC retrofits of 250 hp bulldozers. Again, we used the average, rather than the high end of the cost-effectiveness range, because we believe that technology and installation costs are likely to decrease by 2015. The results are presented in Table A-13 below:

Table A-13. Cost Effectiveness for Diesel Retrofit Scenarios

Summary of Cost-Effectiveness for Various Diesel PM Retrofit Scenarios (April 2006 EPA Study) $/ton PM				
	Measure	**Min**	**Max**	**Average**
School Bus	DOC	$12,000	$49,100	$30,550
	CDPF	$12,400	$50,500	$31,450
Class 6&7 Truck	DOC	$27,600	$67,900	$47,750
	CDPF	$28,400	$69,900	$49,150
Class 8b Truck	DOC	$11,100	$40,600	$25,850
	CDPF	$12,100	$44,100	$28,100
250 hp Bulldozer	DOC	$18,100	$49,700	$33,900

Application to PM NAAQS RIA Package of Retrofit Measures (DOC, DPF, Repower, Replace) $/ton PM	
Highway (low end)	**$17,267**
Highway (high end)	**$35,475**
Nonroad (low end)	**$18,100**
Nonroad (high end)	**$33,900**

Note that these $/ton PM estimates are applied across the board for all types of retrofit measures (DOCs, CDPFs, repower, replacement) and highway vehicle and nonroad engine types.

The overall cost-effectiveness of this measure is estimated to be:

- Highway 1st 50% - $17,267/ton PM
- Highway 2nd 50% - $35,475/ton PM
- Nonroad 1st 50% - $18,100/ton PM
- Nonroad 2nd 50% - $33,900/ton PM

Eliminating Long Duration Truck Idling - For purposes of this analysis, we identified this measure as a no cost strategy: that is to say, at $0/ton PM. Both truck stop and terminal electrifications and mobile idle reduction technologies have upfront capital costs, but for the most part these costs can be fully recovered by fuel savings. The examples below illustrate the potential rate of return on investments in idle reduction strategies.

Truck Stop and Terminal Electrifications (TSEs) The average price of TSE technology is $11,500 per parking space. The average service life of this technology is 15 years. Truck engines at idle consume approximately 1 gallon per hour of idle. Current TSE projects are operating in environments where trucks are idling, on average, for 8 hours per day per space for 365 days per year (or about 2,920 hours per year). Since TSE technology can completely eliminate long duration idling at truck spaces (i.e. a 100% fuel savings), this translates into 2,920 gallons of fuel saved per year per space. At current diesel prices ($2.90/gallon), this fuel savings translates into $8,468. Therefore, an $11,500 capital investment should be recovered within about 17 months. In this scenario, TSE investments offer over a 70% annual rate of return over the life of the technology.

While it is technically feasible to electrify all parking spaces that support long duration idling trucks, we should note that TSE technology is generally deployed at a minimum of 25-50 parking spaces per location to maximize economies of scale. The financial attractiveness of installing TSE technology will depend on the demonstrated truck idling behavior – the greater the rates of idling, the greater the potential emissions reductions and associated fuel and cost savings.

Mobile Idle Reduction Technologies (MIRTs). The price of MIRT technologies ranges from $1,000-$10,000. The most popular of these technologies is the auxiliary power unit (APU) because it provides air conditioning, heat, and electrical power to operate appliances. The average price of an APU is $7,000. The average service life of an APU is 10 years. An APU consumes two-tenths of a gallon per hour, so the net fuel savings is 0.80 gallons per hour. EPA estimates that trucks idle for 7 hours per rest period, on average, and about 300 days per year (or 2,100 hours per year). Since idling trucks consume 1 gallon of fuel per hour of idle, APUs can reduce fuel consumption for truck drivers/owners by approximately 1,680 gallons per year. At current diesel prices ($2.90/gallon), truck drivers/owners would save $4,872 on fuel if they used an APU. Therefore, a $7,000 capital investment should be recovered within about 18 months. In this scenario, APU investments offer almost a 70% annual rate of return over the life of the technology.

Intermodal Transport - We believe that a 1% shift is viable and could occur at a low or no cost, since rail is likely to be less expensive than truck transport due primarily to lower fuel costs. For purposes of economic analysis, we identified this measure as a no cost strategy ($0/ton PM). A certain level of intermodal shifting may require new investments in rail infrastructure, but these costs should be fully recovered over time by the fuel and other transport cost savings. We did not have adequate data to conduct a more detailed cost analysis. Our understanding of costs is based on anecdotal evidence and confidential business information from partners in EPA's SmartWay Transport Partnership program. There will be a great deal of variability in the financial attractiveness of transitioning to intermodal transport versus truck-only transport based on the capacity of current rail infrastructure; willingness of rail and truck companies to cooperate; the rail industry's ability to make capital investments; and local government support for accommodating additional rail lines, rail facilities, and rail operation flexibility.

Best Workplaces for Commuters (BWC) - We used the Transportation Research Board's (TRB) cost-effectiveness analysis of Congestion Mitigation and Air Quality Improvement Program (CMAQ) projects to estimate the cost-effectiveness of this measure.[4] TRB conducted an extensive literature review and then synthesized the data to develop comparable estimates of cost-effectiveness of a wide range of CMAQ-funded measures. We took the average of the median cost-effectiveness of a sampling of CMAQ-funded measures and then applied this number to the overarching BWC measure. The CMAQ-funded measures we selected were:

- regional rideshares

[4] Transportation Research Board, National Research Council, 2002. *The Congestion Mitigation and Air Quality Improvement Program: assessing 10 years of experience*, Committee for the Evaluation of the Congestion Mitigation and Air Quality Improvement Program.

- vanpool programs
- park-and-ride lots
- regional transportation demand management
- employer trip reduction programs

We felt that these measures were a representative sampling of BWC incentive programs. There is a great deal of variability, however, in the type of programs and the level of incentives that BWC employers offer, which can impact both the amount of emissions reductions and the cost of BWC incentive programs.

We chose to apply the resulting average cost-effectiveness estimate to one pollutant – NO_x – in order to be able to compare BWC to other NO_x reduction strategies. TRB reported the cost-effectiveness of each measure, however, as a $/ton reduction of both VOC and NOx by applying the total cost of the program to a 1:4 weighted sum of VOC and NOx [total emissions reduction = (VOC * 1) + (NO_x * 4)]. There was not enough information in the TRB study to isolate the $/ton cost-effectiveness for just NO_x reductions, so we used the combined NO_x and VOC estimate.

We chose to report the cost-effectiveness of controlling NO_x over PM 2.5 for two reasons. First, BWC has a greater impact on NO_x emissions than PM 2.5 since it targets light-duty gasoline vehicles which have very low levels of PM 2.5 emissions. Second, the TRB study did not report cost-effectiveness information for PM 2.5 due to the lack of available data. The results are presented in Table A-14 below:

Table A-14. Cost-Effectiveness for Best Workplaces for Commuters Programs

	Low	*High*	*Median*
Regional Rideshare	$1,200	$16,000	$7,400
Vanpool Programs	$5,200	$89,000	$10,500
Park-and-ride lots	$8,600	$70,700	$43,000
Regional TDM	$2,300	$33,200	$12,500
Employer trip reduction programs	$5,800	$175,500	$22,700
Average of All Measures	$4,620	$76,900	**$19,200**

The overall cost-effectiveness of this measure is estimated as $19,200 per ton of NOx reduced.

Table A-15: Total Annualized Costs Applied to Mobile Sources for 15/65 (millions of 1999$)

Geographic Area	*PM2.5*	*NOx*	*VOC*
Eastern U.S.			
- National Rules	$ 88	$ 400	$440
- Local Measures	$ 2.7	$ 3	$0
Western U.S. (except CA)			
- National Rules	$50	$140	$120
- Local Measures	$0	$0	$0
California			
- National Rules	$13	$69	$57
- Local Measures	$7.1	$7.9	$0
Total Annualized Cost for Mobile Sources	***$160***	***$620***	***$610***

Estimating the Attainment Cost for California

To estimate the cost for California to attain the 1997 standards, we employed the same cost-estimation methodology found in Chapter 6. Table A-16 below summarizes these full attainment costs.

Table A-16: Cost Estimate for California to Meet 1997 Standards in 2015 (million 1999$)[5]

Standard	*NOx Controls Only*	*PM Controls Only*	*NOx and PM Controls*
1997 Standards of 15/65 in 2015			
Modeled	$660	$660	$660
Full	$7,800	$2,900	$4,600
Total	$8,500	$3,600	$5,300

A.6 Comparison of Benefits and Costs

Table A-17: Comparison of Benefits with Social Costs (Million 1999$): Primary Estimate Using Concentration-Response Function Developed from ACS Study Estimate of Mortality

	1997 Standards of 15/65 (µg/m³)[a]		
	Benefits	*Costs*	*Net benefits*
3 percent discount rate**			
East	$9,200	$1,200	$8,000
West	$200	$340	($140)
California	$39,000	$5,400	$34,000
Total	***$48,000***	***$7,000***	***$41,000***
7 percent discount rate			
East	$7,900	$1,200	$6,700
West	$180	$340	($160)
California	$33,000	$5,400	$28,000
Total	***$41,000***	***$7,000***	***$35,000***

[a] The effect estimate used to derive benefits in this table is based on the concentration-response (C-R) function developed from the study of the American Cancer Society cohort reported in Pope et al (2002), which has previously been reported as the primary estimate in recent RIAs.

[5] Note: numbers may not total due to rounding.

Table A-18. Estimate of Net Benefits Using Expert Elicitation-Derived Estimates, Derived Using Social Cost (Millions 1999$)

Using a 3% discount rate	150,000 to 14,000
Using a 7% discount rate	120,000 to 11,000