Appendix B

Direct Costs

Introduction

In this appendix, we present the estimation of direct compliance costs associated with the Clean Air Act Amendment programs under Title I through V that control the following criteria pollutants:

- Volatile organic compounds (VOCs)
- Oxides of Nitrogen (NO_x)
- Carbon monoxide (CO)
- Sulfur dioxide (SO_2)
- Particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10})
- Particulate matter with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$)

The first section of the appendix provides a general overview of our methodology for estimating direct compliance costs and the models used in the analysis.[1] The following section presents costs first by emission sources and then by CAAA title. Cost by emission source reviews the specific costing approach (i.e., source-specific cost equations or operating cost estimates), sources of data, and emission control scenarios applied to five regulated sectors and ozone nonattainment areas. Costs are also presented by CAAA title, where the cost components (i.e., the emission sources and provision) are identified for Titles I through V. In the following section, we discusses several additional issues related to fully accounting for the broader economic consequences of reallocating resources to the production and use of pollution abatement equipment (i.e., estimating social costs versus direct compliance costs). We conclude with a discussion of analytic limitations and characterizations of the potential impact of several key uncertainties of cost estimates.

Summary of Methods

We use two modeling approaches to calculate cost estimates under Post-CAAA control scenarios in the projection years, 2000 and 2010. The control assumptions (i.e. emissions scenarios) used as inputs in the models are consistent with the assumptions used in the analysis of both emissions projections and benefits. The cost data used as parameters in these models includes results and information from EPA regulatory impact assessments (RIAs), background information documents (BIDs), regulatory support documents, and Federal Register notices.

ERCAM Model

We use ERCAM to estimate the costs associated with regulating particulate matter (PM), volatile organic compounds (VOCs), and non-utility oxides of nitrogen (NO_x).[2] The model is essentially a cost-accounting tool that provides a structure for modifying and updating changes in inputs while maintaining consistency with the emission and cost analyses. Cost scenarios and assumptions are developed for source categories (e.g., point, area, nonroad, and motor vehicle sources) and in response to specific provisions and emission targets. The model estimates costs based on inputs such as cost per ton, source-specific cost equations, incremental production, and operating cost estimates. For this analysis, we collected data and inputs from information presented in regulatory impact assessments (RIAs), background information documents (BIDs), regulatory support documents, and Federal Register notices.

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[1] This appendix is a condensed version of more detailed reports completed under EPA's direction. For more details see Pechan, 1998.

[2] This model was developed by E. H. Pechan & Associates, Inc. to facilitate EPA's analysis of emissions control.

IPM Model

We rely on a utility planning model, Integrated Planning Model (IPM), to estimate the costs of NO_x and SO_2 controls for electric utilities. IPM is a linear program/optimization model that can estimate costs and emissions based on key constraints and parameters. One of the significant advantages to this model is that it provides the analysis with flexibility in the level of detail for characterizing constraints and economic assumptions. In this analysis, the model estimates compliance costs based on assessing the optimal mix of pollution control strategies subject to a series of specified constraints. Key inputs to the model include targeted emissions reductions (on a seasonal and annual basis), characteristics of control technology, and economic parameters. The characteristics of control technology examines operational costs and constraints associated with the performance of existing and new utility generating units. Examples of inputs for existing units include plant capacity, fuel usage rates, fixed and variable O&M costs. For new utility generating units, inputs are generally associated with unit characteristics such as capacity and costs of capital. Economic assumptions include the projected electric industry growth, changes in seasonal and regional demand, and forecasts of fuel prices.

Additional Methods

We estimate non-utility SO_2 emission control costs for point sources by applying source-specific cost equations for flue gas desulfurization (FGD)/scrubber technology to affected sources in 2000 and 2010. While we do not explicitly model CO attainment costs, we include in the analysis the costs of programs designed to reduce CO emissions, such as oxygenated fuels and a cold temperature CO motor vehicle emission standard.

Annualization of Costs

The costs presented in this analysis are total annualized costs (TAC) in 2000 and 2010. Annualized costs include both capital costs, such as costs of control equipment, and operation and maintenance (O&M) costs.[3] They do not represent actual cash flow in a given year, but rather are an estimate of average annual burden over the period during which firms will incur costs (i.e., equipment life). In annualizing costs, we convert total capital investment, plus O&M and other re-occurring costs, to a uniform series of per-year expenditures over a given time period. The discounted sum of these annual expenditures is equal to the net present value of total costs incurred over the time period of this analysis.[4]

CAAA Costs

We estimate costs of implementing the Clean Air Act Amendments under two Post-CAAA scenarios, 2000 and 2010. The estimates, therefore, represent differences in costs between pre- and post-scenarios in each of the two years. The cost estimates for implementing Titles I through V of the Clean Air Act Amendments are $19 billion under the Post-CAAA 2000 scenario and $27 billion under the Post-CAAA 2010 scenario. All costs are in 1990 dollars. This appendix presents the costs first by source and then by title.

This section summarizes our costing methods and results for the following CAAA regulated sectors:

- Industrial point sources
- Electric utilities
- Nonroad engines and vehicles
- Motor vehicles
- Area sources
- Ozone nonattainment areas

Compliance with the CAAA provisions for motor vehicles is the single largest cost component: $9 billion for the Post-CAAA 2000 scenario, and $12 billion for Post-CAAA 2010. The costs of compliance

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[3] For a few VOC source categories, we estimate that capital investment will not be necessary; for these sources, compliance costs reflect O&M costs only.

[4] We re-calculate the control cost estimates from regulatory documents that use a seven or ten percent discount rate so that the costs will be consistent with the five percent discount rate assumption used in this analysis. We also calculate cost using three percent and seven percent discount rates, as sensitivity tests: for detail see the discussion of uncertainty later in this appendix.

for industrial point sources, utilities, and area sources are somewhat smaller; they range from $3 to $5 billion dollars each. Table B-1 summarizes the cost estimates by year and emissions source.

Table B-1
Summary of Cost Estimates by Emissions Source

	Annual Cost (million 1990 dollars)	
Sector/Pollutant	**Post-CAAA 2000**	**Post-CAAA 2010**
Total Non-utility Point	**$ 2,900**	**$ 3,400**
Non-utility Point/VOC	900	960
Non-utility Point/NO_x	1,700	2,100
Non-utility Point/Non-VOC MACT[1]	310	320
Utility/SO_2 and NO_x	**$ 3,100**	**$ 4,600**
Non-Road Engines/Vehicles	**$ 100**	**$ 400**
Motor Vehicles	**$ 9,100**	**$ 12,300**
Total Area Sources	**$ 2,900**	**$ 3,300**
Area/VOC	920	1,000
Area/NO_x	16	18
Area/PM	1,900	2,200
Progress Requirements	**$ 1,200**	**$ 2,500**
Permits[2]	**$ 300**	**$ 300**
TOTAL	**$ 19,400**	**$ 26,800**

Notes:

[1] Costs reflect estimates of annualized costs from final rules. Source categories are not modeled in ERCAM-VOC because the National Emission Standards for Hazardous Air Pollutants (NESHAPs) are associated with non-VOC HAP emission reductions, and are therefore not included in the Post-CAAA 2000 and 2010 inventories.

[2] These costs include costs only for State-implemented permitting programs. We exclude the costs of Federally-implemented programs since all Title V permit programs will be State-run in 2005.

Industrial Point Sources

Industrial point sources are non-utility sources that are large enough to be included in the 1990 emissions data base as individual sources of emissions. To determine the level of air pollution controls necessary for reducing emissions under the 2000 and 2010 Post-CAAA scenarios, we apply the following CAAA controls to point source emission inventory:

- Title III 2-year and 4-year MACT standards for VOCs
- Title I CTGs for controlling VOCs
- Title I VOC and NO_x RACT requirements in ozone NAAs
- A 0.15 lbs/MMBtu NO_x cap on fuel combustors of 250 MMBtu per hour or above in the OTAG 37-State region
- Ozone NAA rate-of-progress requirements

To estimate the quantity and type of VOC controls, we apply point source Title I RACT and

CTGs requirements in areas according to ozone nonattainment classification. The Clean Air Act requires VOC controls in moderate and above ozone nonattainment areas (NAA) and throughout the ozone transport region (OTR). Existing controls are taken into consideration in our determination of which CAA-mandated controls are necessary to limit projected emissions. We use a threshold of ten percent efficiency for this determination. We calculate costs for new control if the existing control is less efficient than the model control by more than ten percent (i.e. emissions changes of less than ten percent are assumed to be *de minimus* and are not included in the cost estimate).

To estimate the quantity and type of NO_x controls, we apply these controls to the point source inventory on a year-round basis. The ozone nonattainment provisions of Title I require installation of RACT-level controls for major stationary sources of NO_x located in marginal and above NAAs and the northeast OTR. We determine affected source sizes according to ozone nonattainment classifications. The analysis applies the 0.15 lbs/MMBtu NO_x limit to industrial boilers at or above 250 MMBtu per hour in the Ozone Transport Assessment Group (OTAG) region to approximate the effects of NO_x initiatives under consideration. We also account for Title I requirements that include the application of Level 2 controls in the OTAG region.

Cost Approach

We use ERCAM-VOC and ERCAM-NO_x models for generating cost estimates. Model inputs include costs per ton and incremental cost estimates derived from RIAs and from control measure information provided by EPA, States, industry, and other agencies.[5] Using the projected 2000 and 2010 emission inventories, we also estimate costs by applying cost equations to the following individual source categories:

- Adipic and nitric acid manufacturing plants
- Cement manufacturing
- Gas turbines
- Glass manufacturing
- Industrial boilers
- Internal combustion engines
- Iron and steel mills
- Medical waste incinerators (MWIs)
- Municipal waste combustors (MWCs)
- Process heaters

For some source categories, capital and O&M cost estimates are available in the literature for two or more source sizes typical to that category. For these cases, we apply size-specific cost equations. Operating characteristics and source size, both of which influence the ease of retrofit, reduction performance, and control costs, are major factors in determining costs of controls. Although site specific characteristics can affect the overall cost, this type of information is not available in the emission inventory. Therefore we model costs based on a "typical" set of controls.

For source categories with insufficient data, we estimate annual costs for controls using average cost per ton values from the ACTs, instead of size specific cost equations. These values do not account for economies of scale or variations in capacity factor, which generally impact the cost per ton of pollutant reduced.

Recovery Factor

ERCAM-VOC and ERCAM-NO_x cost equations use a five percent discount rate and a 15-year equipment life, or a capital recovery factor (CRF) of 0.096. To calculate the capital recovery factor for converting capital charges to equivalent annual costs, we use the following formula:

$$CRF = [i * (1 + i)^n] / [(1 + i)^n - 1]$$

where i = pre-tax marginal annual rate of return (discount rate), and
n = equipment economic life (in years).

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[5] The Agency bases cost effectiveness values for rules that have not yet been proposed on engineering judgement and technology transfer from other categories.

To obtain annual costs, we use the following algorithm:

$$\mathit{CRC} = \mathit{CRF} * \mathit{Capital\ Costs},$$

where CRC = capital recovery cost (or annualized capital cost).

Cost Results

Table B-2 summarizes estimated point source VOC control costs. we estimate costs to be approximately $901 million in 2000; of that total, $421 million will be Title I VOC controls costs and $480 million will result from the Title III MACT Standards. In 2010, the total annual cost of point source VOC controls is approximately $962 million: $440 million in Title I controls and $521 million in Title III controls.

Table B-3 summarizes the point source NO_x control costs under the 2000 and 2010 Post-CAAA scenarios. OTAG region costs under the 2000 Post-CAAA scenario total $1.6 billion, increasing to $2.1 billion by 2010. Point source NO_x control costs in the rest of the nation are $21 million under the 2000 Post-CAAA scenario and $22 million under the 2010 Post-CAAA scenario. Nationwide, ICI boilers bear the majority of point source NO_x control costs, which account for seventy-nine percent of the total costs in 2010.

Table B-2
Point Source VOC Cost Summary

	Annual Costs (million 1990 dollars)[1]	
Source Category	**Post-CAAA 2000**	**Post-CAAA 2010**
National Rules		
Marine vessel loading: petroleum liquids	$ 20	$ 30
TSDFs	Less than 0.1	Less than 0.1
New CTGs (moderate)		
Printing - lithographic	(0.7)	(0.7)
SOCMI distillation	0.1	0.1
SOCMI reactor	1.9	2.2
Non-CTG and Group III CTG RACT (moderate and above)		
Automobile surface coating	210	220
Bakeries	0.9	1.1
Beverage can surface coating	47	47
Carbon black manufacture	1.2	1.3
Charcoal manufacturing	0.0	0.0
Cold cleaning	17	18
Fabric printing	22	23
Flatwood surface coating	20	21
Leather products	1	1.1
Metal surface coating	51	57
Organic acids manufacture	1.7	2.0
Paint and varnish manufacture	2.5	2.8
Paper surface coating	5.5	5.5
Plastic parts surface coating	5.1	5.3
Rubber tire manufacture	1.4	1.4
SOCMI processes - pharmaceutical	3.7	4.1
Whiskey fermentation - aging	0.2	0.2

Source Category	Annual Costs (million 1990 dollars)[1] Post-CAAA 2000	Post-CAAA 2010
CTG RACT (marginal and above)		
Cellulose acetate manufacture	1.5	1.6
Dry cleaning - Stoddard solvants	0.1	0.1
In-line degreasing	(0.3)	(0.3)
Open top degreasing	(1.0)	(1.2)
Printing - letterpress	0.5	0.5
Terephthalic acid manufacture	2.3	2.5
Vegetable oil manufacture	Less than 0.1	Less than 0.1
Total Title I Costs	$ 420	$ 440
NESHAP		
Benzene NESHAP	$ 0.2	$ 0.2
2-Year MACT (national):		
Dry Cleaning - PCE	2.2	2.7
SOCMI HON:		
Chemical manufacture	12.0	13.0
SOCMI - process vents	2.1	2.4
SOCMI fugitives	(3.9)	(4.5)
SOCMI processes	22	26
VOL storage	1.5	1.7
4-Year MACT (national)		
Aerospace industry	3.5	4.7
Coke Oven Batteries	21	21
Gasoline distribution - Stage I	12	13
Halogenated solvent cleaning	(8.5)	(9.1)
Marine vessel loading: petroleum liquids[2]	17	20
Petroleum refineries: other sources not distinctly listed	40	45
Polymers and Resins Group I	110	130
Polymers and Resins Group II	4.3	5.0
Polymers and Resins Group IV	5.3	6.7
Printing and Publishing	200	210
Shipbuilding and ship repair	0.4	0.5
Wood furniture surface coating	37	38
Total Title III Costs	$ 480	$ 520
Total Point Source VOC Control Costs (Title I and Title III)	**$ 900**	**$ 960**

Notes:

[1] Control costs reflect growth projections and CAAA control assumptions relative to a 1990 baseline.

[2] The costs for the joint MACT/RACT rule for marine vessel loading are allocated between Title I and Title III based on the 58 percent/42 percent distribution in the addendum to the final rule (EPA, 1995b).

Table B-3
Point Source NO_x Summary

	Annual Costs (million 1990 dollars)	
Source Category	**Post-CAAA 2000**	**Post-CAAA 2010**
RACT (outside of OTAG Region)		
Adipic and Nitric Acid Manufacturing	$ <0.1	$ <0.1
Cement Manufacturing	1.7	1.7
Gas Turbines	0.7	0.7
Glass Manufacturing	3.1	3.2
ICI Boilers	14	15
Internal Combustion Engines	0.8	0.8
Iron & Steel Mills	<0.1	<0.1
Waste Combustors	0.1	0.1
Process Heaters	0.8	0.8
Subtotal (RACT outside of OTAG Region)	**$ 21**	**$ 22**
RACT/OTAG Level 2 (OTAG Region)		
Adipic and Nitric Acid Manufacturing	$ 31	$ 35
Cement Manufacturing	97	110
Gas Turbines	18	28
Glass Manufacturing	38	41
ICI Boilers	1,200	1,700
Internal Combustion Engines	190	190
Iron & Steel Mills	2.5	2.4
Waste Combustors	10	12
Process Heaters	21	23
Subtotal (RACT+OTAG Level 2+0.15 Cap)[1]	**$ 1,600**	**$ 2,100**
Total Point Source NO_x Control Costs	**$ 1,700**	**$ 2,100**

Notes:

[1] The 0.15 lbs/MMBtu cap on fuel combustors of 250 MMBtu per hour and above is only applied under the 2010 Post-CAAA scenario.

* Totals may not add due to rounding.

Utility Sources

The electric power industry is comprised of entities that generate and sell electricity under two types of conditions: (i) under firm contracts to electric utilities; (ii) directly to consumers as electric utilities. These entities include businesses, governmental agencies, and cooperative organizations. In this analysis, we include only independent power producers and cogeneration units in the contiguous United States that report to the North American Electricity Reliability Council (NERC).[6] We exclude a large number of electric utilities that simply distribute power since those facilities are unlikely to directly face CAAA regulations.

Scenarios

Our assumptions of electricity demand are based on NERC's 1994 generation forecast with a slight downward adjustment to reflect expected changes in demand due to the Administration's Climate Change Action Plan. In general, we expect that the industry will respond to CAAA regulations by adjusting the mix of fuel types for future generation capacity (i.e., increasing electricity generation by combined cycles and decreasing use of combustion turbines), rather than significantly altering production levels. Consequently, modeled differences in total generation capacity for Pre- and Post-CAAA scenarios are also relatively small and demand for electricity under both scenarios is essentially the same.[7]

The predominant emitters of air pollutants by the electric power industry are generation units that use fossil fuels. This includes coal-fired steam, oil/gas-fired steam, oil/gas combustion turbine, and natural gas combined cycle units. Under the Pre-CAAA regulatory scenario, we fix standards at prevailing 1990 levels. We assume that existing controls of carbon monoxide and particulate matter remain constant in both Pre- and Post-CAAA scenarios. The Post-CAAA regulatory scenario reflect standards that target these generation units and their emissions of SO_x and NO_x.[8]

In the Pre-CAAA scenario developed for utility SO_x emissions, we assume existing units satisfied State Implementation Plan (SIP) requirements which specify unit-specific permits for individual boilers or plants. Typically, these permits restrict sulfur-content levels of coal or fuel oil that are burned. In addition, new coal-fired units must continue to meet the New Source Performance Standards (NSPS) set in 1978. In the Post-CAAA scenario, units subject to compliance with Title IV Acid Rain Allowance Trading program are existing units that burn fossil fuels and are over 25 megawatts (MW) and all new units that burn fossil fuels (regardless of size). Lastly, compliance with the trading program is phased in by 2000.

Under the Pre-CAAA scenario, we do not model NO_x controls on existing sources. New sources must meet either existing New Source Performance Standards (NSPS) or Best Available Control Technology (BACT) standards, whichever is lower. In the Post-CAAA scenario, existing sources of NO_x emissions are regulated: (i) under Title I, where existing units comply with RACT requirements in ozone transport regions (OTR) and non-attainment areas (NAA), and (ii) under Title IV, where coal-fired units must meet with phased requirements by 2000.[9] New sources must meet the most stringent standard among the following, NSPS requirements of Title I,

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[6] We do not include trust territories, Alaska, and Hawaii in this analysis. Trust territories are not directly covered by the CAA. With respect to Alaska and Hawaii, these States generate such small amounts of power that excluding them does should not have a significant effect on the results of this analysis.

[7] Demand is 3.0 trillion kilowatt hours (kWh) in 2000 and 3.6 trillion kWh in 2010.

[8] Under both regulatory scenarios, we do not account for the costs of regulating air toxics. The Amendments mandate the Agency to evaluate the human health impact of utilities' air toxics emissions. In the case where harmful effects are determined, the Agency is required to promulgate regulation of their emissions. The Agency, however, has not reached any conclusions on air toxic emissions from power plants.

[9] The OTR consists of New England, New York, Pennsylvania, New Jersey, Delaware, Maryland, District of Columbia, and sections of northern Virginia.

BACT requirements of Title I, or Title IV requirements. We summarize the Post-CAAA scenarios for the control of these two pollutants are summarized in Table B-4.

Table B-4
Differences in the Control of Utility NO_X and SO_X for the Pre-CAAA and the Post-CAAA Regulatory Scenarios

Pollutant	Pre-CAAA	Post-CAAA
SO_x	Existing units: Comply with State Implementation Plan (SIP) requirements prevailing in 1990 to ensure compliance with the National Ambient Air Quality Standard.	Existing units: Comply with the Acid Rain Allowance Program under Title IV of the CAAA 1990 with phased-in requirements. Phase I covers the largest 110 coal-fired power plants in 1995. All other units above 25 megawatts are covered in Phase II beginning in 2000.
	New units: Comply with New Source Performance Standards (NSPS) set in 1978 and BACT fixed at 1990 levels applied through the New Source Review (NSR) process.	New units: Comply with the NSPS set in 1978, BACT/LAER (Lowest Achievable Emission Requirements), and the Acid Rain Allowance Trading Program under Title IV of the CAAA 1990.
NO_x	Existing Units: No federal standards, except NSPS for new units built after passage of the law.	Existing units: Meet Reasonably Available Control Technology (RACT) in 1995 in the OTR and all non-attainment areas per Title I. States can file waivers from RACT requirements. Coal-fired units comply with Title IV NO_x requirements that are phased in over time, or RACT, whichever is more stringent. Group 1/Phase I coal-fired units comply in 1996. Group 1/Phase II and Group 2 coal-fired units comply in 2000. Collective action by the 37 eastern States in the Ozone Transport Assessment Group (OTAG) will lead to additional requirements (known as "Level 2 controls") under Title I for reducing NO_x emissions during the summer months (May - September).
	New units: Units using fossil fuels comply with the NSPS for each generation technology and fuel. Application of BACT in the NSR process at levels existing in 1990.	New units: Comply with Title I NSPS and BACT/LAER and Title IV standards for coal-fired units, whichever is more stringent. Units subject to OTAG Level 2 controls for reducing NO_x during summer months.

Compliance Actions

In order to comply with the Title IV SO_x Allowance Trading program under the Post-CAAA scenario, the electric power industry must install continuous emissions monitoring systems. In addition to the monitoring system, they may be required to adopt at least one of the following four types of action:

- Improve the performance of existing scrubber units and scrubbers that facilities will build on new units under the NSPS of the Pre-CAAA Scenario
- Add scrubbers on existing units
- Switch to lower sulfur coals
- Switch over from coal-fired to gas-fired units

We assume in the Section 812 cost analysis that the electric power industry faces four NO_x regulatory programs. These programs require the industry to:

- Place RACT controls on existing generation units in States without EPA waivers
- Build new generation units to meet BACT requirements
- Comply with Title IV NO_x rules for new and existing coal-fired units
- Comply with NO_x Cap-and-Trade program for reducing emissions during the summer months in the eastern United States

Cost Approach

We configured the IPM to forecast the operation of the electric power industry from 2000 to 2010. The baseline case, used in EPA's Clean Air Power Initiative (CAPI), includes the set of CAAA controls that the Agency promulgated or States established through their permit decisions by the middle of 1996. The baseline case also includes RACT and BACT decisions under the New Source Review program, Phase I and Phase II of the Title IV SO_x Allowance Trading Program, and Phase I NO_x control requirements applied to all tangentially-fired and wall-fired boilers that use coal.

In simplest terms, we sets up the Pre-CAAA scenario for the electric power industry by removing the CAAA controls from the CAPI base case and running the IPM model to forecast emission levels and costs of producing electric power. We fix standards under the Pre-CAAA 2000 and Pre-CAAA 2010 scenarios at 1990 levels. To establish the Post-CAAA scenario, we add further NO_x controls to the CAPI base case, which focuses on the emissions and costs of producing electric power under the CAAA Title IV SO_x Allowance Trading program. The Post-CAAA scenario reflects a NO_x cap-and-trade program that EPA presented at OTAG meetings and was considered, at the time the utility analysis was initiated (1995-1996), to be a plausible outcome of the OTAG process. The NO_x control program incorporated in the Post-CAAA scenario may not reflect the NO_x controls that are actually implemented in a regional ozone transport rule.

Cost Results

Cost results are presented in Table B-5 below. Based on the Section 812 cost analysis for the electric power industry, we estimate that the annual national costs of the CAAA will be roughly $3.1 billion in 2000 and $4.6 billion in 2010.

Table B-5
Electric Power Industry Costs from Post-CAAA Controls for SO_X and NO_X

	Annual Control Costs (millions 1990 dollars)	
Pollutant	**Post-CAAA 2000**	**Post-CAAA 2010**
SO_x	$1,900	$1,600
NO_x	$1,200	$2,900
Total	**$3,100**	**$4,600**

Non-Road Engines/Vehicles

Nonroad sources are mobile (non-highway) emission sources. They include the following: lawn and garden equipment, construction equipment, agricultural equipment, industrial equipment, aircraft and airport service vehicles, logging equipment, recreational vehicles, locomotives, and marine vessels. We use ERCAM to estimate future emissions from non-road engines/vehicles. This model incorporates Federal regulatory programs for controlling NO_x, PM_{10}, VOC, and CO emissions from nonroad engines and equipment under the Post-CAAA scenario.

Cost Approach

To develop cost estimates for nonroad control measures, we apply cost-effectiveness values from several sources (e.g., draft or final rules and the Section 812 emission projections analysis (Pechan, 1997a)). The analysis includes costs for control inputs applied to the following nonroad source categories: small SI (gasoline) engines, CI (diesel) engines, locomotives, and marine vessels.

We calculate TACs in each implementation year to calculate the net present value (NPV) of both costs and benefits over the estimated period of fleet turnover.[10] Because we base the benefits analysis on projected emission reductions in 2000 and 2010, rather than the discounted stream of benefits, the inputs to this cost analysis represent the annualized cost per ton of reduction, not the NPV cost-effectiveness. The exception is the input used for the Federal locomotives rule; because TAC in each implementation year are not available, we use the average annualized cost per ton across the entire implementation period in both 2000 and 2010.

Cost Results

Table B-6 summarizes the cost estimates for each nonroad engine/vehicle control measure modeled in this analysis for 2000 and 2010. Total nonroad engine/vehicle costs, under Post-CAAA scenarios, are $104 million and nearly $400 million in 2000 and 2010, respectively. Estimated SI engine costs are $56 million under the 2000 Post-CAAA scenario and $104 million under the 2010 Post-CAAA scenario. Reducing VOC emissions from lawn and garden equipment contributes to the majority of SI engine costs. CI engine control costs are $22 million in the 2000 Post-CAAA scenario, and $32 million in 2010. NO_x emission reductions from construction equipment account for a significant proportion of total CI engine control costs. Locomotive and commercial marine vessel benefits are not realized until after 2000; costs under the 2000 Post-CAAA scenario are therefore zero.[11]

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[10] We were unable to apply the per engine costs of modifying equipment/vehicles to meet EPA standards because engine populations were not available for all areas.

[11] NO_X standards for locomotive and commercial marine vessels do not take effect until 2000. For the purpose of this analysis, costs are small enough in 2000 that they are omitted.

Table B-6
Cost Estimates for Nonroad Engine/Vehicle CAAA Programs

Engine/Vehicle Category	Annual Cost (million 1990 dollars) Post-CAAA 2000	Annual Cost (million 1990 dollars) Post-CAAA 2010
SI Engines:		
Construction Equipment	$ 1.7	$ 3.1
Industrial Equipment	0.5	1.2
Lawn and Garden Equipment	41	74
Farm Equipment	0.2	0.4
Commercial Equipment	12	23
Logging Equipment	0.9	2.1
CI Engines:		
Construction Equipment	$ 12	$ 17
Industrial Equipment	3.6	5.2
Farm Equipment	2.9	4.4
Logging Equipment	0.1	0.2
Airport Service Equipment	2.8	4.6
Other	0.2	0.2
Locomotives	$ 0[1]	$ 35
Marine Vessels:		
Recreational	$ 27	$ 230
Commercial	0[1]	1
Total Nonroad Engine/Vehicle Control Costs	**$ 104**	**$ 400**

Note:
[1] Costs in 2000 are zero because program emissions reductions are not realized until after 2000. See text and Pechan (1998 and 1997a) for further explanation.

Motor Vehicles

Motor vehicle emissions account for almost thirty percent of 1990 anthropogenic VOC emissions and thirty-two percent of NO_x emissions. To determine the costs of controlling VOC and NO_x, we first project motor vehicle emissions with ERCAM-VOC and ERCAM-NO_x (Pechan, 1998). Then we use the emissions projections to estimate future year motor vehicle program costs for each of the modeled control assumptions.[12]

Cost Approach

We convert all motor vehicle-related control costs into one of three forms: cost per new vehicle, cost per registered vehicle, or cost per mile traveled. We calculate separate costs for each vehicle type (i.e., LDGV, light-duty gasoline truck (LDGT) 1, LDGT2). Motor vehicle calculations required projections of vehicle miles traveled (VMT), vehicle registrations, or vehicle sales estimates. We applied the following equations:

*Cost per new vehicle = projected vehicle sales * production cost ($/new vehicle)*

*Cost per registered vehicle = projected vehicle registrations * cost per vehicle ($/vehicle)*

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[12] See the emission projection report for a discussion of the emission projection methodology and the control assumptions (Pechan, 1998).

*Cost per mile traveled = projected vehicle miles traveled (VMT) * cost per mile ($/mile)*

Sources of Data

The 1990 NPI Inventory provides the 1990 VMT data, which we project in the same manner as it our emissions (Pechan, 1998).[13] National registrations from the MOBILE4 FCM are the source of vehicle registration data for 1990 (EPA, 1991d). The source of motorcycle registrations is *Highway Statistics* (FHWA, 1991). National sales data is based on projected sales compiled by Data Resources Incorporated (DRI). This information was also used by EPA in the onboard vapor recovery RIA (DRI, 1993; EPA, 1993d).[14]

Cost Categories

The CAAA motor vehicle provisions generate costs in the following categories: emissions standards, fuel requirements, emissions inspections, and low emission vehicle programs. The following section describes the methodology we use calculate costs for each category of provisions.[15]

Emission Standards:

- **Tier 1 Certification Standards and Evaporative Controls.** We calculate costs for tailpipe standards and evaporative controls with per-vehicle production costs applied to projected sales.

- **Heavy-Duty Vehicle 2g/bhp-hr Equivalent NO_x Standard.** We calculate the cost of complying with the 2004 model year emission standards by estimating the baseline package of emission control technology for meeting 1998 model year standards (EPA, 1997f). We use the 1994 model year sales of different size classes of diesel trucks to establish sales fractions, assumed to represent future sales as well. We multiply these sales fractions by the year 2009 per vehicle cost increases for light, medium, and HDVs to compute a sales-weighted per vehicle cost increase.

- **Onboard Vapor Recovery.** To estimate the costs of onboard vapor recovery, we use expected increases in vehicle price (also referred to as retail price equivalent) and average lifetime operating cost (net present value) (EPA, 1993f).

- **Cold Temperature CO Standard.** The cost of the cold temperature CO standard to the consumer includes the cost to the manufacturer, the manufacturer's and dealer's overhead and profits, and the increase or decrease in maintenance and fuel costs. We do not include fuel economy improvements in the analysis. We base cost estimates on retail price increases of $19 per LDV, $32 per LDT1, and $48.50 per LDT2 (Pechan, 1998).

- **Onboard Diagnostic (OBD) Systems.** With OBD now appearing on all 1996 model year cars and light-trucks, Federal OBD costs are approximately $65 to $100 per vehicle.[16]

Fuels:

- **Gasoline Volatility Limits.** In order to calculate the costs of lowering the Reid vapor pressure (RVP) from 10.5 to 9.0 in Class C areas, we apply the cost estimate of

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[13] EPA uses MOBILE4 FCM national projections, scaled to metropolitan statistical areas (MSAs) according to population projections, to project VMT and vehicle registrations.

[14] EPA assumes that motorcycle sales from Highway Statistics (FHWA, 1991) increase at the same rate as light-duty gasoline vehicle (LDGV) sales.

[15] For more details on these standards see Appendix A.

[16] We apply the per vehicle cost estimate of $65. However, there is evidence that OBD costs are more likely in the range of $65 to $100 per vehicle (EPA, 1993d).

0.225 cents per gallon in the five month ozone season (Wysor, 1988).

- **Federal Reformulated Gasoline.** We base reformulated gasoline costs on an incremental refiner's cost increase and a monetized fuel economy disbenefit. An estimate of 3.9 cents per gallon for Phase I and 5.1 cents per gallon for Phase II was used (EPA, 1993g). Phase II reformulated gasoline modifications occur only in the summer. As a result, we consider Phase II costs to only five months out of the year. The Phase I benefits will occur year-round and are primarily due to the oxygenate (affecting the aromatic content) and the reduction of fuel benzene content.

- **California Reformulated Gasoline.** We use the estimates from the California Air Resources Board (CARB) to determine the increase in per gallon fuel costs to consumers (CARB 1990; CARB, 1991).

- **Oxygenated Fuels.** We base oxygenated fuel costs on an incremental cost of 3.8 cents per gallon (EPA, 1993g).

- **California Reformulated Diesel.** We base reformulated diesel costs on an incremental per gallon increase of six cents (Green, 1994).

- **Diesel Fuel Sulfur Limits.** We use an average value of 2.1 cents per gallon as an estimate of the incremental cost of reducing the sulfur content of conventional diesel fuel (EPA, 1990). The cost estimate do not include a fuel economy penalty for low sulfur diesel fuel because we estimate that energy content is essentially the same as that of conventional fuel (less than 1% lower).

Emissions Inspection Programs:

- **Basic I/M.** We use the RIA on enhanced I/M for deriving this program's basic costs. Total per vehicle costs include the inspection fee, average repair cost, and the fuel economy benefit. The average per vehicle cost is approximately $5.70. We apply this estimate to LDGVs, LDGT1s, and LDGT2s in areas where basic I/M is required. Basic I/M costs are evenly apportioned among VOC, NO_x, and CO. No additional costs are attributed to areas that face I/M program requirements, but already have a program in place (EPA, 1992c).

- **Low Enhanced I/M.** Costs for low enhanced I/M and OTR low enhanced I/M are not well defined. Therefore, we equate low enhanced I/M costs equivalent to those of basic I/M. The average cost per vehicle for this program is approximately $5.70. This per vehicle cost applies to all registered LDGV, LDGT1, and LDGT2 (EPA, 1992c).

- **Enhanced I/M.** Estimates of enhanced I/M costs are subject to change as States make decisions about their program designs. I/M program costs may be higher or lower according to each State's selected program designs such as centralized testing and caps on the costs of required repairs.[17] The estimated per-vehicle cost is $15.70. We base this figure on a test fee ($18), an average repair cost ($14.20 per vehicle), and an average fuel economy benefit ($16.50 per vehicle) (EPA, 1992c).[18] We estimate annual costs by applying the per vehicle costs to an area's projected vehicle registrations.

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[17] To date, only four States have implemented Enhanced I/M programs. Preliminary cost estimates indicate that opportunity costs to vehicle owners in the form of travel and wait time do not play as significant role as originally anticipated. (Harrington and McConnell, 1999.)

[18] Test fee and the relationship between test sites and States vary. In some cases the test fee represents a payment to the state or local government. In other cases, the fee covers the direct costs of the testing program. It is not clear, however, how the test fee could be apportioned between the two possibilities. To the extent the fee represents a transfer payment, we may be overestimating the direct cost and social cost of the program.

Low Emission Vehicles:

- **California Low Emission Vehicle Program.** We base costs for the California LEV on the incremental production cost of vehicles meeting each of the LEV standards (Pechan, 1998). The overall incremental production cost for a vehicle type reflects the projected fraction of sales of each type of LEV for each projection year.

- **National Low Emission Vehicle Program.** We calculate costs for the National LEV program by multiplying the incremental production cost of vehicles meeting each of the LEV standards by the estimated new vehicle sales volumes (Pechan, 1998).

Additional Programs:

- **Clean Fuel Fleet Program (CFFP).** CAAA mandated implementation of CFFP beginning in 1998 for ozone NAAs designated serious and above. We estimate that the model year 1998 fleet demand for clean-fuel vehicles under the CFFP will be approximately 47,000 LDVs and 12,000 HDVs (Oge, 1997). However, we do not include these costs in the analysis.[19]

- **Transportation Conformity.** Under the transportation conformity rule, the Metropolitan Planning Organizations (MPOs) must perform regional transportation and emissions modeling and document the regional air quality impacts of transportation plans and programs. We expect these requirements will generate the primary costs of this rule.

Table B-7 summarizes the motor vehicle unit costs used in this analysis. Costs of individual motor vehicle provisions are listed in 1990 dollars by vehicle type. Phase II RVP and Phase II Federal reformulated gasoline limits generate costs only in the ozone season, while oxygenated fuel provisions result in CO season (winter time) costs. All other fuel programs listed in Table B-7 generate year round costs.

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[19] EPA cannot require manufacturers to produce CFVs and areas covered by the CAAA can opt out of the program.

Table B-7
Motor Vehicle Unit Costs by Provision

Provision	Year Dollars	Cost Unit	Cost Estimate by Vehicle Type:[1] LDGV	LDGT1	LDGT2	MC	HDGV	HDDV	LDDV	LDDT
Emission Standards:										
Tier 1 Tailpipe Standards: VOC	1990	Sales	36.8	33.7	11.7					
Tier 1 Tailpipe Standards: NO_x	1990	Sales	115.0	80.6	45.3		16.0	78.0		
Cold Temperature CO Standard	1989	Sales	15-23	15-48	42-55					
Evaporative Controls (New Evaporative Emissions Test Procedure)	1993	Sales	1.0	8.0	8.0		(13.0)			
On-Board Vapor Recovery System	1992	Sales	4.54	4.48	4.48					
On-Board Diagnostics	1993	Sales	65.0	65.0	65.0					
Heavy Duty Engine Standard (2 gram equivalent)	1995	Sales						140.0		
Low Emission Vehicles:										
TLEV	1996		53.0	53.0						
LEV			95.0	95.0						
ULEV			145.0	145.0						
ZEV			5,000.0	5,000.0						
Fuels:										
Phase II RVP Limits	1990	Cents/gallon	0.2	0.2	0.2	0.2	0.2			
Federal Reformulated Gasoline: Phase I	1993	Cents/gallon	3.9	3.9	3.9	3.9	3.9			
Phase II	1993	Cents/gallon	1.2	1.2	1.2	1.2	1.2			
Oxygenated Fuels	1993	Cents/gallon	3.8	3.8	3.8	3.8	3.8			
Low-Sulfur Diesel Fuel Requirements (0.05% sulfur)	1990	Cents/gallon						2.1	2.1	2.1
California Phase II Reformulated Gasoline	1991	Cents/gallon	12.3	12.3	12.3	12.3	12.3			
California Reformulated Diesel								6.0	6.0	6.0
Inspection/Maintenance Programs:										
Basic	1992	Registrations	5.7	5.7	5.7					
Low Enhanced	1992	Registrations	5.7	5.7	5.7					
High Enhanced	1992	Registrations	15.7	15.7	15.7					

Notes:

[1] LDGV = light duty gasoline vehicle; LDGT = light duty gasoline truck; MC = motorcycle; HDGV = heavy duty gasoline vehicle; HDDV = heavy duty diesel vehicle; LDDV = light duty diesel vehicle; LDDT = light duty diesel truck

Cost Results

Table B-8 summarizes the motor vehicle costs for 2000 and 2010. The total cost post-CAA is $9 billion in 2000 and $12 billion in 2010.

Table B-8
Cost Estimates of Motor Vehicle Program

Program	Annual Cost (million 1990 dollars)	
	Post-CAAA 2000	Post-CAAA 2010
Title I		
California LEV	$ 320	$ 1,100
National LEV	180	1,060
Basic I/M	57	69
Low/OTR Enhanced I/M	82	99
High Enhanced I/M	1,100	1,400
Title II		
Onboard Vapor Recovery*	$ 63	$ 69
Stage II Vapor Recovery*	71	86
Phase II RVP	280	340
Tailpipe/Extended Useful Life - VOC	504	550
Tailpipe/Extended Useful Life - NO_x	1,500	1,700
Evaporative/Running Losses	42	46
Onboard Diagnostics	880	960
Cold Temperature CO Standard	380	410
Federal Reformulated Gasoline	720	860
California Reformulated Gasoline	2,000	2,400
Oxygenated Fuels	160	204
2 gram NO_x Heavy Duty Standard	0	69
Low Sulfur Diesel Fuel	570	740
California Reformulated Diesel**	170	230
Total Motor Vehicle Control Costs	**$ 9,070**	**$ 12,300**

Notes:

* The benefits of onboard vapor recovery and stage II vapor recovery are accounted for under area sources. The cost for onboard vapor recovery systems is estimated assuming phase-in for light duty gasoline vehicles and light duty trucks. Heavy duty trucks are not affected.

** The analysis does not account for the benefits (emission reductions).

Area Sources

Area sources comprise small stationary sources not listed in the point source database (e.g., dry cleaners, graphic arts, industrial fuel combustion, gasoline marketing) and solvent use (e.g., consumer solvents, architectural coatings). Area sources of NO_x emissions include industrial fuel combustion units in the industrial, commercial/institutional, and residential sectors. The following are VOC sources: pharmaceutical manufacturing, wood furniture surface coating, aerospace manufacturing (surface coating), ship building and ship repair (surface coating), halogenated solvent cleaning, dry cleaning - perchloroethylene (PCE), and petroleum refinery fugitives. Area sources of PM_{10} are paved roads, unpaved roads, construction, cattle feedlots, agricultural tilling, and agricultural burning.

Cost Approach

To assess the costs of reducing emissions from area sources, we use annualized costs per ton reduced.[20] We estimate total annual costs under each of the Post-CAAA scenarios by applying annualized costs per ton from a variety of regulatory documents to corresponding emission reductions. The annual cost formula is:

*Annual Cost = Annualized Cost Per Ton * Emission Reduction.*[21]

ERCAM-NO_x and ERCAM-VOC incorporate separate cost equations for each area source category.

Cost Results

Table B-9 summarizes area source control measure costs for NO_x and PM under the 2000 and 2010 Post-CAAA scenarios. The costs associated with applying NO_x point source fuel combustion controls to smaller sources are approximately $16 million in 2000 and $18 million in 2010. Control measures applied to reduce PM emissions from area sources are estimated to cost $1.9 billion under the 2000 Post-CAAA scenario and $2.2 billion under the 2010 Post-CAAA scenarios. Controlling fugitive dust emissions from construction activity generates the majority of PM control costs.

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[20] Source-specific data are not available for area and nonroad sources.

[21] In the present analysis, we annualize total capital costs with a five percent discount rate. In some cases, we re-calculate the annualized cost per ton reported in the source material if that estimate was based on a discount rate other than five percent.

Table B-9
Cost Summary of Area Source NO_X and PM Controls

Source Category	Annual Costs (million 1990 dollars) Post-CAAA 2000	Annual Costs (million 1990 dollars) Post-CAAA 2010
Area Source NO_x Controls		
Industrial Fuel Combustion - Coal	$ 6.6	$ 7.5
Industrial Fuel Combustion - Oil	0.8	0.8
Industrial Fuel Combustion - Natural Gas	8.5	9.9
Total Area Source NO_x	**$ 16**	**$ 18**
Area Source PM Controls		
Agricultural Burning	$ 37	$ 39
Agricultural Tilling	4.1	3.6
Beef Cattle Feedlots	1.4	1.7
Construction	1,500	1,800
Paved Roads	350	440
Unpaved Roads	1.1	0.8
Total Area Source PM	**$ 1,900**	**$ 2,200**

Reasonable Further Progress Requirements

Title I of the CAAA includes provisions that require ozone nonattainment areas to make steady progress toward compliance with NAAQS. NAAs classified as moderate, serious, severe, or extreme must demonstrate that they are working to lower ambient ozone concentrations at a reasonable rate of progress (ROP) and, by 1996, reduce annual VOC emission by fifteen percent from 1990 levels. In addition to satisfying ROP requirements, areas classified as having an ozone nonattainment problem that is serious or worse must continue to cut emissions and make reasonable further progress (RFP) toward attainment. To meet RFP standards, after 1996, NAAs have to reduce precursor emissions by three percent per year until they each reach their respective compliance deadlines. While ROP requirements mandate VOC cuts to comply with RFP standards it is often possible to substitute NO_x for VOC. (Refer to Appendix A for more discussion of ROP/RFP requirements.)

Title I progress requirements establish minimum emissions reduction standards for ozone NAAs. In many cases, the areas subject to ROP/RFP regulations satisfy these requirements simply by complying with other existing emissions standards. VOC and NO_x reductions made to meet other regulations are credited towards ROP/RFP requirements. For the purposes of the prospective analysis, we assume that where possible, credit is given for all available NO_x cuts and that any remaining emission reduction needed to satisfy Title I progress requirements come from VOC. In the majority of cases, credited VOC cuts account for this remaining reduction. For NAAs that are not able to fulfill the remainder of their ROP/RFP obligations with credited VOC emissions reductions, there is a shortfall. This shortfall represents the quantity of VOC that ozone NAAs must reduce through control efforts beyond those mandated by other clean air provisions.

Tables B-10 and B-11 show, for the years 2000 and 2010 respectively, which NAAs are assumed to satisfy, and not satisfy, their Title I progress requirement. Failure to meet the requirement is indicated by a shortfall. The shortfall is measured by the amount ozone season daily (OSD) level exceeds the maximum allowable daily VOC emission. The OSD level of VOC emission represents the predicted daily emission in the absence of RFP/ROP requirements, and VOC target presents the maximum allowable daily VOC emissions.

Table B-10
2000 Rate of Progress Analysis

Ozone Nonattainment Area	VOC OSD[1]	VOC Target[2]	Shortfall
Atlantic City	37.97	45.71	0.00
Baltimore	318.33	376.47	0.00
Baton Rouge	203.77	415.65	0.00
Beaumont-Port Arthur	340.66	450.66	0.00
Chicago-Gary-Lake County	1,240.89	1,202.25	38.64
Cincinnati-Hamilton	305.34	341.18	0.00
Cleveland-Akron-Lorain	521.14	573.07	0.00
Dallas-Fort Worth	694.53	673.97	20.56
El Paso	85.38	69.02	16.36
Grand Rapids	182.72	175.66	7.06
Houston-Galveston-Brazoria	1,426.65	2,268.31	0.00
Lewiston-Auburn ME	34.08	35.98	0.00
Los Angeles-South Coast	972.91	939.08	33.83
Louisville	219.66	215.97	3.69
Milwaukee-Racine	327.09	293.24	33.85
Muskegon	46.67	44.32	2.35
Nashville	231.71	205.60	26.11
New York-N New Jersey-Long Is	1,994.96	2,407.97	0.00
Philadelphia-Wilmington-Trenton	1,090.49	1,376.55	0.00
Phoenix	377.43	347.91	29.52
Pittsburgh-Beaver Valley	407.05	399.80	7.25
Portland ME	70.05	73.33	0.00
Portsmouth-Dover-Rochester	53.54	58.70	0.00
Providence	173.78	180.51	0.00
Reading PA	60.53	61.14	0.00
Richmond-Petersburg	179.97	201.70	0.00
Sacramento Metro	158.01	155.08	2.93
St. Louis	465.64	549.14	0.00
Monterey Bay	64.16	79.63	0.00
Salt Lake City	182.75	150.80	31.95
San Diego	192.90	189.71	3.19
Santa Barbara-Santa Maria-Lomp	82.75	83.10	0.00
Sheyboygan	24.49	22.44	2.05
Washington DC	402.76	477.03	0.00
Knox & Lincoln Cos ME	9.95	10.37	0.00
Kewaunee Co Wi	4.86	4.56	0.30
Manitowoc Co WI	19.72	17.20	2.52
San Joaquin Valley	470.50	532.41	0.00
Ventura Co CA	65.69	70.52	0.00
Southeast Desert Modified	227.71	219.32	8.39
Boston-Lawrence-Worcester-E.MA	822.65	918.01	0.00
Springfield/Pittsfield-W. MA	155.51	152.42	3.09
Greater Connecticut	316.27	370.11	0.00

Notes:

[1] The VOC OSD (ozone season daily) values are the estimated daily emissions in the absence of ROP/RFP requirements. These estimates do, however, incorporate the effect of the VOC reductions that are credited towards Title I progress requirements.

[2] The VOC target represents the maximum allowable daily VOC emission for NAAs to comply with ROP/RFP requirements. The VOC target is calculated based upon the assumption that all available NOx cuts are credited towards ROP/RFP requirements and that all necessary remaining reductions come from VOC.

Table B-11
2010 Rate of Progress Analysis

Ozone Nonattainment Area	VOC OSD[1]	VOC Target[2]	Shortfall
Atlanta	492.40	541.99	0.00
Atlantic City	33.21	45.71	0.00
Baltimore	293.56	376.47	0.00
Baton Rouge	206.65	415.65	0.00
Beaumont-Port Arthur	377.63	450.66	0.00
Chicago-Gary-Lake County	1,236.73	840.15	396.58
Cincinnati-Hamilton	283.74	341.18	0.00
Cleveland-Akron-Lorain	485.90	573.07	0.00
Dallas-Fort Worth	687.15	673.97	13.18
El Paso	84.33	69.02	15.31
Grand Rapids	183.11	175.66	7.45
Houston-Galveston-Brazoria	1,530.07	1,606.75	0.00
Lewiston-Auburn ME	32.03	35.98	0.00
Los Angeles-South Coast	847.66	670.95	176.71
Louisville	216.86	215.97	0.89
Milwaukee-Racine	321.89	204.72	117.17
Muskegon	46.86	44.32	2.54
Nashville	230.00	205.60	24.40
New York-N New Jersey-Long Is	1,842.53	2,407.97	0.00
Philadelphia-Wilmington-Trenton	1,070.05	1,194.41	0.00
Phoenix	347.52	347.91	0.00
Pittsburgh-Beaver Valley	358.67	399.80	0.00
Portland ME	66.88	73.33	0.00
Portsmouth-Dover-Rochester	52.49	58.70	0.00
Providence	166.61	193.15	0.00
Reading PA	55.33	61.14	0.00
Richmond-Petersburg	179.35	201.70	0.00
Sacramento Metro	135.99	120.24	15.75
St. Louis	439.47	549.14	0.00
Monterey Bay	61.76	79.63	0.00
Salt Lake City	189.83	150.80	39.03
San Diego	174.04	202.24	0.00
Santa Barbara-Santa Maria-Lomp	81.53	83.10	0.00
Sheyboygan	24.69	22.44	2.25
Washington DC	355.35	477.03	0.00
Knox & Lincoln Cos ME	8.98	10.37	0.00
Kewaunee Co Wi	4.77	4.56	0.21
Manitowoc Co WI	19.37	17.20	2.17
San Joaquin Valley	448.37	566.96	0.00
Ventura Co CA	62.33	63.11	0.00
Southeast Desert Modified	213.87	172.34	41.53
Boston-Lawrence-Worcester-E.MA	775.66	918.01	0.00
Springfield/Pittsfield-W. MA	147.45	166.51	0.00
Greater Connecticut	292.53	370.11	0.00

Notes:

[1] The VOC OSD (ozone season daily) values are the estimated daily emissions in the absence of ROP/RFP requirements. These estimates do, however, incorporate the effect of the VOC reductions that are credited towards Title I progress requirements.

[2] The VOC target represents the maximum allowable daily VOC emission for NAAs to comply with ROP/RFP requirements. The VOC target is calculated based upon the assumption that all available NOx cuts are credited towards ROP/RFP requirements and that all necessary remaining reductions come from VOC.

Cost Results

We base the RFP cost estimate on the assumption that ozone nonattainment areas (NAAs) will take credit for NO_x reductions for meeting progress requirements. Additional area-specific analysis would be necessary to determine the extent to which areas find NO_x reductions beneficial in meeting attainment and progress requirement targets. Trading of NO_x for VOC to meet RFP requirements may result in distributions of VOC and NO_x emission reductions that differ from those used in this analysis. In part as a response to these uncertainties, we adopt a conservative strategy for estimating the costs of RFP reductions, using the relatively high cost per ton reduced value of $10,000 for all required reductions. We calculate these annual figures by multiplying the aggregate daily shortfall by 365, and then multiplying this number by the estimated cost of each ton of reduction, $10,000. Based on this calculation, the annual estimated cost of Title I progress requirements is $1,150 million in Post-CAAA 2000 and $2,460 million in Post-CAAA 2010.

Since the time we conducted our initial cost analysis, control measures for several nonattainment areas (NAA) have been identified that suggest controls may be much less. For example, the dollar per ton estimate associated with control measures selected in Chicago is $3,500. We incorporate this information in our sensitivity analysis. In the sensitivity test analysis, we calculate overall costs by applying the cost per ton of reduction associated with each identified control. Where the required reduction cannot be achieved through implementation of all of the identified controls, we assume unidentified controls will be used to eliminate the remaining shortfall. We apply the $10,000 per ton reduced estimate for these unidentified controls (see Appendix B for more details). Results of the sensitivity analysis suggest that our conservative approach of applying $10,000 per ton reduced to all VOC shortfalls may overstate cost by as much as several billion dollars in 2010.

Costs by Title

Examining CAAA costs by title, in addition to reviewing them by source, is useful for understanding the cost components. Table B-12 summarizes the cost estimates generated in this analysis by year and Title. As shown in the table, the cost estimate under the Post-CAAA 2000 scenario is $19 billion, increasing to nearly $27 billion under the Post-CAAA 2010 scenario. All costs are in 1990 dollars.

Table B-12
Summary of Cost Estimates by CAAA Title

Title	Sector/Pollutant	Annual Cost (million 1990 dollars) Post-CAAA 2000	Annual Cost (million 1990 dollars) Post-CAAA 2010
Title I - Provisions for Attainment and Maintenance of NAAQS			
	Non-utility Point/VOC	$ 420	$ 440
	Non-utility Point/NO_x	1,700	2,200
	Utility/SO_2 and NO_x	790	2,500
	Area/VOC	920	1,040
	Area/NO_x	16	18
	Area/PM	1,900	2,200
	Motor Vehicle	1,800	3,700
	Progress Requirements	1,200	2,500
Title II - Provisions Relating to Mobile Sources			
	Motor Vehicle	$ 7,300	$ 8,700
	Nonroad	104	400
Title III - Hazardous Air Pollutants			
	Point/VOC	$ 480	$ 520
	Area/VOC	130	150
	Non-VOC MACT[1]	170	170
Title IV - Acid Deposition Control			
	Utility/SO_2 and NO_x	$ 2,300	$ 2,040
Title V - Permits		$ 300[2]	$ 300[2]
TOTAL		**$ 19,400**	**$ 26,800**

Notes:

[1] Costs reflect estimate of annualized costs from final rules. We do not use ERCAM-VOC to model source categories, because the National Emission Standards for Hazardous Air Pollutants (NESHAPs) are associated with non-VOC HAP emission reductions. Consequently, they are not included in the Post-CAAA 2000 and 2010 inventories.

[2] Includes costs only for State-implemented permitting programs, excluding the costs of Federally-implemented programs, since all Title V permit programs will be State-run in 2005.

Joint Rules

Assigning costs to a CAAA Title is difficult in the case of "joint rules" issued under more than one Title. For example, the marine vessel rule incorporates controls to reduce VOC emissions through reasonably available control technology (RACT) standards and hazardous air pollutant (HAP) emissions through maximum achievable control technology (MACT) standards. In general, we assign the costs for joint rules to the CAAA title based on the implementation dates and the year by which emission reductions are expected to occur. In some cases, we assign joint rules costs to the more stringent rule (in terms of sources covered or reduction required). Examples of source categories with overlapping Title I and Title III control measures include the following: aerospace, surface coating, petroleum refineries, shipbuilding, synthetic organic chemical manufacturing industry (SOCMI) categories, printing, and wood furniture. In cost accounting, we generally allocate the costs for these source categories to Title III, rather than Title I.

Title I

Title I, Provisions for Attainment and Maintenance of National Ambient Air Quality Standards (NAAQS), includes national VOC rules and any controls that NAAs will likely apply to meet Federal standards for ozone and PM. For Title I, determining which rules are CAAA-related and which are associated with other legislation is sometimes difficult. For example, EPA actually promulgated the hazardous waste transport, storage, and disposal facilities (TSDF) rule under the authority of the Resource Conservation and Recovery Act (RCRA). We attribute, however, the costs and associated VOC emission reductions of the Phase I and Phase II RCRA rule to Title I, because the rule is consistent with CAAA programs that promote attaining and maintaining the NAAQS.

The costs associated with Title I consist of point and area source costs for VOC, NO_x, and PM control measures. Total Title I costs are $8.6 billion in 2000 and $14.5 billion in 2010.[22] The following two tables summarize the cost analysis results for provisions promulgated under Title I of the CAAA. Table B-13 presents costs specifically associated with Title I national point and area VOC rules. Table B-14 costs by national Title I provisions regulating sectors ranging from motor vehicles to utilities. To preserve consistency with the assumptions made in the emission projections analysis, we simulate attainment of the ozone and PM NAAQS as they were prior to the 1997 revisions.

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[22] Note that provisions included in other CAAA Titles, as well as the decisions that individual States make about how best to meet progress requirements and attainment targets, affect Title I costs.

Table B-13
Title I National Rules, Point and Area Source VOC Control Costs

	Annual Costs by Sector (million 1990 dollars)					
	Post-CAAA 2000			Post-CAAA 2010		
Title I National Rules	**Point**	**Area**	**Total**	**Point**	**Area**	**Total**
Consumer Products	$ 0.0	$ 81	$ 81	$ 0.0	$ 88	$ 88
AIM Coatings	0.0	24	24	0.0	27	27
Automobile Refinish Coatings	0.0	6	6	0.0	7	7
Hazardous Waste TSDFs	<0.1	300	300	<0.1	350	350
Municipal Landfills	0.0	160	160	0.0	170	170
Marine Vessel Loading	24	0	24	28	0	28
TOTAL	**$ 24**	**$ 570**	**$ 590**	**$ 28**	**$ 650**	**$ 680**

Notes:

[1] Costs reflect estimates of annualized costs from final rules. We do not use ERCAM-VOC to model source categories, because the NESHAPs are associated with non-VOC HAP emission reductions.

[2] The Off-site Waste Treatment NESHAP was not modeled in this analysis. We assume that the Title I modeling of the RCRA Phase I and Phase 2 rules for hazardous waste TSDFs will capture any future MACT reductions and costs.

[3] EPA estimated that the Medical Waste Incineration guideline would cost between $59 million per year to $120 million per year, depending on the extent to which affected facilities switch to less expensive methods of treatment and disposal. The cost above represents the midpoint of this range.

Table B-14
Summary of Costs for Title I

	Annual Cost (million 1990 dollars)	
Provision	**Post-CAAA 2000**	**Post-CAAA 2010**
Area Specific:		
California LEV	$ 320	$ 1,100
National LEV	180	1,060
Basic I/M	57	69
Low/OTR Enhanced I/M	82	99
High Enhanced I/M	1,100	1,400
RACT:		
VOC RACT	620	660
Non-utility NO_x RACT	37	40
Utility NO_x RACT/Best Available Control Technology (BACT)	140	530
New CTG	130	150
OTR:		
Utility Cap-and-Trade Program	640	1,200
NO_x Stationary (Non-utility)	1,600	2,100
PM NAA Controls	1,900	2,200
Progress Requirements	$ 1,200	$ 2,500
TOTAL	**$ 8,050**	**$ 13,900**

Title II

Title II provisions include Federal motor vehicle and nonroad engine/vehicle rules, in addition to regulations requiring fuel reformulations. Table B-15 summarizes the results of our cost analysis for provisions promulgated under Title II of the CAAA.

Table B-15
Summary of Title II Motor Vehicle and Nonroad Engine/Vehicle Program Costs

	Annual Cost (million 1990 dollars)	
Provision	**Post-CAAA 2000**	**Post-CAAA 2010**
Motor Vehicles/Fuels:		
Motor Vehicle Emission Standards:		
Tailpipe/Extended Useful Life - VOC	$ 504	$ 550
Tailpipe/Extended Useful Life - NO_x	1,500	1,700
2 gram NO_x Heavy Duty Standard[1]	0	69
Onboard Vapor Recovery	63	69
Cold Temperature CO Standard	370	410
Onboard Diagnostics	880	960
Evaporative/Running Losses	42	46
Fuels:		
Phase II RVP	280	330
Federal Reformulated Gasoline	720	860
California Reformulated Gasoline	2,000	2,400
Oxygenated Fuels	170	204
California Reformulated Diesel	170	230
Low Sulfur Diesel Fuel	570	740
Stage II Vapor Recovery	71	86
Motor Vehicle Total	**$ 7,300**	**$ 8,700**
Nonroad Engines/Vehicles:		
Phase I CI engine standards	$ 22	$ 32
Phase I and II SI engine standards	56	104
Federal locomotive standards[1]	0	35
Federal commercial marine vessel standards[1]	0	1
Federal recreational marine vessel standards	27	230
Nonroad Engine Vehicle Total	**$ 104**	**$ 400**
Total Title II Costs	**$ 7,400**	**$ 9,100**

Notes:
Columns may not sum to totals due to rounding.
[1] Costs under the 2000 Post-CAAA scenario are zero because emission reductions are not realized until after 2000.

Table B-16
Title III, MACT Standards, Point and Area Source VOC Control Costs

	Annual Costs by Sector (in million 1990 dollars)	
Source Category	**Post-CAAA 2000**	**Post-CAAA 2010**
Benzene NESHAP	$ 0.2	$ 0.2
2-Year MACT:		
Dry Cleaning-Perchloroethylene	28	31
SOCMI HON	26	29
4-Year MACT:		
Aerospace Industry (surface coating)	4	5.3
Chromium Electroplating[1]	17	17
Coke Ovens	21	21
Commercial Sterilizers[1]	7	7
Gasoline Distribution-Stage I	12	13
Halogenated Solvent Degreasing	(37)	(42)
Industrial Process Cooling Towers[1]	14	14
Magnetic Tape[1]	0.8	0.8
Marine Vessels	17	20
Medical Waste Incineration[1,3]	89	89
Municipal Waste Combustors[1]	43	43
Off-Site Waste Treatment[2]	-	-
Petroleum Refineries-Other Sources Not Distinctly Listed	160	180
Printing/Publishing	200	207
Polymers & Resins Group I	110	128
Polymers & Resins Group II	4.3	5.0
Polymers & Resins Group IV	5.3	6.7
Secondary Lead Smelters[1]	2.0	2.0
Shipbuilding and Ship Repair	8.5	11
Wood Furniture (surface coating)	49	50
TOTAL	**$ 780**	**$ 840**

Notes:

[1] Costs reflect estimates of annualized costs from final rules. Source categories are not modeled in ERCAM-VOC because the NESHAPs are associated with non-VOC HAP emission reductions.

[2] The Off-site Waste Treatment NESHAP was not modeled in this analysis. We assume that the Title I modeling of the RCRA Phase I and Phase 2 rules for hazardous waste TSDFs will capture any future MACT reductions and costs.

[3] EPA estimated that the Medical Waste Incineration guideline would cost between $59 million per year to $120 million per year, depending on the extent to which affected facilities switch to less expensive methods of treatment and disposal. The cost above represents the midpoint of this range.

Title III

Title III of the CAAA requires the promulgation of MACT regulations to control HAP emissions from specific source categories. Total Title III costs represent the TACs for individual two- and four-year MACT standards. Not all Title III regulations are modeled by ERCAM-VOC because Title III regulations target HAP emissions which are not included in the Section 812 base year inventory. To provide a complete cost accounting, we use the annual cost estimates from the final rules for MACT standards that are expected to reduce non-VOC HAP emissions. The cost for these MACT categories is $173 million. The cost estimates for Title III are summarized in Table B-16. Costs do not differ significantly under the Post-CAAA 2000 and the Post-CAAA 2010 scenarios because we do not derive the costs from ERCAM-VOC using future year emission estimates.[23]

Title IV

Title IV of the CAAA is the Acid Deposition Control Program. Title IV controls include SO_2 and NO_x controls at electric utilities and are summarized in Table B-17, below. The model for SO_2 controls incorporates EPA's program for SO_2 allowance trading. The annual national costs of Title IV of the CAAA are $2.3 billion in 2000 and $2.0 billion in 2010. The decline in annual costs from 2000 to 2010 results primarily from the increase in use of Western coal, the cost of which we project will decrease over time. Cost reductions also occur following the increased use of gas-fired combined-cycle units to generate electricity without SO_x emissions. As employed technology becomes more efficient, we expect that generation costs will decrease.

Table B-17
Annual Costs of Title IV

	Annual Costs (million 1990 dollars)	
Title	Post-CAAA 2000	Post-CAAA 2010
Title IV	$ 2,300	$ 2,000

Note: These estimates reflect the base case used in the Clean Air Power Initiative. See EPA, "Analyzing Electric Power Generation Under the CAA" (1996) for detail on scenario development. For more information on its application to the cost analysis, see EPA, 1997a.

Title V

Title V of the CAAA establishes requirements for a new operating permits program. Using costs from final regulations rather than models, we estimate that Title V will cost $300 million. Consequently, we base this on the estimated cost of State-developed programs, excluding Federally-implemented State programs. The States are expected to implement all Title V permit programs by 2005. We estimate each source's permit fees and administrative costs in the first five-year implementation period, including the explicit cost to the permitted sources (industry), State and local permitting agencies, and EPA. The $300 million cost estimate may be an overestimate, since many States already have operating permit systems with fee provisions in place, and we do not incorporate existing state programs into the baseline in the RIA documents (EPA, 1992a and EPA, 1995).

Social Costs

In an ideal setting, a cost-benefit analysis would not only identify but also quantify and monetize an exhaustive list of associated social costs due to a regulatory option. This would include assessing how regulatory action targeting a specific industry or set of facilities can alter the level of production and consumption in the directly affected market and related markets. For example, regulation of emissions from the electric utility industry that results in higher electricity rates would have both supply-side and demand-side responses. In secondary markets, the increased electricity rates affect production costs for various industries and initiate behavioral changes (e.g., using alternative fuels as a substitute to electric

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[23] We do not estimate the costs associated with seven- and ten-year standards due to the lack of adequate data regarding the implementation of these standards.

power). With each affected market, there are also associated externalities that should be included in estimating social costs. Returning to the utilities example, the externalities associated with electric power generation versus nuclear power generation can be very different. The mix of externalities could change as consumers substitute nuclear power for electric power. It is frequently difficult to accurately characterize one or all of these dimensions of market responses and estimate the resulting social costs.

There are three generally practiced approaches to estimating regulatory costs: (i) direct compliance cost, (ii) partial equilibrium modeling, and (iii) general equilibrium modeling. The direct compliance cost approach is the most straightforward of the three. Direct compliance cost estimates are calculated differently than economic welfare impact estimates that result from partial or general equilibrium. This technique develops *ex ante* estimates of increased production costs, and may in some cases (such as in the case of the IPM model for utilities in our analysis) measure supply-side response to a regulatory action by modeling changes in supply price and quantity. In general, the technique does not account for how demand and consumption levels may change in response to higher production costs and prices. Instead, this approach measures how an industry's or firm's marginal cost curve shifts due to the additional production costs associated with pollution abatement controls.

The direct compliance approach, however, is a reasonable estimate of incremental expenditures. In certain instances, this method may be a conservative approximation of primary social costs because it overstates direct costs by not reflecting efficiency enhancing demand-side responses. There are two major difference between direct and social costs that influence the results. First, direct cost methods may overstate the actual compliance costs that are associated with demand and consumption level changes in response to higher production costs. By not accounting for market responses, total direct costs reflect the incremental costs per unit of output multiplied by the higher, pre-regulation quantity produced. Second, a direct cost approach assumes firms incur the full costs of pollution abatement activities. The marginal cost curves of firms, however, do not necessarily increase by the full amount of the pollution abatement technology. For example, firms can adopt cost-saving activities that help to offset the new costs.[24] (Morgenstern *et al.*, 1998).

Capturing consumer and producer behavioral responses to regulatory action requires either partial or general equilibrium modeling. These more complicated approaches estimate social costs by accounting for a wider range of consequences associated with altered resource allocation due to the use of pollution abatement equipment. A partial equilibrium analysis requires modeling both supply and demand functions in affected markets. Therefore, measures of social cost reflect behavioral responses by both producers and consumers in one or more markets. The variation between results from a direct cost approach and a partial equilibrium approach will generally depend on the extent price and quantity demanded change. Moreover, the estimates of a partial equilibrium model can overstate or understate total, economy-wide social costs depending on the type of existing market distortions and the extent to which there are spillover effects from the targeted sector to other economic sectors.

The partial equilibrium approach is particularly appropriate when social costs are predominantly incurred in a limited set of directly affected markets, and has minimal effects on other sectors. In cases where the regulatory action is known to have an impact on a broad range of sectors in the U.S. economy, the general equilibrium model can be a more appropriate approach to estimating social costs. Like the partial equilibrium model, the general equilibrium model estimates social costs by accounting for direct compliance costs and producer and consumer dynamics. The general equilibrium model can capture large and small first-order effects that occur in multiple sectors of the economy.

It is difficult to determine the relationship between general equilibrium estimates and direct cost estimates. Relative to the general equilibrium estimates, direct cost estimates are likely to overstate costs in the primary markets because they do not reflect consumer and producer responses. General equilibrium estimates, however, have a broader basis from which to estimate social costs and reflect net social welfare changes across the economy's economic sectors. There still remain significant barriers to

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[24] Morgenstern et al. (1998) estimates the multiplier of abatement expenditures to total costs can be as low as 0.8.

assessing the potential magnitude and direction of actual total welfare changes, as experienced by the economy as a whole, to those estimated by a general equilibrium model.[25] Without insight into the accuracy of general equilibrium model estimates, it is difficult to characterize how direct cost estimates relate to general equilibrium cost estimates.

In the 812 retrospective analysis (EPA, 1997), we opted for the general equilibrium approach, recognizing that the Clean Air Act has a pervasive impact on the U.S. economy. Moreover, the retrospective nature of the analysis provided us with fairly well-developed historical data sets of goods and service flows throughout the economy. These data sets facilitated the construction of extensive expenditure data from which we modeled producer and consumer behavior and estimated net social costs. In the retrospective, our central estimate of total annualized costs, from 1970 to 1990, was $523 billion. In comparison, the aggregate welfare effects were estimated between $493 and $621 billion.[26]

Although a general equilibrium approach represents a theoretically preferable, and potentially more accurate, method for measuring social costs, as described in Chapter 3 we adopted a direct compliance cost approach for the prospective analysis. We selected the simpler direct cost modeling method for three reasons:

- First, we believe that the direct cost approach provides a good first approximation of the economic impact of the CAAA on the U.S. economy. For example, recent research suggests that *ex ante* analyses of regulatory costs are far more likely to overstate than understate costs.[27] In addition, the direct cost approach, because it does not reflect adjustments to prices and quantities that might be adopted to mitigate the effects of regulation, likely overstates the producer surplus loss to the entity that incurs the pollution control cost expenditure. Under these conditions, direct cost may actually overestimate the social costs of a particular economic sector. It is also possible that the direct cost estimates understate the effects of long-term changes in productivity and the ripple effects of regulation on other economic sectors.

- Second, we believe that the precision in estimating social costs that might be gained through a general equilibrium approach could be compromised by the difficulty and uncertainty associated with projecting future economic and technological change. The general equilibrium approach could provide many insights that the direct cost approach cannot, but as a tool for estimating social costs it is very data-intensive and introduces a significant level of additional uncertainty as a result.

- Third, undertaking a general equilibrium modeling exercise remains a very resource-intensive task. In light of our concerns about the potential gains in precision or accuracy of our social costs estimates for the purposes of comparing costs to benefits, we concluded that more detailed modeling would not be the most cost-effective use of the project resources.

Limitations and Uncertainties

Several factors contribute uncertainty to the cost estimates.

- **Emissions Projections.** We base total cost estimates for individual CAAA provisions on projected emission reductions in 2000 and 2010. As a result, the quality of the cost

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[25] Harrington et al. (1999): "The general equilibrium effects of environmental regulations are likely to be important, but are likewise impossible to examine empirically. Computable general equilibrium models have not been tested against real-world outcomes and may be untestable."

[26] Estimates are presented in 1990 dollars. The retrospective states, "In general the estimated second order macroeconomic effects were small relative to the size of the U.S. economy." The rate of long term GNP growth between the control and no-control scenarios amounted to roughly one-twentieth of one percent less growth. It is important to note that although the difference is small, the direct compliance cost method does represent an underestimation.

[27] See, for example, Harrington et al (1999) for a comparative analysis of *ex ante* and *ex post* regulatory cost estimates.

analysis results is dependent, in part, on the quality of the emission projection estimates.

- **Evolving Rules.** We estimate many of the costs based on assumptions regarding how stringent evolving or draft rules may be when finalized. Costs are likely to change as these rules are amended or finalized.
- **Facility response to regulation.** Facilities may respond to regulations in a manner different from our model assumptions and thereby affect cost estimates. The cost estimates for individual CAAA provisions will ultimately depend on the mix of compliance options facilities choose to meet each rule's requirements. In addition, we do not quantify the effect of economic incentive provisions, which provide greater flexibility to facilities affected by the rules.[28]
- **SIPs for meeting ozone NAAQS.** It is difficult for us to predict how States will design control plans for meeting ozone NAAQS attainment requirements.
- **Technology assumptions.** We develop costs based on data for today's technologies. To the extent that control technologies improve over time and lower cost control alternatives become available, we may overstate costs.
- **Discount rate.** Discount rates affect costs. In some instances of this cost analysis, we use data sources that do not explicitly list the applied discount rate assumptions.

In this section, we first discuss the impact of the above listed key limitations. We then identify cost inputs and conduct quantitative uncertainty analyses for those factors. Table B-18 summarizes the limitations and the likely effect on the cost analysis results.

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[28] For example, the cost savings associated with a cap-and-trade program, such as South Coast Air Quality Management's Regional Clean Air Incentive Market (RECLAIM), is not reflected in the prospective cost assessment.

Table B-18
Potential Effects of Uncertainty on Cost Estimates

Description	Potential Effect on Cost Estimates
Innovations in future emission control technology	Decrease
Emission projections:	
Growth factors/activity indicators	Unknown
RACT controls for individual States	Unknown
Inclusion of economic incentive provisions[1]	Decrease
Use of costs for rules that are currently in draft form (not yet finalized)	Unknown
Uncertainty of final State strategies for meeting Reasonable Further Progress (RFP) RFP requirements	Unknown
Inclusion of 7- and 10-year MACT standards	Increase
Revisions to Title V cost estimate to reflect current State permit program costs	Decrease

Note:
[1] Examples include banking, trading, and emissions averaging provisions.

Emission Projections

The selection of activity indicators for individual source categories can have significant impacts on projected emissions, and in turn, on the cost estimates in this analysis. In addition, we select RACT controls based on representative controls, yet the controls for individual States/facilities may differ from these representative controls.

Draft Rules

EPA is currently revising several promulgated rules in response to public comments, legal actions, or other factors. The cost data used in this analysis reflect the latest available estimates, yet these costs are subject to change as the Agency modifies existing rules. For example, while we were developing CAAA costs, the Agency was also proposing a rule to limit summer season NO_x emissions in a group of OTAG-participating States. Cost estimates for the regional OTAG NO_x strategy will most likely be different than those for the Ozone Transport Rulemaking due to uncertainty about the final form of the rulemaking.

In an effort to maintain consistency between emission and cost data, we do not update its costs to reflect modification to drafted and existing rules. For example, because EPA revised the ozone and PM NAAQS *after* projecting emissions, we continued to use earlier cost estimates that are consistent with the prior NAAQS control assumptions. Another example is that of estimating cost for the proposed compression ignition (CI) engine Phase II rule which was not proposed by the time we completed our emissions projection for the nonroad sector. Although costs are now available for the Phase II rule, to maintain consistency with the benefits analysis we include only Phase I costs.[29]

In general, rule amendments such as exemptions for particular types of sources or opportunities for sources to postpone compliance dates are likely to ease the regulatory burden on regulated sources, and therefore, will result in lower total costs than those estimated in this analysis.

Economic Incentive Provisions

EPA created economic incentive provisions in several rules to provide flexibility for affected facilities that comply with the rules. These provisions include banking, trading, and emissions-averaging provisions. Flexible compliance provisions lower the cost of compliance. For example, the emissions-averaging program grants flexibility to facilities affected by the marine vessels rule, the petroleum refinery NESHAP, and the gasoline distribution NESHAP; these facilities can choose which sources to control, as long as they achieve the required overall emissions reduction. In many of the cost analyses, we do not

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[29] However, this implies CI nonroad engine rule costs are understated.

attempt to quantify the effect that economic incentive provisions will have on the overall costs of a particular rule. In these cases, to the extent that affected sources use economic incentive provisions to minimize compliance costs, costs may be overstated.

Reasonable Further Progress (RFP) and Attainment Costs

Considerable uncertainty surrounds the development of States' control plans for meeting ozone NAAQS attainment requirements. We develop the RFP cost estimate by assuming that ozone nonattainment areas (NAAs) will take credit for NO_x reductions for meeting progress requirements. Additional area-specific analysis would be necessary to determine the extent to which areas find NO_x reductions beneficial in meeting attainment and progress requirement targets. Trading of NO_x for VOC to meet RFP requirements may result in distributions of VOC and NO_x emission reductions that differ from those used in this analysis.

Future Year Control Cost Assumptions

The regulatory documents which provide cost inputs to ERCAM and the IPM contain the most recent data available, given existing technological development. Between 2000 and 2010, additional control technologies will allow sources to comply with CAAA requirements at lower costs. For example, we anticipates technological improvements for complying with the multiple tiers of proposed emission standards during the phase-in of nonroad engine controls; these improvements will likely lead to reduced costs. In addition, the costs for certain control equipment may decrease over time as demand increases. The trend in cost of selective catalytic reduction (SCR) costs illustrate this. Costs have decreased over the past three years as more facilities begin to apply the technology. We also believes that even in the absence of new emission standards, manufacturers will eventually upgrade engines to improve performance or to control emissions more cost-effectively; firms will institute technologies such as turbocharging, aftercooling, and variable-valve timing, all of which improve engine performance.

Discount Rate Assumptions

We apply a rate of five percent to both the discount rate and cost of capital. In some cases, we base costs on analyses that apply alternative discount rate assumptions (usually seven percent). Whenever possible we recalculate total annualized costs (TAC) for these rules in an effort to maintain consistency. We use TACs, in turn, to calculate cost per ton estimates that are applied to cost-equations. For some source categories, there was insufficient data available to identify the discount rate assumptions used in the TAC estimate and the relevant cost per ton estimates. For example, the national municipal landfills rule applies only to facilities that emit above 50 megagrams of non-methane organic compounds (NMOC). However, the cost analysis for the proposed rule used a different emissions cutoff (150 megagrams of NMOC). Because we did not revise the cost analysis to reflect the new cutoff, it is impossible to replicate the calculations used to estimate the TAC in the final rule. Additional research would be necessary to calculate costs for the national municipal landfills rule under alternative discount rate assumptions.

Source-Specific Cost Equations

We estimate the costs of Title III control measures for point and area source emitters using an average annual cost per ton value. For future analyses, assuming sufficient data are available, it may be possible to develop source-specific control equations using a similar approach to that used for point source NO_x emitters. The point source inventory generally includes larger, inventoried point sources, and the area source inventory includes emissions for smaller emission points. For this reason, we try to determine whether sufficient cost data by plant size are available to model costs specific to smaller plants, rather than using an overall cost effectiveness value across all plant sizes. If costs are available for sources by size, we apply the cost estimates for larger sources to point sources and apply cost estimates for smaller model plants to area sources. We do not, however, use this approach in all cases due to insufficient data.

Sensitivity Analyses to Quantify Key Uncertainties

We develop cost estimates based on a variety of studies and assumptions regarding future behavioral responses to provisions of the CAAA. These assumptions (i.e., changes in consumption patterns, input costs, and technological innovation) introduce some uncertainty to the cost projections. In order to characterize the potential importance of these uncertainties with respect to several provisions, we conduct sensitivity tests on selected Post-CAAA 2010 cost estimates. They are:

- Progress Requirements
- PM_{10} Nonattainment Area Controls
- Non-utility Stationary Source NO_X Costs
- California Reformulated Gasoline
- Low Emission Vehicle Costs
- NO_X Tailpipe/Useful Life Standards

These provisions represent the most significant contributors to total costs. Collectively, they constitute nearly half of the total 2010 Post-CAAA estimated costs. In addition, we examine the impact of alternative discount rates on the cost assessments. We summarize the results of the sensitivity analyses in Table B-19.

A significant portion of the cost of attaining and maintaining the one-hour average ozone NAAQS is attributable to rate of progress (ROP) and rate of further progress (RFP) compliance expenses. The costs associated with reducing VOC (and NO_x) emissions in order to satisfy these progress requirements are particularly difficult to estimate because cost-effective control measures have not been identified that will readily enable some ozone NAAs to make the required precursor emissions cuts. The estimated costs of unidentified VOC controls is one source of uncertainty that affects the overall cost of ROP/RFP requirements.

In the prospective, we assume that the cost of Title I progress requirements is equal to the cost of eliminating the VOC shortfall. We expect NAAs will reduce VOC emissions using identified control measures. The cost-effectiveness of each of these measures is known, and we assume that the control technique yielding the greatest reduction per dollar is the first to be implemented, followed by the second most cost-effective option, and so on until further VOC cuts are no longer necessary to satisfy ROP/RFP requirements.

We estimate that it will be possible to sufficiently lower VOC emissions through implementation of identified VOC controls for every NAA with a shortfall, except Chicago and Milwaukee. These two exceptions, however, have NOx waivers and cannot credit NO_x cuts towards RFP requirements. As a result, they will have to significantly lower VOC emissions; the necessary reduction is so sizable in both areas that neither will be able to make the required cuts, even if it adopts all of the identified control measures. Thus, in order to satisfy ROP/RFP requirements, Chicago and Milwaukee will have to implement unidentified VOC emissions control techniques. The estimated costs associated with these measures are a source of uncertainty potentially influencing the overall cost of Title I progress requirements. We conduct a sensitivity analysis to help characterize the influence of this uncertainty on the 2010 progress requirements cost estimate.

We base the three scenarios of the sensitivity analysis upon different assumptions regarding the cost-effectiveness of VOC shortfall controls. For the lower estimate, after applying identified controls (the approximate cost per ton of reduction is known for these measures), the remaining shortfall is eliminated through the implementation of unidentified controls. In the lower estimate scenario, we estimate the marginal cost of these unidentified measures is equal to the weighted average of the cost per ton estimate from the recently revise ozone NAAQS RIA, which is $10,000, and the average dollar per ton cost for identified measures.[30] The central estimate is identical to the lower estimate with one exception, unidentified controls are assumed to cost $10,000 per ton of

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[30] For example, in Chicago sixty percent of the required reduction of VOC emissions will come from identified measures at an average cost of $3,500 per ton. The remaining forty percent will thus come through unidentified controls. This means that, according to the lower estimate, the approximate cost per ton of reduction through the implementation of unidentified controls is $6,000 [$3,500(.60) + $10,000(.40)].

reduction in the central scenario. A flat $10,000 per every ton of shortfall VOC emissions reduced, from both identified and unidentified measures, is assumed for the upper estimate. Our sensitivity analysis shows that ROP/RFP costs range from $0.61 billion to $2.5 billion, with a central estimate of $1.1 billion. We provide a more detailed breakdown of these costs in Table B-20. It is important to note, that this sensitivity analysis is the only case in which the primary estimate of our cost analysis differs from the central case in a sensitivity test.

Table B-19
Factors Affecting Cost of Major CAAA Provisions

Provision	Factors Affecting Cost	Conduct Sensitivity Analysis?	Strategy for Sensitivity Analysis	Potential Effect of Uncertainty on Post-CAAA 2010 Cost Estimates[1]
Progress Requirements	Cost for unidentified measures is most uncertain.	Yes	Continue to examine costs of identified measures in other specific areas. Lower Bound: Assume average per ton cost of identified measures (e.g., $3,500 in Chicago) for all reductions, including unidentified measures. Central Estimate: Use cost figure for identified measures for that fraction of reductions (e.g., $3,500 for 60 percent in Chicago) and assume $10,000 per ton cost for unidentified measures. This central estimate reflects more recent cost per ton information than was applied to our primary cost estimate. Upper Bound: Assume $10,000 per ton cost for all reductions, including identified measures. Our cost analysis adopts a conservative approach and applies this cost per ton value to our primary cost analysis.	Central Estimate: $1.1 Range: ($0.06 - $2.5)
	Impact of revised ozone standard.	No	Emissions projections in the 812 Prospective do not include revisions to the ozone NAAQS.	no estimate
California Reformulated Gasoline	Incremental fuel costs show wide range and are most uncertain.	Yes	Lower Bound: Assume 7.3 cents per gallon cost from CARB. Central Estimate: Current analysis assumes 12.3 cents per gallon cost from CARB. Upper Bound: Assume 17.3 cents per gallon cost from CARB.	Central Estimate: $2.5 Range: ($1.4 - $3.5)
	Gasoline sale quantities are important, but less uncertain.	Yes	Gasoline sales are a function of vehicle miles traveled (VMT). Apply alternative VMT projection for California: *California Motor Vehicle Stock, Travel, and Fuel Forecast*, California Department of Transportation, November 1997. Alternative VMT would impact emission scenario.	

Provision	Factors Affecting Cost	Conduct Sensitivity Analysis?	Strategy for Sensitivity Analysis	Potential Effect of Uncertainty on Post-CAAA 2010 Cost Estimates[1]
PM NAA Controls	Base year emissions and growth.	No	Emissions projections and growth estimates are underlying assumptions of the cost analysis.[2]	no estimate
	Area specific plans may differ from the "model plan" applied.	Yes	Strategy for sensitivity analysis includes: 1) Apply area-specific control measures where available. 2) Use "model plan" when area plans are unknown.	Central Estimate: $2.2 Range: ($0.9 - $3.3)
	Cost per ton estimates and effectiveness of individual measures.	Yes	Apply upper and lower bound cost estimates for model plan controls based on the SCAQMP, the MRI study of agricultural operations, and the PM NAAQS study: Agricultural Tilling: Low $154/ton (1997 SCAQMP) High $5,900/ton (midpoint of range from MRI study) Construction: Low $1,900/ton (50% below value used) High $5,700/ton (50% above value used) Paved Roads: Low $50/ton (1997 SCAQMP) High $1,350/ton (50% above value used) Unpaved Roads: Low $560/ton (1997 SCAQMP) High $2,700/ton for rural roads (PM NAAQS)	

Provision	Factors Affecting Cost	Conduct Sensitivity Analysis?	Strategy for Sensitivity Analysis	Potential Effect of Uncertainty on Post-CAAA 2010 Cost Estimates[1]
LEV Costs	Will 49-State LEV occur?	No	Recently agreed to by the 23 automobile manufacturers that sell cars in the US and are regulated by EPA. Four States in the Northeast (MA, ME, NY, VT) have opted not to join the NLEV program.	no estimate
	Per vehicle costs.	Yes	Current analysis uses CARB's per vehicle cost estimates. These estimates are the lowest and most fully documented, and differ from other industry estimates by a factor of ten. Lower Bound: 50% below study per vehicle cost estimates. Central Estimate: Use current study (CARB adjusted for national sales volume) per vehicle cost estimates. Upper Bound: Use unadjusted CARB per vehicle cost estimates.	Central Estimate: $2.2 Range: ($1.08 - $2.5) (national and CA LEV combined)
	Projected vehicle sales.	Yes	Vehicle sales data were obtained from EPA's onboard vapor recovery RIA. Apply alternative sales projection: DOE's *Annual Energy Outlook 1998* - NEMS Transportation Demand Model.	

Provision	Factors Affecting Cost	Conduct Sensitivity Analysis?	Strategy for Sensitivity Analysis	Potential Effect of Uncertainty on Post-CAAA 2010 Cost Estimates[1]
Non-Utility Stationary Source NOx Costs	Unit-level cost equations and cost per ton.	Yes	ICI boilers account for 79 percent of the total point source NOx control cost estimate in 2010. Apply ±50 percent range. Other available data are 3-4 years old and would not reflect the fact that the control technology is being manufactured and applied by more sources.	Central Estimate: $2.2 Range: ($1.1 - $3.2)
	Inventory data elements (e.g., capacity, operating rate) used in cost calculations.	No	Inventory data elements are well-defined for each point source category.	no estimate
	Cap applied to 37 States, proposed NOx budgets affect only 22 States.	No	Current estimates overstate costs for fuel combustors in the 15 States not affected by the NOx cap. NOx SIP call RIA provides estimates for 22-state program.	no estimate
	Banking not accounted for.	No	None	no estimate
NOx Tailpipe/Useful Life Standards	Per vehicle costs date to 1991 FR Notice.	Yes	Lower Bound: No alternative estimates. Scale down medium estimate by 50 percent. Central Estimate: Use current $115 estimate from EPA. Upper Bound: No alternative estimates. Scale up medium estimate by 50 percent.	Central Esimate: $1.7 Range: ($0.83 - $2.5)
	Vehicle Sales	Yes	Same as LEV projected vehicle sales. See above.	
High Enhanced I/M	Per vehicle costs are most uncertain.	No	Alternative per vehicle cost estimates are similar to the costs currently used in the model.	no estimate

Provision	Factors Affecting Cost	Conduct Sensitivity Analysis?	Strategy for Sensitivity Analysis	Potential Effect of Uncertainty on Post-CAAA 2010 Cost Estimates[1]
	Vehicle registrations are important, but less uncertain.	No	1990 vehicle registrations are well-documented, and the method used to project future registrations based on population projections is sound.	no estimate
Discount Rate	Vary the discount rate.	Yes	Current cost estimates use a five percent discount rate. Vary the cost estimates using two alternative discount rates, three percent and seven percent.	Central Estimate: $3.0 Range: ($2.8 - $3.2)
Economic Growth Case Study	Macroeconomic growth projections may affect cost drivers.	No	The current methodology for calculating PM emissions relies on activity level projections more than macroeconomic growth rates. For example, the model uses the USDA agricultural baseline projections of farm acres planted to calculate PM emissions from agricultural production, the largest source of PM. The PM sources influenced by macroeconomic growth rates contribute only about five percent of total PM emissions.	no estimate

Notes: [1] Estimates are in billion 1990 dollars.

An additional source of uncertainty associated with estimating the cost of ROP/RFP requirements stems from the fact that the impact of the revised ozone NAAQS is not incorporated into the Post-CAAA scenario. We do not, however, conduct a sensitivity test designed to characterize the influence of the stricter NAAQS. In this instance, developing a cost range would not be very meaningful since benefits, as well as costs, would be affected by the changed NAAQS.

Table B-20
Rate-of-Progress Cost Sensitivity Summary

Ozone Nonattainment Area	Annual Post-CAAA 2010 Costs (million 1990 dollars)		
	Low Estimate	Central Estimate	High Estimate
Chicago-Gary-Lake County	$ 430	$ 810	$ 1,400
Dallas-Fort Worth	0.4	0.4	61
El Paso	8.5	8.5	76
Grand Rapids	0.2	0.2	27
Los Angeles-South Coast	0.8	0.8	44
Louisville	0.1	0.1	30
Milwaukee-Racine	120	210	430
Muskegon	0.6	0.6	9.3
Nashville	15	15	130
Salt Lake City	28	28	180
Sheyboygan	0.5	0.5	8.2
Kewaunee Co. WI	0.2	0.2	1.7
Monitowoc Co. WI	1.1	1.1	11.3
Total	**$ 607**	**$ 1,080**	**$ 2,500**

PM_{10} nonattainment area controls account for roughly seven percent of total annual costs in 2010. Two sources of uncertainty with respect to our estimate are: (i) how well the model plan mirrors actual application of controls in nonattainment areas, and (ii) how representative the cost per ton estimates used in the model are of actual control measure costs. We develop a sensitivity analysis that incorporates both factors. We analyze how well the model replicate selected SIP controls by applying the prospective cost equations to areas that have already implemented controls.[31] The second part of the sensitivity analysis assesses the impact of higher and lower cost per ton estimates on the original set of control measures. In cases where there were no alternative estimates, we adjust values up and down by fifty percent.[32]

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[31] We use a survey of SIPs designed in 1991 and implemented in 1995.

[32] The sensitivity analysis does not reflect point source controls.

Our analysis highlights two primarily differences between model and actual SIP designs. First, the model plan probably overstates the application of fugitive dust controls in practice. Second, over half of the areas that have adopted emission measures emphasized point source controls, at lower cost than reductions that could be achieved through other measures. Testing the uncertainty of cost per ton values resulted in a range between $0.9 and $3.3 billion in PM_{10} nonattainment costs. Total area source PM control costs had a low estimate of $1.5 billion and a high estimate of $3.3 billion. We summarize these results in Table B-21.

Table B-21
Area Source PM Control Cost Sensitivity Analysis, Year 2000
(in million 1990 dollars)

Source Type	Central Estimate	Model Plan Sensitivity Analysis	Low Estimate	High Estimate
Agricultural Burning	$ 39	$ 23	$ 20	$ 58
Agricultural Tilling	3.9	1.5	0	20
Beef Cattle Feedlots	1.7	0.3	0.9	2.6
Construction Activity	1,700	1,070	870	2,600
Paved Roads	440	380	13	650
Unpaved Roads	0.8	0.5	0.2	1.2
Total	**$2,200**	**$1,500**	**$907**	**$3,300**

Note:

[1] Examples include banking, trading, and emissions averaging provisions.

* Costs are in millions of 1990 dollars.

Another significant portion of total CAAA cost is incurred by non-utility stationary NO_X sources. This category contributes approximately eight percent of total costs in 2010. Its costs reflect unit-level costs for combustion processes at industrial, commercial, and institutional facilities. We identify the accuracy of future control costs assessment (nationwide and for the subset of OTAG states subject to the NO_X SIP Call) as a source of uncertainty that may affect cost projections. Our evaluation of this uncertainty involves applying alternative unit cost estimates. For the sensitivity analysis, we estimate upper and lower estimates by varying prospective costs up and down by fifty percent.[33] As a result, the central estimate for 2010 is $2.1 billion, and costs range from $1.1 billion to $3.2 billion.

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[33] After reviewing alternative cost studies sponsored by STAPPA/ALAPCO and the OTAG stationary source committee EPA found the studies relied on the same sources used by the 812 Project Team. Consequently, the agency opted for the above mentioned approach to varying cost inputs.

By 2010, we estimate California's reformulated gasoline program will cost $2.5 billion annually. The program is a significant factor in the our cost analysis, because it represents eight percent of total annual CAAA costs and ten percent of national gasoline sales. We identify two primary sources of uncertainty, projected car sales and projected gasoline consumption levels. The sensitivity analysis varies costs by applying the high and low cost per gallon estimates developed by CARB. The test indicates that cost may range between $1.4 and $3.5 billion. Moreover, we integrate into the sensitivity test alternative projections of car sales as a proxy for consumption levels.[34] California's Department of Transportation calculated VMT projection approximately five percent lower than the projection we use in the prospective. This lower VMT estimate estimaes costs of $2.27 billion in 2010 (compared with the central estimate of $2.45 billion).

Our estimate of low emission vehicle (LEV) costs are also subject to similar sources of uncertainty. We rely on assumptions regarding the types of implemented emission control technology, its associated costs (estimated as costs per vehicle), projected vehicle sales, and the extent to which LEV will be adopted around the country. We conduct sensitivity analyses for costs of both the California LEV program and a 49-State LEV program. The analyses reflect uncertainty with respect to cost per vehicle and vehicle sales. To test the uncertainty related to car sales, we use an alternative set of projections from the Department of Energy. The low estimate reflects per vehicle costs that are fifty percent below baseline costs. We use CARB's high estimates, which were unadjusted for national sales volume, to develop a high estimate. Our sensitivity analysis result are a low estimate of $0.55 billion and a high estimate of $1.34 billion for California's LEV costs in 2010. For a 49-State LEV program, the estimates range between $0.53 billion to $1.34 billion. The central estimates are $1.1 billion for the California LEV program and $1.06 billion for the 49-State LEV program. We summarize results in Table B-22.

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[34] EPA used VMT projections by California Department of Transportation.

Table B-22
Results of Sensitivity Analysis of LEV Costs

	Post-CAAA 2010 Annual Cost (million dollars)			
Program	Central	Low	High	Alternative VMT
California LEV	$ 1,100	$ 550	$ 1,100	$ 870
49-State LEV	1,060	530	1,300	820
TOTAL	**$ 2,200**	**$ 1,080**	**$ 2,500**	**$ 1,700**

Note: Columns may not sum to totals due to rounding

Costs associated with NOx Tailpipe/Useful Life Standards are a sizable portion of both Title II and total CAAA costs. By 2010, we estimate these costs will contribute nineteen percent of the Title II motor vehicle costs. As a share of total CAAA costs, it is six percent. Key sources of uncertainty are the same as those associated with LEV, per vehicle costs and projected car sales. Similarly, the sensitivity analyses: (i) scaled per vehicle costs up and down by fifty percent; and (ii) used alternative sales projections generated by the Department of Energy. The variation of cost inputs produced a cost range of $0.83 billion to $2.48 billion for 2010. Application of sales projections by the Department of Energy resulted in costs slightly lower than the central estimate, $1.25 billion compared with $1.65 billion respectively.

Unlike the other sensitivity analyses, the discount rate affects cost estimates for multiple provisions. As noted, we calculate total annualized cost estimates using a 5 percent discount rate. However, variations in the discount rate can potentially have a significant effect on the overall cost estimate, because the discount rate is also used as an estimate of the real cost of capital to finance pollution control equipment. Our sensitivity analysis of annualized focuses on source categories where available information is available to distinguish capital from operating and maintenance expenses. Source sectors and pollutants include non-utility VOC and NO_X and area source VOC, NO_X, and PM.

We present the discount rate sensitivity analysis results in Table B-23. We estimate total annualized costs using three discount rates, three percent, five percent, and seven percent. As a result, costs estimates vary from two percent to fifteen percent. The results of the analysis do not assess how the discount rate would impact a large fraction of the total estimated costs in the Post-CAAA scenarios. Excluded costs include motor vehicles and PM_{10} area source categories in nonattainment areas. Most of the capital costs associated with motor vehicle provisions are in the form of research and development. PM_{10} area source costs are generally calculated using a cost per ton estimate, which does not have sufficient available data for identifying the discount rate.

Table B-23
Discount Rate Sensitivity Analysis for 2010 Cost Estimates

Sector	Pollutant	Capital Cost (million 1990 dollars) Discount Rate 3%	5%	7%	Percent Difference Between 3% and 7% Rate
Non-Utility	VOC	$ 480	$ 501	$ 530	11%
	NO_x	1,400	1,500	1,600	12%
Area	VOC	508	540	570	11%
	NO_x	17	18	20	15%
	PM	430	440	440	2%
Total		**$ 2,800**	**$ 3,000**	**$ 3,100**	**11%**

The sensitivity analyses assess the potential effect of uncertainty on components of the total CAAA costs. We project costs for progress requirements, PM nonattainment area controls, non-utility NO_X sources, and utility emissions, based on modeling future emission controls. Accurately identifying the set of controls that will be adopted introduces a key source of uncertainty. The analyses indicate that there may be considerable variability in the cost estimates. However, it is important to note that for most of these scenarios, the high estimates are most likely representative of upper bounds. There are two sources of uncertainty associated with the motor vehicle provisions. The first source is projecting future car sales. The second is the accuracy of per vehicle costs. The high and low estimates relative to the central estimate do not present as wide a range.

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