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AIR POLLUTION

EPA's Progress in Determining the Costs and Benefits of Clean Air Legislation

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Resources, Community, and
Economic Development Division

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The Honorable Max Baucus
Chairman
The Honorable John H. Chafee
Ranking Minority Member
Committee on Environment and
Public Works
United States Senate

The Honorable John D. Dingell
Chairman
The Honorable Carlos J. Moorhead
Ranking Minority Member
Committee on Energy and Commerce
House of Representatives

Each year, millions of Americans face adverse health risks as a result of exposure to airborne pollutants. The Congress has attempted to improve the quality of the nation's air by enacting and updating clean air legislation, but air quality problems have proved difficult to alleviate. In the 1990 Clean Air Act amendments—the most recent attempt to improve air quality—the Congress enacted additional requirements for, among other things, attaining the national ambient air quality standards and reducing hazardous air pollutants and precursors to acid rain.

During the debate over the 1990 amendments, the Business Roundtable estimated that it could cost as much as $104 billion annually to implement three of the amendments' major provisions: those on acid deposition, air toxics, and the attainment of ozone standards. In light of this and other high cost estimates, the 1990 amendments required that the Environmental Protection Agency (EPA) conduct cost-benefit analyses of the 1990 amendments and any previous amendments to the Clean Air Act. By November 15, 1991, EPA was to begin reporting its findings of the costs and benefits of the Clean Air Act prior to the 1990 amendments. By November 15, 1992, EPA was to begin biennially updating its initial report and estimate future costs and benefits of the Clean Air Act including the 1990 amendments.

The Congress also mandated that, beginning in 1992, GAO annually examine the costs and benefits of the 1990 amendments. During discussions with your offices, it became apparent that this requirement was likely to duplicate EPA's analyses. Consequently, it was agreed that we would provide the Congress with a status report on EPA's efforts by describing EPA's (1) methodology for conducting the cost-benefit analyses, (2) progress in completing the analyses, and (3) costs incurred for contractors and EPA staff resources used to complete these analyses.

Results in Brief

EPA plans to conduct two major studies, with biennial updates of the second, to fulfill its mandate. To determine the costs and benefits of legislation enacted before the 1990 amendments, EPA is undertaking what it has termed a retrospective study, using a sequential, six-step methodology. In this study, EPA is comparing the economic, health, and environmental conditions that have resulted from the amendments enacted before 1990 with projections of what these conditions would have been without the amendments. In step one, EPA is estimating the direct costs of compliance with clean air regulations. EPA will maintain a data base of these costs. In steps two, three, and four, EPA is using computer models to estimate changes in economic activity, emissions levels, and ambient air quality resulting from actions taken in response to the amendments. In the last two steps, EPA is estimating the adverse effects of air pollution on human health and the environment and assessing the economic value of these effects. For the second study, known as the prospective study, EPA will contrast the effects of air quality standards imposed by legislation enacted before 1990 with the effects of all potential post-1990 standards. EPA also plans to update the prospective study biennially. As of December 1993, EPA had begun to develop a methodology for the prospective study but had not yet begun any analysis.

Although the 1990 amendments specified that EPA complete the retrospective study by November 15, 1991, the agency has estimated that it will not complete this study until 1994. EPA has spent 2 years developing and carrying out the methodology for the retrospective study. The agency's efforts have been delayed primarily because of the size and complexity of the study. Precisely isolating the effects of federal clean air legislation—some of which the Congress enacted over 20 years ago—is a difficult analytical task. According to agency officials, EPA will not concentrate its efforts on the prospective study until the retrospective study is finished. These officials could not estimate when the prospective study will be completed.

As of December 1993, EPA had spent approximately $1.3 million for contract work on the retrospective study, and an agency official estimated that the total cost of contract work could reach $1.6 million. In addition, EPA had used about 12 staff-years to oversee the study. This estimate of staff-years includes the use of staff in the three EPA offices involved in the project—the Office of Air and Radiation (OAR); the Office of Policy, Planning, and Evaluation (OPPE); and the Office of Research and Development (ORD). EPA officials could not estimate how much staff time would be spent during fiscal year 1994. Agency officials believe that the cost of the prospective study will be comparable to the cost of the retrospective study. Thus, the total cost for both studies could reach $3.2 million for contract work and 24 staff-years.

Background

The Congress enacted the Clean Air Act in 1963 to protect the quality of the nation's air and promote public health and welfare. In the 1970 Clean Air Act amendments, the Congress created a comprehensive program under which (1) EPA established national ambient air quality standards and (2) the states developed plans describing how they would control emissions from vehicles and stationary sources of pollution to meet and maintain the national standards. The 1977 Clean Air Act amendments added new requirements, including provisions to help areas that failed to comply with deadlines for the national ambient air quality standards (known as nonattainment areas) achieve attainment. For example, permits were required for the construction of new or modified major stationary sources of pollution.

The 1990 Clean Air Act amendments added stricter provisions addressing, among other things, the attainment and maintenance of the national ambient air quality standards, motor vehicle emissions, hazardous air pollution, acid rain, chlorofluorocarbons, permits, and enforcement. As noted above, the 1990 amendments also required that EPA assess the costs and benefits of these and previous amendments—an expansion of a requirement in the 1970 Clean Air Act amendments that EPA submit annual cost estimates to the Congress. Specifically, under the 1970 amendments, EPA was to estimate (1) the cost of carrying out the act's requirements; (2) the cost to federal, state, and local governments of implementing the programs; and (3) the economic impact of air quality standards on industries and communities, including the costs of controlling emissions. EPA was also required to reevaluate these estimates annually.

Cost-benefit analysis has been an integral part of EPA's regulatory process since Executive Order 12291 was issued in 1981. This order requires federal agencies to prepare a cost-benefit analysis for all proposed major rules—rules requiring expenditures that could exceed $100 million a year. However, the requirement for the cost-benefit analyses in the 1990 amendments is much more extensive than the requirements in either the 1970 Clean Air Act amendments or Executive Order 12291. Under the 1990 amendments, EPA is required to conduct comprehensive analyses of the impact of clean air regulations and programs on the public health, economy, and environment of the United States. In doing so, EPA is to take into account the costs, benefits, and other effects of complying with each standard issued under the authority of the 1990 amendments and previous Clean Air Act amendments.

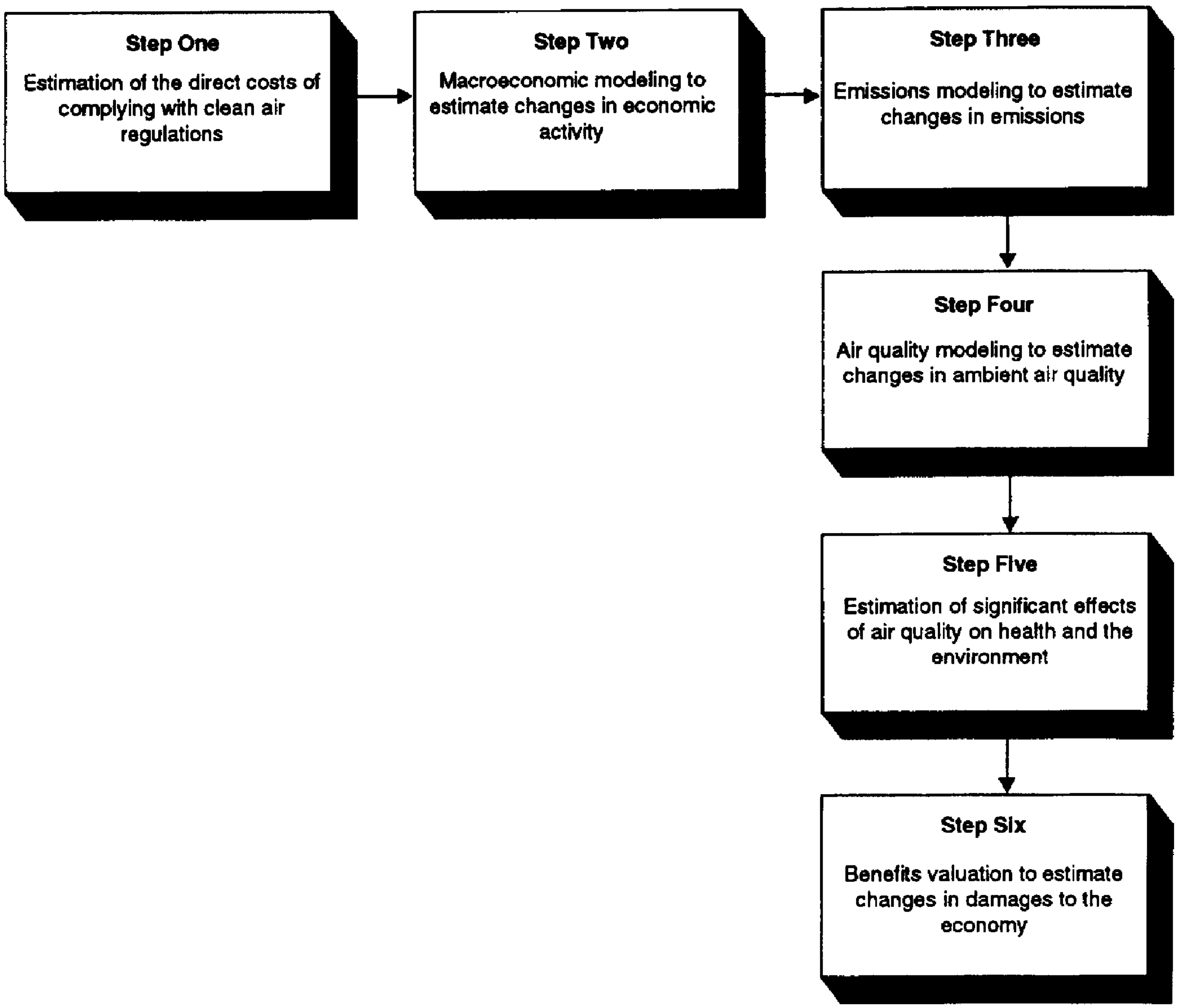
In early 1991, EPA decided to establish a joint management structure involving OPPE, ORD, and OAR to perform the required analyses. OPPE was assigned lead responsibility. As it became clear that no one office had the skills and resources needed to complete the analyses, OAR's role increased.

In conducting the cost-benefit studies, EPA is to consult with the Departments of Labor and Commerce and with an EPA-appointed advisory council, specified in the 1990 amendments as the Advisory Council on Clean Air Compliance Analysis (ACCACA). The ACCACA consists of recognized experts in the fields of health and the environmental effects of air pollution, economic analysis, environmental sciences, and other disciplines that EPA believes are appropriate. The role of the ACCACA is to review (1) EPA's methodology for conducting the cost-benefit analyses, (2) the data used in the analyses, and (3) the findings of the cost-benefit reports that result. The ACCACA can also recommend appropriate changes.

Methodology for the Cost-Benefit Analyses

For the retrospective study—which will assess the costs and benefits to public health, the economy, and the environment of legislation enacted before the 1990 amendments—EPA is using a six-step methodology. As shown in figure 1, the methodology is generally sequential because each step depends on the previous step for input. EPA is also assessing the uncertainty associated with each of the six steps. (App. I contains a detailed description of the methodology used for the retrospective study.) As of December 1993, EPA had begun to develop a methodology for conducting the prospective study—which will contrast the effects of the existing pre-1990 standards with the effects of all potential post-1990 standards—but no analysis was under way.

Figure 1: EPA's Six-Step Methodology for Conducting the Retrospective Study



Note: In each step, EPA estimates the changes that have occurred as a result of the Clean Air Act amendments.

In step one of the retrospective study, EPA estimated the direct costs of compliance with clean air regulations. These data then became input for the second step of the study. For this second step, EPA opted for a general equilibrium macroeconomic modeling approach rather than the partial equilibrium approach the agency had used for previous cost-benefit assessments.[1] EPA believes that the general equilibrium approach allows it to assess more accurately the likely effects of compliance with clean air regulations. The partial equilibrium approach does not address a number of these effects. For example, air pollution regulations that apply to one industry may affect other industries that are linked to the regulated industry through market transactions. In addition, clean air regulations may affect the distribution of labor, capital, and other factors of production within the economy as well as the distribution of goods and services. Furthermore, the general equilibrium approach accounts for possible actions that both businesses and households take to avoid unnecessary costs. The partial equilibrium approach does not account for these effects.

EPA's contractors used the Jorgenson-Wilcoxen general equilibrium model of the U.S. economy.[2] In the Jorgenson-Wilcoxen model, expenditures that industries have made to comply with pre-1990 regulations are used to estimate the effects of those regulations. Using this model, EPA generated estimates of U.S. economic activity, including the costs of compliance, for two policy scenarios: (1) conditions with the pre-1990 Clean Air Act amendments in place, or the base-case scenario, and (2) conditions without the pre-1990 Clean Air Act amendments, or the counterfactual scenario. EPA then calculated the net changes in economic activity between the two scenarios. Although EPA has evaluated and will continue to evaluate the uncertainties associated with using the Jorgenson-Wilcoxen model (uncertainties are inherent in all models), the agency believes that the current modeling results represent its best estimates and are therefore valid input for the third step of the retrospective study.

In step three, using the base-case and counterfactual estimates, EPA estimated emissions and calculated the net changes in emissions resulting from the legislation. To estimate emissions, EPA used the Argonne National Laboratory's Integrated Model Set; the Trends methodology of EPA's Office

[1]In this context, the term "general equilibrium" refers to an economywide analysis, while the term "partial equilibrium" refers to an industry-specific analysis.

[2]Professor Dale W. Jorgenson of Harvard University and Professor Peter J. Wilcoxen of the University of Texas at Austin developed the Jorgenson-Wilcoxen model.

of Air Quality, Planning, and Standards (OAQPS); and ICF Resources' model of the electric utility industry, the Coal and Electric Utilities Model (CEUM). These approaches assume that economic activity requires energy consumption and that consuming energy generates emissions. In general, higher levels of economic activity result in higher levels of emissions. In these approaches, emissions estimates are also generated for noncombustion sources, such as industrial processes, consumer solvents, and others.

In step four, EPA is estimating changes in air quality on the basis of the emissions estimates from step three. According to the Chief of the Air Quality Modeling Section, EPA is estimating the differences in air quality between the base-case and the counterfactual scenarios. For the base-case scenario, EPA is using historic concentrations of air pollutants to develop profiles for air quality in each county or urban area. For the counterfactual scenario, EPA is using several air quality models and statistical estimating techniques to assess the effects on air quality of the absence of air pollution controls.[3]

In step five, EPA is estimating the effects of projected air quality on human health and welfare and on the environment. These effects are being estimated using concentration-response functions.[4] Starting with the air quality estimates from step four, EPA will estimate concentration-response functions for each of the criteria air pollutants using available scientific literature.[5] EPA will then use these functions to estimate how air quality affects human health—as measured by morbidity and mortality (sickness and death)—and how it affects the environment—as measured by visibility, surface water quality, agricultural productivity, forest quality, and damage to materials.[6]

[3]These models include a set of interrelated equations that simulate and analyze the effects of wind speed, wind direction, and other atmospheric conditions on the movement of airborne pollutants.

[4]Concentration-response functions are mathematical functions used to predict changes in health effects on the basis of specified air pollution concentrations.

[5]Criteria air pollutants are air pollutants for which EPA has promulgated ambient air quality standards to protect public health. There are six criteria air pollutants: ozone, carbon monoxide, particulate matter, sulfur dioxide, nitrogen dioxide, and lead.

[6]EPA can derive concentration-response functions (which are based on scientific literature) at the same time air quality estimates are made. But the estimates of air quality must be complete before EPA can generate estimates of the effects because concentration-response functions and air quality estimates are used together to estimate the effects of degradation in air quality on human health and the environment.

In step six, EPA is estimating the economic value of these estimated effects on health and welfare and on the environment. For example, EPA's contractors have recommended estimating people's willingness to pay to avoid the symptoms commonly associated with poor air quality, including eye irritation and throat congestion. To estimate the values of these effects, EPA is relying on evaluations published in the economic literature.

The estimates in steps one through six include considerable uncertainty. According to EPA, uncertainties in the retrospective study are due to, among other things, poor data quality, modeling or sampling error, incomplete knowledge of key processes and relationships, and major uncertainties about the details of the counterfactual scenario. In addition, according to the ACCACA, incomplete knowledge about many of the underlying relationships in each of the steps in the analysis leads to uncertainties. Moreover, the uncertainty associated with each step's estimates carries through to the next step's estimates. As part of its analysis, EPA plans to evaluate the uncertainty in the estimates from each of the six steps and to identify key uncertainties and their implications for policy decisions.

EPA has consulted with the ACCACA and other experts in the fields of public health, economics, and environmental science in deciding on and implementing the methodology for the retrospective study. In April 1992, the ACCACA reviewed EPA's work plan for the study and determined that it was "basically sound." In addition, representatives from the Departments of Labor, Commerce, and Energy as well as representatives from the Council of Economic Advisers, the Council on Environmental Quality, and the Office of Management and Budget reviewed EPA's work plan and agreed with the ACCACA that it was sound.

Progress in Completing the Studies

As of December 1993, EPA had completed steps one, two, and three of its six-step retrospective study; preliminary work for steps four through six was well under way. Although the 1990 amendments required EPA to complete the study by November 15, 1991, the agency now estimates that it will complete the study in 1994. The study's size and complexity are the primary reasons for the delay. EPA's choice of a sequential, general equilibrium approach does not seem to be a major contributing factor in the delay. According to the Chairman of the ACCACA, a different methodology could have been as costly and time-consuming as the approach adopted by the agency.

According to agency officials, EPA has initiated planning for the prospective study and expects to begin work on it before the retrospective study is completed. These officials could not estimate when the prospective study will be finished.

For step one of the retrospective study, EPA completed development of a data base on the costs of compliance in early 1992. These data were used as input for step two; that is, modeling of U.S. economic activity using the Jorgenson-Wilcoxen model.

For step two, although additional analysis of the macroeconomic model is being conducted to further assess its uncertainties, EPA and the ACCACA were confident that modeling results presented in March 1993 were adequate to serve as input for step three. Initial modeling was completed in April 1992. EPA reviewed the contractors' results—which included estimates of economic activity for both the base-case and the counterfactual scenarios—and the internal consistency of the model before consulting with the ACCACA in December 1992. The ACCACA raised several concerns about the modeling and requested additional analysis using the model. This analysis was intended to help EPA and the ACCACA assess the uncertainties inherent in the model and increase the ACCACA's confidence in the model's results. Specifically, the ACCACA was concerned about the (1) assessment of direct and indirect costs, (2) treatment of productivity growth, (3) accuracy of cost estimates for stationary and mobile sources of pollution, and (4) treatment of foreign savings and investment behavior. EPA's contractors presented additional results from the model to the ACCACA in March 1993.[7] The ACCACA was impressed with the progress on its concerns and endorsed the general approach but still had concerns about certain assumptions inherent in the model. EPA said that it is confident that these concerns can be addressed in its final report on the retrospective study.

For step three, OPPE retained the Argonne National Laboratory, using its Integrated Model Set, as the primary contractor for the emissions estimates. OPPE also employed OAQPS' Trends methodology to help with emissions modeling. Argonne presented EPA with preliminary emissions estimates in June 1992 and revised estimates in September 1992.

OAR disagreed with Argonne's original estimates of emissions from electric utilities. Because OAR considered these emissions particularly important, it contracted with ICF Resources to provide additional estimates of utility

[7]Professor Jorgenson presented the additional model results to the ACCACA.

emissions to serve as a check on and to help resolve any problems that might emerge with Argonne's estimates. The results of the Argonne and ICF models were similar for particulates and nitrous oxides but very different for sulfur oxides. For example, the difference between the counterfactual and base-case scenarios that ICF estimated for sulfur oxides for 1990 was over twice the difference that Argonne estimated, and the difference that ICF estimated for 1980 was almost 10 times the difference that Argonne estimated for that year. According to EPA, this inconsistency arose because Argonne's estimates did not reflect fuel switching—that is, utilities changing from one fuel to another—among other factors. In December 1992, the ACCACA expressed its preference for ICF's approach and estimates. Once ACCACA made its preference known, OAR expanded ICF's work, requesting estimates for more pollutants over more years to substitute for Argonne's utility emissions estimates. These emissions estimates were completed in June 1993.

For step four, in 1992 EPA's air quality modeling contractor began developing a software program to make the emissions data compatible with EPA's main air quality model, the Regional Acid Deposition Model (RADM). At the December 1992 ACCACA meeting, EPA presented its initial ideas for using RADM. However, EPA's assessment of the effects on air quality was delayed because of the delay in completing the utility emissions estimates noted above. Thus air quality modeling did not begin until July 1993. According to the Chief of the Air Quality Modeling Section, because of the delay in completing the utility emission estimates and because ICF's estimates included additional details, EPA's contractor was required to rewrite the software program to make the final data on emissions compatible with RADM. As of December 1993, modeling using RADM was ongoing. EPA expects to employ other models and methodologies to assess air quality in early 1994, and all air quality assessment activities are to be completed by May 1994.

For step five, agency officials anticipate having preliminary concentration-response functions available for review in February 1994. EPA has used "criteria documents" as the basis of its assessment of the available scientific literature to establish links between pollution and its adverse effects. These documents are used primarily to support the national ambient air quality standards. EPA has also begun to review and summarize peer-reviewed scientific literature and staff papers that became available after the criteria documents were published. In addition, EPA has reviewed the scientific literature that assesses health risks resulting from exposure to toxic air emissions. According to EPA, it will quantify some health benefits that result from reductions in air toxics and attempt to place a dollar value on such benefits.

Finally, so that EPA can place a value on the benefits in step six, a contractor has recommended benefits categories and approaches to setting dollar values on them. These recommendations were presented to the ACCACA in December 1992. In a March 1993 letter, the ACCACA suggested changes to the approaches developed by the contractor. As of December 1993, the contractor had incorporated these suggestions and was continuing to refine the valuation methodologies.

Contract Costs Incurred and EPA Staff Used for the Retrospective Study

EPA had spent approximately $1.3 million for contract work on the retrospective study as of December 1993, and an agency official estimated that the final cost for contract work would be about $1.6 million. In addition, as of December 1993, EPA had used about 12 staff-years for EPA staff dedicated to the study. EPA could not estimate the staff-years needed for fiscal year 1994. Although EPA will not concentrate its efforts on the prospective study until the retrospective study is finished, OPPE and OAR officials expect that the costs of that study will be comparable. Thus, expenditures for the two studies could total $3.2 million for contract work and 24 staff-years. Table 1 shows how much the three EPA offices had spent on contract work for the retrospective study as of December 1993.

Table 1: EPA's Estimates of the Cost of Contract Work for the Retrospective Study, as of December 1993

	EPA office			
Step in the retrospective study	**OPPE**	**OAR**	**ORD**	**Total**
Direct compliance cost estimation (step one)	$81,000	$20,000	[a]	**$101,000**
Macroeconomic modeling (step two)	$105,000	[a]	[a]	**$105,000**
Emissions modeling (step three)	$380,900	$67,000	[a]	**$447,900**
Air quality modeling (step four)	[a]	$191,000[b]	$70,000	**$261,000**
Concentration-response functions (step five)	$70,000	$13,000	[a]	**$83,000**
Benefits valuation (step six)	$75,000	$145,000	[a]	**$220,000**
Uncertainty valuation[c]	[a]	$64,000	[a]	**$64,000**
Total by office	**$711,900**	**$500,000**	**$70,000**	**$1,281,900**

[a]Not applicable.

[b]This figure includes $80,000 in contract money that OAR transferred to ORD.

[c]Each step in the retrospective study includes some uncertainty. As reflected in this cost figure, EPA has already started to evaluate these uncertainties, and it will continue to do so.

As the table shows, EPA has spent $101,000 on step one of the study (estimating direct compliance costs). This includes the cost of maintaining a data base of compliance costs for both mobile and stationary sources of pollution. For step two (macroeconomic modeling), EPA has spent $105,000, including the cost of initial modeling and additional analysis. For step three (emissions modeling), EPA has spent $447,900, including the costs of analysis using Argonne's Integrated Model Set, ICF's CEUM, and OAQPS' Trends methodology. For step four (air quality assessment), EPA has spent $261,000, including the costs of developing air quality profiles and of initial air toxics modeling. For steps five and six, EPA has spent $83,000 on developing concentration-response functions and $220,000 on establishing the value of benefits, including reviews of the scientific and economic literature.

The three EPA offices involved in the retrospective study funded specific parts of the study. OPPE has spent $711,900 on work completed by contractors, including (1) researching the cost data on mobile sources used in the macroeconomic model, (2) modeling the base-case and counterfactual scenarios, (3) performing additional analyses using the macroeconomic model, (4) estimating emissions, and (5) developing concentration-response functions. As of December 1993, OPPE had used 4.5 staff-years for the study. OPPE officials expect the prospective study to require a level of cost and effort similar to that of the retrospective study.

OAR has spent $500,000 for contract work on the study, including (1) reviewing data on compliance costs; (2) estimating emissions from electric utilities; (3) assessing air quality; (4) estimating concentration-response functions for the effects of pollutants on mortality, morbidity, and welfare; and (5) configuring a model to analyze the uncertainties in the study's results. OAR has used approximately 6.5 staff-years for the study, according to an estimate made by OAR in December 1993. OAR officials also expect to use comparable resources for the prospective study.

To date, ORD's expenditures on the retrospective study have been minimal. As of December 1993, ORD had spent $70,000 and used approximately 1 staff-year on the retrospective study.

Conclusions

The 1990 Clean Air Act amendments require EPA to assess the costs and benefits of federal clean air regulations, including compliance with each standard associated with earlier Clean Air Act amendments as well as with the 1990 amendments. This task is difficult because of the size and complexity of the analyses required. As a result, EPA is taking longer to complete the analyses than the Congress mandated. Isolating the effects of clean air legislation on human health and the environment is an analytical task that requires a complex and sophisticated methodology, and EPA has expended substantial effort in developing and implementing an appropriate methodology.

EPA consulted experts in the fields of economics, public health, and environmental science before developing and implementing the methodology it is using for the retrospective study—the first part of its cost-benefit analyses. Although EPA's choice of methodology may be costly, time-consuming, and inherently uncertain, other methodologies could have been as costly and time-consuming, according to the Chairman of the ACCACA.

Given the size, scope, and complexity of the required cost-benefit analyses, it is not surprising that EPA has been unable to meet the specified deadlines. According to EPA, the retrospective study will not be completed until sometime in 1994. EPA will not concentrate its efforts on the prospective study until the retrospective study is completed; thus, the agency has not yet estimated when the prospective study will be completed.

Agency Comments

In commenting on a draft of this report, EPA said the report accurately describes several of the difficulties that the agency has had in implementing the program, including the size and complexity of the cost-benefit studies. In addition, EPA offered a number of technical corrections and clarifications, which have been incorporated into the report where appropriate. EPA's comments are reproduced in appendix II.

Scope and Methodology

We conducted our review between December 1992 and December 1993 in accordance with generally accepted government auditing standards. To describe EPA's methodology for the cost-benefit analyses mandated in the 1990 amendments, we reviewed the agency's work plan and assessed the extent to which this plan conformed with requirements established in the 1990 amendments. We also reviewed work completed by EPA and its contractors as of December 1993. We discussed EPA's methods with agency officials, contractors, and experts in the fields of economics, modeling, and environmental science. To determine EPA's progress toward fulfilling the mandate in the 1990 amendments, we reviewed preliminary reports prepared by EPA's contractors and internal agency documents describing the progress of the analyses. In addition, we discussed EPA's progress with agency officials, contractors, and the Chairman of the ACCACA. To describe the costs of the cost-benefit analyses, we obtained documentation from EPA on the costs of work by contractors and the expenditure of agency staff-years and funds. We obtained estimates of contract costs and staff resources from EPA offices conducting the retrospective study, including OPPE, OAR, and ORD. We also discussed the costs of the analyses with agency officials.

We are sending copies of this report to appropriate congressional committees; the Administrator, EPA; the Director, Office of Management and Budget; and other interested parties. We will also make copies available to others on request.

This report was prepared under the direction of Peter F. Guerrero, Director, Environmental Protection Issues, who may be contacted at (202) 512-6111 if you or your staffs have any questions. Major contributors to this report are listed in appendix III.

Sincerely yours,

Keith O. Fultz
Assistant Comptroller General

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Abbreviations

ACCACA	Advisory Council on Clean Air Compliance Analysis
ARGUS	Argonne Utility Simulation Model
CEUM	Coal and Electric Utilities Model
CO	carbon monoxide
CRESS	Commercial/Residential Energy and Emissions Simulation Systems
EPA	Environmental Protection Agency
GAO	General Accounting Office
GDP	gross domestic product
HC	hydrocarbons
HPA	Hierarchically Partitioned Assessment model
ICE	Industrial Combustion Emissions model
IEc	Industrial Economics, Inc.
IMS	Integrated Model Set
ISTUM	Industrial Sector Technology Use Model
NAPAP	National Acid Precipitation Assessment Program
NO_x	nitrogen oxide
OAQPS	Office of Air Quality Planning and Standards
OAR	Office of Air and Radiation
OPPE	Office of Policy, Planning, and Evaluation
ORD	Office of Research and Development
OZIP	Ozone Isopleth Model
PROMPT	Process Model Projection Technique
R&D	research and development
RADM	Regional Acid Deposition Model
SO_2	sulfur dioxide
SO_x	sulfur dioxide
TAMM	Timber Assessment Market Model
TEEMS	Transportation, Energy, and Emissions Modeling Systems
TSP	total suspended particles
VOC	volatile organic compound
VOCM	Volatile Organic Compounds Model

EPA's Methodology for the Retrospective Study

This appendix provides detailed information on the Environmental Protection Agency's (EPA) methodology for the retrospective study. Information is presented on each step in the study's methodology.

EPA has stated that the quantitative estimates resulting from each step will include considerable uncertainty and that the agency is committed to including quantitative measures of uncertainty associated with the major parts of an analysis, identifying those uncertainties that are important for policy decisions and assessing the impact of uncertainty on final estimates of net benefits. For the retrospective study, EPA plans to use a variety of methods to characterize uncertainty, including measures of central tendency, standard deviations, probability distributions, and the judgment of experts. Furthermore, the Advisory Council on Clean Air Compliance Analysis (ACCACA) recommended in March 1993 that EPA pay attention to uncertainty associated with (1) model specifications and (2) input data. The ACCACA recommended that EPA not rely totally on the Hierarchically Partitioned Assessment model (HPA).[1] The HPA cannot substitute for another method of analyzing the Jorgenson-Wilcoxen model—the principal model used in step two— and other complex models. Nor can it substitute for the use of judgment in the analysis of uncertainty. The ACCACA also recommended that EPA use probability distributions and expert judgment in the uncertainty assessment.

Step One: Costs of Compliance

For the first step in the retrospective study, EPA is estimating the direct costs of complying with clean air legislation. The data on compliance costs will be used as a stand-alone analysis as well as for input for step two. Compliance costs average $18.1 billion (in constant 1982 dollars) over the period 1973 to 1990. Of this total, capital and net operating expenditures for stationary sources of pollution average $5.4 billion and $5.2 billion (in 1982 dollars), respectively. Government outlays average just over $0.5 billion, and costs for mobile sources average about $7.0 billion (in 1982 dollars). Private research and development (R&D) expenditures, which were omitted from consideration in this analysis, average $1.2 billion (in 1982 dollars).

These costs, while significant in absolute terms, are small in comparison with the overall economy. On average, they represent only one-third of one percent of domestic output from 1973 to 1990. However, the cost burden falls somewhat more heavily early in the period, as these costs account for

[1]The Hierarchically Partitioned Assessment (HPA) model is a spreadsheet accounting system that handles the straightforward, mechanical propagation of confidence intervals.

almost one-half of one percent of total output in 1973, but only one-quarter of one percent in 1990. In terms of real household income, the costs are only slightly more significant, averaging just over two-thirds of one percent from 1973 to 1990.

EPA's costs of compliance include direct and indirect costs. The agency's approach entails determining (1) direct costs through estimates of expenditures for capital and operation and maintenance of pollution control programs and (2) indirect costs from the Jorgenson-Wilcoxen model. The main source of data on direct pollution abatement expenditures is EPA's Environmental Investments: The Cost of a Clean Environment (Nov. 1990). Changes in direct expenditures for compliance were processed through the Jorgenson-Wilcoxen model to estimate indirect costs, such as changes in employment, productivity, cost of living, and economic growth.

Step Two: Macroeconomic Modeling

The Jorgenson-Wilcoxen model, which EPA chose for step two of the retrospective study,[2] divides the economy into the following sectors: business, household, government, and foreign. The key features of the Jorgenson-Wilcoxen model are summarized below.

The business sector is divided into 35 industries. These industries produce commodities to fill the orders of the household, government, and foreign sectors. The industries also provide each other with commodities or materials needed in their production processes. Each of the 35 industries is represented in the model by a mathematical equation that explains how the costs of production are determined. Each of these cost equations is estimated from data spanning the period 1947 through 1985. These equations represent costs as dependent on capital, labor, energy, materials, and technological change or productivity growth. In the model, technological change is influenced by the prices of capital, labor, energy, and materials. The model assumes that producers in these industries use capital, labor, and other inputs to produce 35 separate commodities at minimum costs.[3]

[2]Professors Dale W. Jorgenson of Harvard University and Peter J. Wilcoxen of the University of Texas at Austin developed the model on the basis of economic research they conducted over many years.

[3]In the model, there is a price equation for each industry's output. This equation represents the price of the commodity produced as depending on the prices of energy, materials, capital, labor services, and a time variable. In turn, the model represents the price of energy as depending on the prices of coal, crude oil, refined petroleum, electricity, and natural gas. The price of materials depends on the prices of all other commodities used by the industries to produce their final products for sale. In the model, the amounts of capital, energy, labor, and materials used to produce commodities are derived mathematically from these price equations.

The household sector is divided into demographic groups that differ by family size, the age of the head of the household, race, the region in which the household resides, and urban versus rural location. The model assumes that each household decides how much of its available time to pursue earning income and enjoying leisure and, in turn, how much of its income to consume and to save so as to maximize its satisfaction. Mathematical equations describing this behavior are also estimated from data spanning the period 1947 through 1985.[4] In the model, households buy energy, food, nondurable consumer goods like clothing, and services. To determine total expenditures on all 35 commodities represented in the model, each household goes through a two-step process. First, it decides how much of its total wealth[5] to use each year.[6] Then, for each year, it decides how much of its wealth to spend on commodities and services and in the form of leisure time.[7] The difference between the household's total time available and leisure time determines how much time it spends earning income in that year. Finally, household saving is equal to the difference between current income from the supply of capital and labor services provided by the household and personal consumption expenditures.

In the Jorgenson-Wilcoxen model, investment is derived from the behavior of households and businesses described above. The model includes a system of demand equations for investment goods by these two sectors. For example, the business sector purchases goods for investments in producer durables, residential and nonresidential structures, and inventories. The household sector invests in consumer durables like personal computers and housing. In the model, each new unit of capital is an aggregate of these commodities purchased for investment. Thus, the

[4]In the model, each household's behavior is represented by an equation in which the household's satisfaction depends on commodity prices, total household expenditures, and differences in tastes related to the demographic characteristics of the household. Assuming that the household maximizes its satisfaction, how much it spends on individual commodities depends on the prices paid for the commodities and the household's demographic characteristics and total expenditures.

[5]Wealth includes future earnings from the supply of capital and labor services by the household, transfer payments from the government, and an imputed value of leisure time.

[6]In making these decisions, it turns out that the amount of wealth that is consumed and saved in any given year depends on what the household expects future prices and interest rates to be. The model represents this consumption of goods, services, and leisure time as depending on the interest rate and the price of this consumption.

[7]For each year, the model represents the household's satisfaction as depending on the prices of leisure and an aggregate consumption good. The price of leisure is assumed to be equal to the after-tax wage rate, and the price of the aggregate consumption good is equal to a price index based on the commodities consumed. From this relationship, it follows that the household's demand for consumer goods and leisure in each year depends on the prices of these goods and leisure and the amount of wealth that the household has decided to spend in that year.

price of new capital depends on commodity prices.[8] As in the case of households, intertemporal behavior is also assumed on the part of investors.[9] For each year, the supply of capital depends on past investment. Investment during the year is determined by household savings. Would-be investors also compare the price of these new investment goods with the present value of future capital services. In the model, commodity prices and interest rates adjust to bring about an equilibrium in which the returns on additional investment equal the cost of new capital goods, and savings equal investment.

The behavior modeled for the two remaining sectors—the government and foreign sectors—is less detailed. The key assumptions about these two sectors are that the government deficit and current account surplus are exogenous; that is, predetermined outside the model. In the government sector, tax revenues are determined given a set of tax rates. These revenues, together with the given deficit, determine government spending. Government purchases of the various commodities are based on historical spending patterns. For the foreign trade sector, imports are assumed to be imperfect substitutes for similar domestic commodities. The responsiveness of imports to prices is estimated from historical data. The prices of imports are determined outside the model. Exports are determined by the level of foreign income and the foreign prices of U.S. exports. Foreign income is determined outside the model, while foreign prices are calculated from domestic prices and exchange rates. The responsiveness of exports to prices is also estimated from historical data.[10] The foreign exchange rate is determined in the model.

Given this outline of the Jorgenson-Wilcoxen model, the effects of environmental regulation can be explained. Using historical data, the shares of the operating costs of pollution abatement to the total costs for each industry are computed. Then the share of total costs excluding those pollution abatement outlays can be calculated. To simulate the effect of eliminating these operating costs, these shares are inserted into the cost equations of each industry.[11] The effect of this operation is to lower commodity prices. Thus, the price of investment goods is lower.

[8]New capital goods are produced out of individual commodities according to a production equation estimated from investment data for the period 1947 through 1985. The technology for producing these new capital goods is represented by a price equation for investment goods that is estimated using the data described above.

[9]In the model, households are also investors.

[10]A set of foreign demand equations is included, in which foreign consumption of U.S. goods and services depends on foreign income and prices for these goods and services.

[11]The price equation described in footnote 1 is modified.

Lower-priced investment goods lead to a higher rate of return on capital, stimulate savings, and generate more rapid capital accumulation. Additional capital leads to a lower price of capital. Cheaper capital services lead to further declines in prices of other goods and services, and an increase in consumption[12] and a greater gross domestic product (GDP). In addition, the exchange rate falls, increasing the international competitiveness of the U.S. economy.

The next step is to simulate the effect of eliminating investments in pollution control equipment. This elimination is simulated as a decrease in the price of investment goods.[13] This decrease leads to higher rates of return on capital, increased capital accumulation, a lower price for capital, lower overall prices, increased consumption, and higher GDP.

Step Three: Emissions Estimates

To estimate emissions, EPA used several models. EPA entered into a cooperative agreement with Argonne National Laboratory to conduct the emissions analysis for the retrospective study. EPA used Argonne's Integrated Model Set (IMS); the Office of Air Quality Planning and Standards' (OAQPS) Trends methodology; and ICF Resources' model of the electric utility industry, the Coal and Electric Utilities Model (CEUM). Output from the macroeconomic model became input for EPA's efforts to determine net changes in emissions between the two scenarios generated in step one; that is, the base-case and counterfactual scenarios.

The Integrated Model Set (IMS)

The IMS, designed for the National Acid Precipitation Assessment Program (NAPAP), estimates emissions for criteria air pollutants, broken down by source for each state.[14] The IMS is driven by data from a macroeconomic model, such as the Jorgenson-Wilcoxen model, and predicts energy use and subsequent emissions for each state and energy source on the basis of estimates of economic activity and cost-effective fuel choices.[15] The IMS

[12]Recall that consumption includes leisure time as well as personal consumption expenditures.

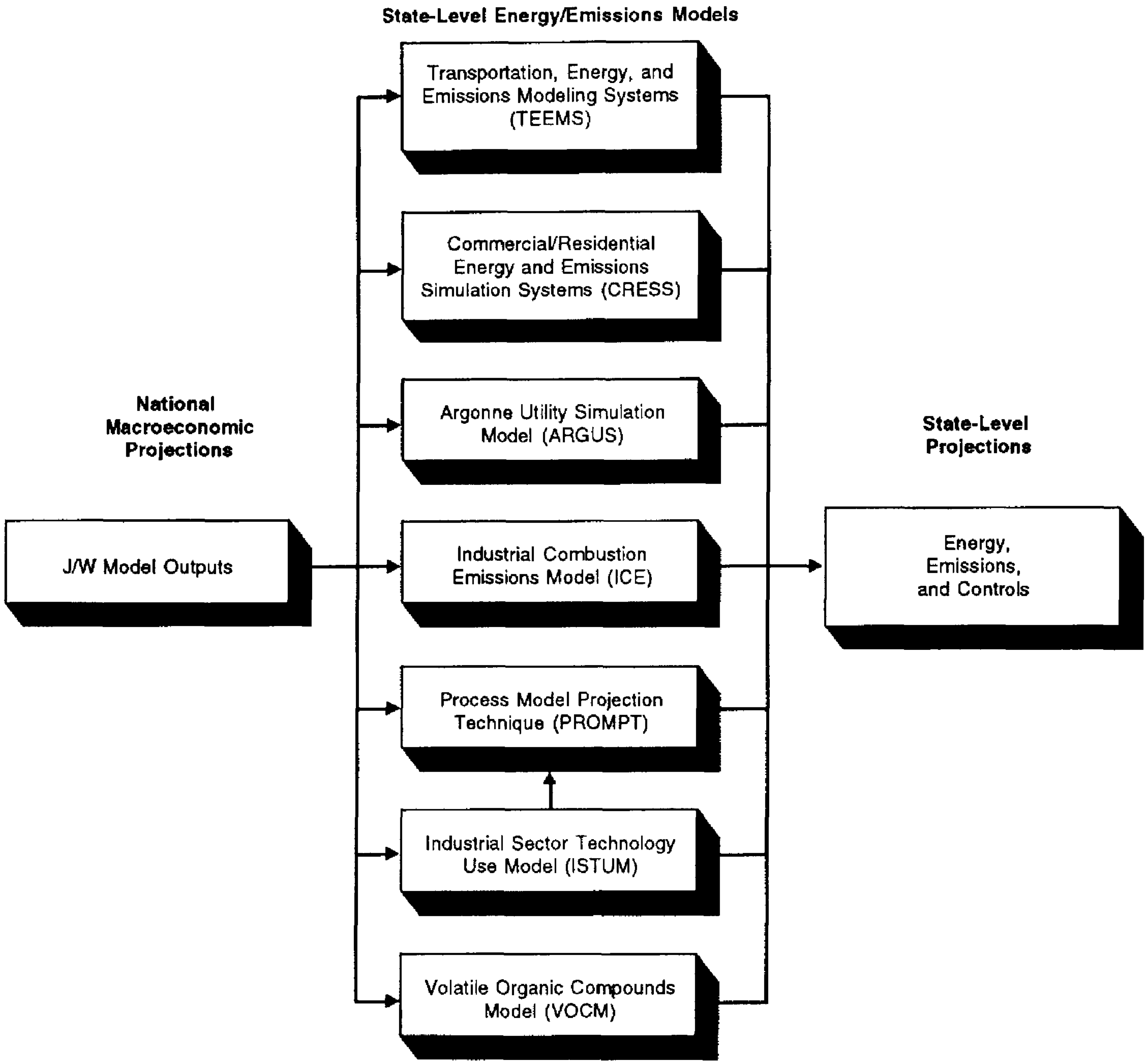
[13]The price of investment goods is reduced by the proportion of total investment attributable to pollution control.

[14]The 1970 Clean Air Act amendments provided authority to establish ambient air quality standards. Currently, there are six national ambient air quality standards, or standards for criteria air pollutants: ozone, including precursor compounds, i.e., volatile organic compounds (VOC); carbon monoxide (CO); particulate matter (PM-10), formerly called total suspended particles (TSP); sulfur dioxide (SO_2); nitrogen dioxide (NO_2); and lead.

[15]The IMS accounts for the effect of the fuel choices of one source on other sources. For example, if utilities chose coal for fuel, their decision may affect the fuel choices of industrial users, which would in turn change emissions from these sources.

contains separate models for emissions from mobile sources, utilities, industrial sources, and commercial and residential sources. (See fig. I.1.)

Figure I.1: IMS Modeling Framework



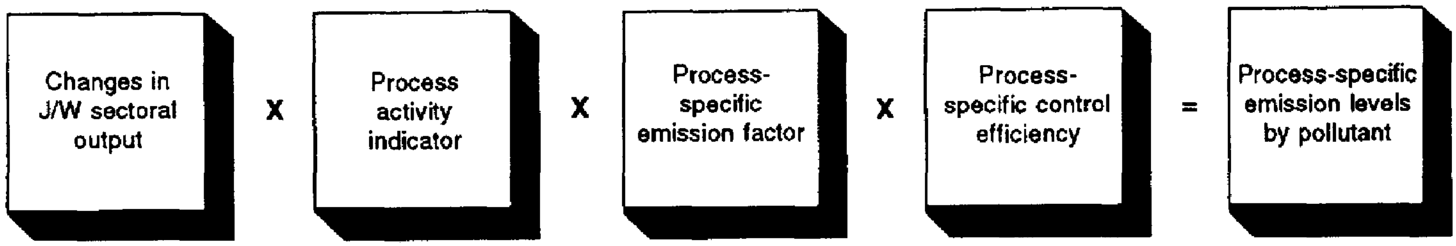
Note: The J/W model is the Jorgenson-Wilcoxen Model.

For the retrospective study, the IMS supplied emissions data for the base-case and counterfactual scenarios for SO_2, NO_x, VOC, total suspended particles (TSP), CO, hydrocarbons (HC), and lead for the transportation sector, by state, by sector, by 5-year intervals over the period 1975-90, and by fuel type. Even though the base-case scenario represents what actually happened—that is, implementation of the Clean Air Act—EPA chose to estimate emissions for this scenario rather than to use data on actual emissions. EPA made this choice because comparing actual and modeled emissions data may bias any outcome, since actual emissions data may result from variables not accounted for in the emissions models. Argonne modeled historical emissions (base-case) using assumptions similar to those used for the counterfactual scenario so that the scenarios could be compared.

The Trends Methodology

EPA supplemented estimates from the IMS with estimates from the OAQPS Trends methodology. The Trends methodology uses point-source estimates and area-source estimates to develop emissions figures. Point-source estimates include estimates of emissions from specific, identifiable sources. Areas-source estimates include estimates of emissions from many small sources, such as residential fuel combustion, solid waste disposal, and fugitive dust emissions such as those resulting from wind erosion of land. The Trends methodology uses estimates of economic activity as indicators of emissions. Fuel consumption and deliveries, tons of refuse burned, and raw material processed are examples of some of the activities used as indicators. Emissions factors—that is, estimates of the average rate of emissions from many sources combined—are then used to translate these activity levels into the estimates of emissions. The Trends methodology is depicted in figure I.2. Also, table I.1 includes information on how IMS and Trends cover emissions estimates.

Figure I.2: Trends Methodology



Note: J/W is the Jorgenson-Wilcoxen Model.

Table I.1: Emissions Estimates Covered Using IMS, Trends Methodology (Tr), and CEUM

	Pollutant					
Source	**SO_x**	**NO_x**	**TSP**	**VOC**	**CO**	**Lead**
Mobile sources						
On-highway light- and heavy-duty vehicles	IMS	IMS	IMS	IMS	IMS	TR
Off-highway vehicles	TR	TR	TR	TR	TR	TR
Utilities	CEUM	CEUM	CEUM	IMS	IMS/ TR	IMS/ TR
Industrial sources						
Fuel combustion boilers	IMS	IMS	IMS	TR	TR	IMS
Nonboilers	IMS	IMS	TR	IMS	TR	TR
Commercial/residential	IMS	IMS	IMS	IMS	IMS	TR
Waste disposal/miscellaneous	IMS	IMS	IMS	IMS	IMS	TR

Step Four: Air Quality Assessment

For its overall approach to assessing air quality, EPA is estimating the differences in air quality, by state, between the base-case and the counterfactual scenarios. For the counterfactual scenario, EPA is using several air quality models and statistical estimating techniques to assess the effects on air quality of not having air pollution controls. EPA is modeling the base-case scenario using historical air quality concentrations to develop profiles for each state's air quality.

To assess air quality for the counterfactual scenario for the eastern states, EPA is using the Regional Acid Deposition Model (RADM) as its primary means for estimating SO_x, NO_x, ozone, and the sulfate and nitrate components of total particulates. RADM is a highly sophisticated computer model whose output consists of estimates of air quality in 20- to

80-kilometer zones, or grids, in the 31 eastern states. EPA will aggregate these substate grid measurements into statewide estimates of air quality for the eastern states. Ozone measures will be supplemented by the Ozone Isopleth Model (OZIP). For the western states, EPA will use heuristic models to estimate regional air quality and roll up or roll back historical concentrations of air pollutants on the basis of these changes.[16] Heuristic models are simple models that assume that air quality varies in direct proportion to changes in emissions. According to the Chief of EPA's Air Quality Modeling Section, the agency must depend on heuristic models for the western states because other, more elaborate models like RADM have not been developed for use in the west.

Step Five: Concentration-Response Functions

Once estimates of changes in air quality have been completed, EPA plans to estimate the effects of those changes on human health and the environment. The relationship between air quality and its adverse effects is being assessed using concentration-response functions; that is, specific concentrations of air pollutants may result in negative health or environmental responses. EPA will estimate the effects of air pollution concentrations on human health, including morbidity and mortality (sickness and death) and on the environment, including changes in visibility, surface water quality, agricultural productivity, and forest quality, and damage to materials. EPA will develop concentration-response functions for each of the criteria air pollutants on the basis of existing and published scientific literature and the air quality estimates from step three.

According to EPA officials, the agency's criteria documents will serve as the basis for developing concentration-response functions. Criteria documents are EPA's assessments of the available scientific literature and are used to support setting national ambient air quality standards. The agency prepares separate criteria documents that include toxicological, epidemiological, and clinical studies for each standard. Agency officials noted, however, that criteria documents are sometimes outdated and may be less comprehensive than what is needed for this step in the retrospective study. As a result, the agency intends to update its scientific understanding of concentration-response functions by reviewing and summarizing the scientific literature published since the criteria

[16]"Roll up" methodologies involve using local and county level pollution concentrations and extrapolating these to the state level on the basis of emission sources, prevailing weather patterns, and pollutant type.

documents were issued.[17] Agency officials stated that this approach will allow the three types of research (toxicological, epidemiological, and clinical studies) to complement one another and will result in a more complete understanding of the concentration-response functions for each criteria air pollutant.

According to agency officials, toxicological, epidemiological, and clinical studies contribute to an understanding of how exposure to air pollution affects health and the environment. In toxicology research, animals are exposed to contaminants under laboratory conditions. In epidemiological studies, the effects of air pollution on humans are measured in natural, uncontrolled settings, and clinical analyses examine human responses to pollution under these controlled conditions. EPA plans to use all three types of research in its assessment of concentration-response functions.

Each research approach offers a different perspective on how pollution affects people and the environment, and each has its strengths and weaknesses relative to the other approaches. The major advantage of the toxicological approach is its ability to examine the physiological effects of pollution over a long period of time, making it the preferred methodology to study chronic effects. In addition, the toxicology approach enables researchers to test animals at higher doses and to use more invasive techniques than can be used in human studies. The major disadvantage is that, in general, applying the results of animal studies to humans is highly uncertain. The clinical approach is better for studying acute health effects in humans because, under controlled conditions, these effects can be isolated. The drawback of this approach is that for cost reasons, it usually involves only a few subjects. As a result, clinical studies are unlikely to adequately describe the average population. In addition, the role of actions taken to reduce exposure (e.g., installing air purifiers) complicates the interpretation of clinical research because such mitigating behavior cannot be accounted for with laboratory controls. Typically, epidemiological studies use ambient air concentrations as a proxy for exposure, taking into account the population's activity patterns and defensive actions. Thus, the epidemiological approach implicitly addresses the effects of actions people take to avoid pollution. However, epidemiological studies have weaknesses because observed statistical associations between health effects and air pollution may be influenced by unmeasured variables. Epidemiological research is sometimes

[17] Because criteria documents are used mainly to support the national ambient air quality standards, they emphasize establishing the lowest level of exposure that will result in adverse effects, not on a more inclusive, general understanding (best guess) of the relationship between concentrations of air pollutants and physiological or environmental responses.

questionable because associations between effects and pollution concentrations may be influenced by unmeasured factors, or by not accounting for all plausible factors because of measurement problems.

Step Six: Benefits Valuation

To assess benefits, EPA hired Industrial Economics, Inc. (IEc), to recommend categories of the benefits of changes in air quality and to recommend methodologies for setting values for these categories. IEc has identified seven categories of benefits, including reduced morbidity, reduced mortality, increased visibility, improved surface water quality, increased agricultural productivity, improved forest quality, and decreased materials damage. For each category of benefit, IEc located a source document in which a literature review (i.e., a broad sweep of the economic literature) was conducted. IEc then integrated empirical estimates from the literature with estimates from EPA offices. IEc stated that according to existing models, changes in surface water quality, agricultural productivity, and forest quality are the primary benefits being quantitatively measured.

To assess the effects on morbidity, IEc began its work with a literature survey conducted by David Weitzel of National Economic Research Associates, Inc.[18] The survey includes information on symptoms and effects, as well as dollar estimates of the cost of avoiding symptoms.[19] Also, estimates of benefits in the survey are presented as ranges to reflect variability in the underlying estimates. IEc recommended that EPA consider the estimates of economic benefits presented in table I.2; all the reported estimates reflect a willingness to pay to avoid one day of each symptom. To assess the effects on mortality, IEc reviewed three existing surveys of literature on the value of life, including Viscusi (1992), Miller (1990), and Fisher et al. (1989).[20] Each survey evaluates three types of value-of-life estimates: wage-risk studies, contingent valuation studies, and hedonic

[18]David L. Weitzel, Economic Valuation of Environmental Health Benefits: A Review of the Literature, National Economic Research Associates, Inc., report to the Washington State Department of Ecology, Dec. 31, 1990.

[19]The estimates of benefits related to morbidity were drawn from existing contingent valuation studies cited in the Weitzel survey. In contingent valuation studies, individuals are asked how much they value specific changes in environmental quality. For example, individuals are asked how much they would be willing to pay for increased visibility in the Grand Canyon.

[20]W.K. Viscusi, Fatal Tradeoffs: Public and Private Responsibilities for Risk (New York: Oxford University Press, 1992); T. Miller, "The Plausible Range for the Value of Life: Red Herrings Among the Mackerel," Journal of Forensic Economics, vol. 3, no. 3 (1990), pp. 17-39; A. Fisher, L.G. Chestnut, and D.M. Violette, "The Value of Reducing Risks of Death: A Note on New Evidence," Journal of Policy Analysis and Management, vol. 8, no. 1, (1989), pp. 88-100.

studies.[21] IEc recommended a lognormal distribution for the value of a statistical life.[22]

Table I.2: IEc's Recommended Morbidity Values

	Estimates of willingness to pay to avoid one day of each symptom (in 1990 dollars)		
Symptom	**Low**	**Best**	**High**
Throat congestion	$3.77	$16.35	$36.44
Head congestion/sinus	4.40	8.20	65.41
Coughing	1.26	4.98	52.83
Asthma attack	11.81	32.48	53.80
Eye irritation	15.72	15.72	34.88
Headache	1.26	25.16	50.44
Shortness of breath	0	10.57	98.12
Chest tightness	6.29	6.29	22.71
Nausea	22.01	22.01	63.25
Drowsiness	18.87	18.87	39.51
Allergy (chronic)	5.66	15.72	25.79
Bronchitis and emphysema (chronic)	55.35	84.28	111.96
MRRAD[a]	38.37	38.37	82.52
Angina pectoris	83.12	106.71	124.60

[a]Minor respiratory restricted activity day.

To assess the value of environmental effects (reduced visibility, changes in surface water quality, changes in agricultural productivity, changes in forest quality, materials damage), IEc considered several approaches and recommended that EPA use parts of the National Acid Precipitation Assessment Program (NAPAP) analysis. To assess the value of visibility, IEc used contingent valuation studies from the economic literature that calculate individuals' willingness to pay for changes in visual range. It then generated benefit curves on the basis of the economic literature. To assess the value of surface water quality, IEc considered existing models of the effect of acid rain on recreational fishing, as well as contingent valuation studies of other values. To place a value on recreational fishing, IEc recommended generating new estimates using the NAPAP model set for the

[21]Wage-risk studies assume that people will demand higher wages for taking riskier jobs. If higher wages can be correlated with riskier jobs and vice versa, a value for the risk can be derived. Hedonic studies rely on the prices people pay for commodities being affected by changing environmental quality.

[22]IEc identified three sources of bias that should be considered in assigning a distribution to the value of a statistical life: risk perception, age, and income. It has been found that such values depend on differences in the perception of the risk faced, the age of the person affected, and personal income.

New England/Adirondack and Mid-Atlantic regions or using the existing NAPAP results to generate estimates for these regions.[23] IEc recommended considering qualitative approaches to assess the value of other environmental effects.

To assess the value of effects on agricultural productivity, IEc recommended considering the effects on economic welfare of changes in agricultural productivity and using agricultural sector models and estimates of economic impact. To place a value on agricultural productivity, IEc recommended generating benefits using agricultural sector models. IEc also recommended applying estimates from the literature for agricultural benefit categories not captured by the model.

To assess the value of effects on forest quality, IEc recommended using existing forest sector models to assess the implications for economic welfare of changes in forest productivity. IEc also conducted a literature review and related analysis to determine the potential magnitude of other categories of benefits for the forest. Furthermore, to place a value of the effects on timber production, IEc recommended using the most recent version of the Timber Assessment Market Model (TAMM) to generate estimates of benefits.[24] Finally, to assess the value of the effects on materials, IEc recommended using existing models designed to capture the effects on economic welfare of materials damage induced by air pollution. IEc conducted a literature review to determine the potential magnitude of economic benefits not addressed by these models.

To include the benefits of reduced air toxics, IEc conducted a literature review to determine if these benefits had been estimated; it determined that no studies had been conducted. IEc is working with Professor Mark Dickey of the University of Georgia to research ways to set a value on the benefits of reduced air toxics. In the meantime, the ACCACA recommended that EPA use the same mortality valuation measure for effects related to the criteria pollutants.

[23]To use the existing NAPAP results to generate estimates for the New England/Adirondack region, EPA would have to include wide-error bounds to account for the limited scope and uncertainties introduced by transferring one set of benefits (e.g., the benefits of acid rain reductions) to this problem.

[24]TAMM does not address the effects on federal land or on other nations, e.g., acid rain on Canadian forests.

Comments From the Environmental Protection Agency

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

SEP 2 2 1993

OFFICE OF ADMINISTRATION AND RESOURCES MANAGEMENT

Mr. Richard L. Hembra
Director
Environmental Protection Issues
Resources, Community, and Economic Development Division
U. S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Hembra:

As you requested, I am transmitting comments from the Environmental Protection Agency on the GAO draft report entitled Air Pollution: EPA's Progress in Determining the Costs and Benefits of Clean Air Legislation (GAO/RCED-93-172). The report reviews EPA's cost-benefit analyses program carried out under the Clean Air Act Amendments of 1990.

The report accurately describes several of the difficulties that the Agency has had in implementing the program including the size and complexity of the cost-benefit studies. Our comments, which are described in more detail in the enclosure, suggest changes and clarifications to the GAO report in three major areas: the steps necessary for conducting cost-benefit analyses, how the program will be managed at EPA, and the role and use of modeling work performed by several contractors.

Thank you for the opportunity to review and comment on the draft report. I look forward to receiving the final report.

Sincerely,

Sallyanne Harper

Sallyanne Harper
Acting Assistant Administrator

Enclosure

Recycled/Recyclable Printed on paper that contains at least 75% recycled fiber

EPA Comments on the GAO Draft Report,
Air Pollution: EPA's Progress in Determining the Costs and Benefits of Clean Air Legislation
(GAO/RCED-93-172)

Comments on the Letter

Now on p. 2.
See comment 1.

Page 2, para 3: As implied by the first paragraph, EPA will be conducting biennial assessments, rather than completing just two studies to fulfill section 812 requirements.

Now on p. 2.
See comment 1.

Page 2, para 3: The sequence involves six steps. Direct compliance cost estimation and macroeconomic modeling are best presented as separate steps since the direct costs will be considered on a stand-alone basis as well as being used as inputs to the macroeconomic modeling.

Now on p. 2.
See comment 1.

Page 3, para 1: The prospective study will not necessarily isolate the incremental effect of the Clean Air Act Amendments of 1990 (CAAA90). It is more likely that EPA will contrast the effect of pre-1990 standards in place with all potential post-1990 regulatory programs, including those initiated or continued under pre-CAAA90 authorities.

Now on p. 2.

Page 3, para 2: The draft report is correct in stating that the size and complexity of the analytical burden is the principal reason the statutory deadlines were not met.

Now on p. 4.
See comment 1.

Page 5, para 2: The last sentence requires clarification. In early 1991, a decision was made to have a joint management structure involving, OPPE, ORD and OAR, with OPPE assigned as the analytic lead. Over time, OAR contributed more co-equally (for more detail, see comment for page 13 footnote 9).

Now on p. 4.
See comment 1.

Page 6, para 2: Again six steps, not five.

Now on p. 5.
See comment 1.

Page 7: Graphic should show direct compliance cost estimation as step prior to macroeconomic modeling.

Now on p. 6.
See comment 1.

Page 8, para 1: Modify test to reflect six steps, not five.

Now on p. 7.
See comment 1.

Page 9, para 2: Emissions also occur from non-combustion sources, such as industrial processes, consumer solvents, etc.

Now on p. 7.
See comment 1.

Page 9, para 3: The air quality profiles will ultimately be compiled by county or urban area, not state.

Now on p. 8.
See comment 1.

Page 10, para 2: The air quality estimates need to be in hand before the concentration-response outputs can be generated, but they do not need to be in hand before the concentration-response functions are derived.

Now on p. 8.
See comment 1.

Page 11, para 2: There are numerous causes of uncertainty in the analysis, including instances of poor data quality, modeling or sampling error, incomplete knowledge of key processes and relationships, and major uncertainties surrounding the specification of the "no-control" case.

Now on p. 8.
See comment 1.

Page 11, para 3: The Interagency Review Group includes Labor, Commerce, Energy, CEA, CEQ, and OMB.

Now on p. 9.
See comment 1.

Page 12, para 2: EPA has already initiated planning for the Prospective, and expects to begin actual work well before the Retrospective is completed.

Now on pp. 9-10.
See comment 1.

Page 13, footnote 9: The history of section 812 project management needs clarification. In early 1991, the Assistant Administrators for OPPE and OAR met to discuss implementation of the new Clean Air Act amendments. During that meeting, a decision was made to pursue the section 812 projects through a joint management structure involving OPPE, OAR and ORD, with lead analytic responsibility assigned to OPPE. Over time, it became clear that no one office had all of the skills and resources needed to implement the analysis, and OAR contributed more co-equally to the analytic effort.

Now on p. 10.
See comment 1.

Page 13, para 2: OAR had contracted with ICF to provide CEUM-based utility emissions estimates on a parallel track with the Argonne ARGUS-based work. Because CEUM could not be readily configured for years before 1980 due to data limitations, the original CEUM effort was designed to provide a "reality check" for the ARGUS results. Based on the emergent problems with the ARGUS results, OAR expanded the CEUM effort to cover more pollutants and more years and serve as a substitute for the ARGUS results. (NOTE: the 1975 estimates were based on historical fuel deliveries and generation for 1975, not the CEUM model due to data limitations).

Now on p. 10.
See comment 2.

Page 13, para 2: At the December 22 meeting of the ACCACA, the committee clearly stated a preference for the ICF CEUM utility results over the Argonne ARGUS-based results. This is omitted from the GAO report, creating the misimpression that as of June 1993 EPA was still considering which utility results to use.

Now on p. 10.
See comment 1.

Page 13, para 3, line 1-2: Change to "...in 1992 EPA augmented the statement of work to Computer Sciences..."

Now on pp. 10, 26-27.
See comment 1.

Page 13, para 3: The report should point out that there are a number of other elements of the air quality modeling effort in addition to RADM runs, including OZIPM4 runs to obtain ozone profiles for 100 urban areas and linear roll-up/roll-back modeling to obtain air quality profiles for remaining criteria pollutants.

Now on p. 10.
See comment 1.

Page 14, para 1, line 2: Change to "...utility emission estimates and the additional detail available from the new, expanded ICF CEUM results may cause EPA to rewrite the..."

Now on p. 11.
See comment 1.

Page 14, para 2, last sentence: Actually, EPA will quantify and monetize some benefits (especially cancer mortality reductions) of air toxics reductions.

Now on p. 12.
See comment 1.

Page 16, chart:

a. Direct compliance cost estimation and macroeconomic modeling should be presented as separate steps. OPPE spent $81,000 for direct cost estimation and $105,000 for macroeconomic modeling.

b. Concentration-response and valuation work should be separated. As of the April cut-off date, OAR had committed $145,000 for valuation work. OPPE had spend $20,000 on concentration-response work.

c. The $20,000 attributed to OAR for macroeconomic modeling was actually a review of uncertainty underlying the direct compliance cost estimates. As such, it could be allocated to either direct compliance cost estimation or uncertainty analysis. OAR did not spend any resources on macroeconomic modeling.

d. ORD has not spent $60,000 on concentration-response work. In fact, ORD has not used contractor support for review of the concentration-response curves beyond incidental activities (e.g., clerical support).

e. The $90,000 figure in footnote c should be changed to $70,000.

Now on p. 12.
See comment 1.

Page 18, para 1: OPPE spent another $75,000 for lead benefits work and $50,000 for concentration-response work since the April cut-off applied to Table 1. This complements OAR's expectation of a total additional Fiscal Year 1993 expenditure of approximately $425,000.

Now on p. 13.
See comment 1.

Page 18, para 2: ORD has spent $70,000, not $90,000, for air quality modeling.

Now on p. 12.
See comment 1.

Page 18, para 2: ORD has not spent $60,000 on air toxics concentration-response work.

Now on p. 13.
See comment 1.

Page 18, para 2: ORD has revised its estimate of in-house staff time commitment through February 1993 to equal one staff-year.

Comments on the Appendices

Now on p. 18.
See comment 1.

Page 23, para 2: The Hierarchical Partition Assessment (HPA) model is not, as the GAO letter implies, intended as a substitute for either feeder models based on nonlinear functions or expert judgment. It is merely a candidate repository for outputs from expert judgment solicitations and detailed feeder models such as the J/W macro model. The ACCACA concurs with EPA's general approach of using a top-level management model to assimilate and process fundamental results. This is a function which the HPA could serve, though EPA will also look at alternative frameworks.

Now on p. 25.
See comment 1.

Page 28, para 2: In addition to the CEUM model for target years 1980, 1985, and 1990, ICF estimated emissions for 1975 using historical data on generation and sulfur content of delivered coal.

Now on p. 26.
See comment 1.

Page 33, chart: Utility emission estimates for SOx, NOx, and PM will be derived from the ICF CEUM model, supplemented by the 1975 estimates referenced above. VOC and CO emissions from utilities are relatively minor and, if used at all, will be taken from the Argonne ARGUS revised results. Lead emissions will be derived from by applying lead emission factors to plant-level fuel consumption data provided by ICF.

Now on p. 27.
See comment 1.

Page 33, para 2: "RADM" stands for Regional Acid Deposition Model.

Now on p. 27.
See comment 1.

Page 33, para 2: RADM will not be used to estimate CO emissions.

Now on p. 27.
See comment 1.

Page 33, para 2: RADM will estimate only the sulfate and nitrate components of total particulates, and only for eastern 31 states covered by the RADM grid.

Now on p. 27.
See comment 1.

Page 34, para 1: Substate grid measurements from RADM will be aggregated to obtain state-level totals, not "rolled-up." When used in the context of air quality modeling, the term "roll-up" implies changes in air quality within a given location based on changes in emissions.

Now on p. 27.
See comment 1.

Page 34, para 1, lines 6-7: Change to "...EPA will use heuristic models to estimate changes in regional air quality and roll up or roll back historical concentrations of air pollutants based on these changes."

Now on p. 28.
See comment 1.

Page 36, para 2: Note that additional advantages to toxicology include the ability to test animals at higher doses and to use more invasive techniques than can be used in human studies.

Now on pp. 29-31.
See comment 3.

Page 37: Overall, the section on benefits valuation in Appendix I attributes too much independence to IEc's efforts. For example, in the second sentence, it states that EPA hired IEc ... to determine categories of benefits ... to value." It should be made clear that EPA will make all final decisions, though these decisions will certainly consider the findings and recommendations of IEc. Another example occurs at the top of page 40, which states IEc "will also use parts of the [NAPAP] analysis." In fact, IEc only recommends that EPA use the NAPAP information.

Now on p. 29.
See comment 1.

Page 37, para 2: "Reduced visibility" should be changed to "increased visibility" as a benefit.

Now on p. 29.
See comment 1.

Page 37, para 3: On morbidity valuation, the Weitzel review was a starting point, but the supplemental work performed by IEc overtook the Weitzel survey in terms of the significance of the potential contributions to section 812. The report implies the Weitzel survey provides the bulk of the morbidity valuation information. It does not. The paragraph goes on to state that Weitzel's survey includes information for "hundreds of symptoms and effects." Actually, the number of effects reviewed is considerably smaller.

Now on p. 29.
See comment 1.

Page 37, para 3: Weitzel is with NERA (as indicated in the footnote) not with University of Washington (as stated in the text).

Now on p. 30.
See comment 1.

Page 38, para 1: IEc actually recommends a lognormal distribution for the value of a statistical life, not the endpoints implied by the Viscusi survey.

Now on p. 31.
See comment 1.

Page 40, para 1: (See second part of "Page 37" comment above.)

Now on p. 31.
See comment 1.

Page 41, para 2: Barring development by IEc and Mark Dickie of a refined mortality valuation measure more suitable for air toxics-related effects, the ACCACA had recommended at the April meeting that EPA use the same mortality valuation measure used for effects related to criteria pollutants.

GAO's Comments

1.The report has been amended to include updated information as well as clarifications in response to EPA's technical and editorial concerns.

2.We clarified the language in the report to reflect that ACCACA expressed its preference for the ICF Resources utility emissions estimates. However, because ACCACA is an advisory committee, EPA is not bound to accept its recommendations.

3.We revised the language in the report to correct the possible impression that IEc played a role other than a strictly advisory one.

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